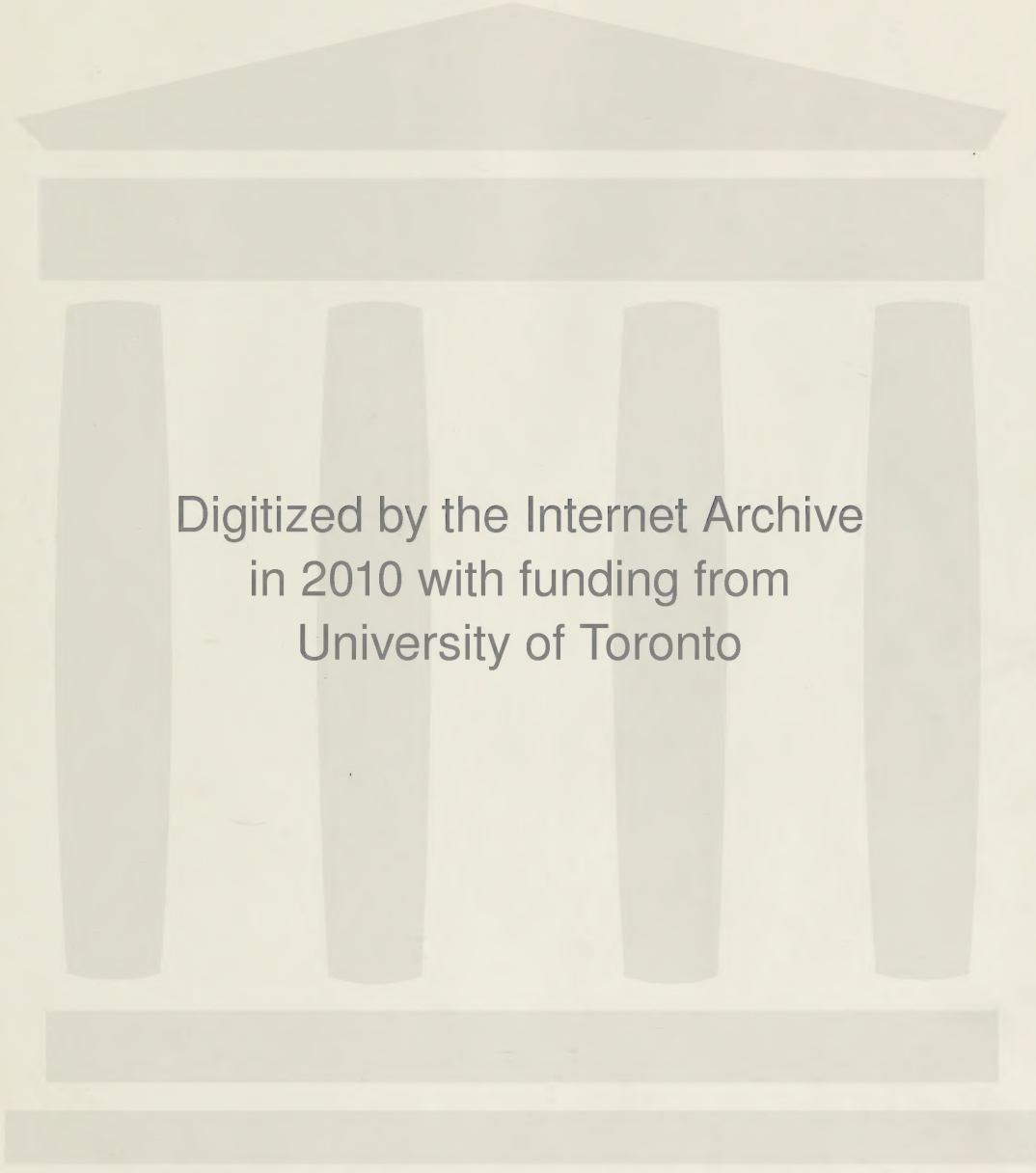


Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/chemicalengineer22newy

Chemical & Metallurgical Engineering

A Weekly Technical Newspaper,
Being the Incorporation of
Electrochemical and Metallurgical Industry
and Iron and Steel Magazine

Volume XXII

From January 1 to June 30, 1920

436847
3. 7. 45

NEW YORK
McGRAW-HILL COMPANY, Inc.

INDEX TO VOLUME XXII

GENERAL ALPHABETICAL INDEX

PAGES

Jan.	7	1 to	48
Jan.	14	49 to	96
Jan.	21	97 to	144
Jan.	28	145 to	192
Feb.	4	193 to	240
Feb.	11	241 to	288
Feb.	18	289 to	336
Feb.	25	337 to	384
March	3	385 to	432
March	10	433 to	480
March	17	481 to	528
March	24	529 to	576
March	31	577 to	624
April	7	625 to	672
April	14	673 to	720
April	21	721 to	764
April	28	765 to	824
May	5	825 to	872
May	12	873 to	916
May	19	917 to	960
May	26	961 to	1008
June	2	1009 to	1052
June	9	1053 to	1096
June	16	1097 to	1140
June	23	1141 to	1184
June	30	1185 to	1224

A

Abrasive, Aluminous. Hutchins. (P.).. 1128
Abrasive, New aluminous. Hutchins..... *565
Absorption of gases in spray systems and towers. Baker..... *122
Absorption tower packing, Resistance to gas flow. Correction. Zeisberg.... 244
Acetaldehyde from ethylene by electrolytic oxidation. Curme. (P.)..... 40
Acetates from carbohydrates. Randall. (P)..... 1128
Acetic acid, From calcium carbide. Rooney *847
——From corn-cobs..... 407
——From ethylene by electrolytic oxidation. Curme. (P.)..... 40
Acetone by fermentation. Weizmann and Hamlyn. (P.)..... 662
——From acetic acid. Morton. (P.)..... 40
——From Burton still waste gases..... 407
——From calcium carbide. Rooney..... *847
Acetylene, Acetone from. Matheson. (N.) 710
——From hydrocarbons. Curme. (P.).. 40
——Solvent for. Smith and Curme. (P.) 708
Acid fumes on Riverside Drive. Mudge... 676
Acids, Pumping with compressed air. Oliphant..... *408
Acid-resisting materials:
——Acid resisting metals. Matignon. (S.) 376
——Cu-Al-Fe bronze. Kowalke..... 37
Adsorption, Theory of. Patrick. (N.).... 950
Air, Compressed, Pumping acid with. Oliphant..... *408
Air conditioning in the industries. Leason 279
Air conditioning prevents explosions ignited by static electricity..... 614
Air-lift system for pumping acids. Oliphant *408
Airplanes, Discharge of clouds from..... *407
Ajo, Arizona, Leaching operations at.... 388
Alaska, Committee urges pulp wood development..... 1176
Alaska-Gastineau Mining Co., Milling plant of. Daveler..... *361

ALCOHOL:
——As motor fuel. Tunison..... 297
——As motor fuel..... 952
——Dangers of denatured alcohol. Chute. 149
——From coal in England..... 487
——Industrial alcohol under the new law and regulations. Tunison..... 513
—— Changes in formulas. Tunison.... 1056
——Industrial alcohol. Rodebush. (N.). 665
——In patent medicines..... 1132
——Primary and secondary. Dehydrogenation by catalytic oxidation. Moureu and Mignonac. (S.)..... 1083
——Transportation regulation for denatured alchol in Texas..... 437
——Wood alcohol as beverage. Nolan.... 533
——Wood alcohol must be labeled poison 910
——Woodine..... 321
Alizarine cyanine, British mfr..... 1033
Alkalis. Caustic mixtures. Armstrong. (P.)..... 1174
——Industry in 1919..... 2
Alkaline earth chlorides. Schotoff. (B.P.) 1129
Allotropism among metals. Getman. (N.) 1000

ALLOYS:
——Acid-resisting Cu-Al-Fe bronze. Kowalke..... 37
——Duralumin in aëronautics..... 1125
——Electric-resistance. Schench. (P.).. 1085
——For feed water regulator floats. Mumford. (B.P.)..... 1129
——Iron-nickel, Magnetic properties of. Yensen. (S.)..... *1039
——Magnesium..... 61
——Melting point of, Determinations of.. *27
——Nickelene..... 1191
——Non-ferrous, Nomenclature..... 1191
——Tungsten..... 15
Aloxite, Hutchins..... *565
Alsace, Potash mines in..... 1206
Alsatian petroleum industry..... 1124
Alum, Chrome. Hultman. (B.P.)..... 1129
Alumina from labradorite..... 544
——Mfr. of Halvorsen. (P.)..... 812

ALUMINUM:
——Acid-resisting qualities of..... *230
——Aluminum rolling-mill practice. R. J. and M. B. Anderson
I. Commercial pig and scrap..... 489
II. Melting furnaces—Ingot pouring 545
III. Ingot heating and mill calculations..... 599
IV. Slabbing..... *647
V. Finishing operations..... *697
——As engineering material..... 298
——Norwegian industry..... 544
——Powdered or granulated. Terrets. (P.) 661
Aluminum alloys, Duralumin in aëronautics 1125
——Fatigue tests on. Gibson. (N.).... 1191
Aluminum chloride, Anhydrous. Heap and Newberg. (P.)..... 857
Aluminum nitride, Electric furnace for. Shoeld. (P.)..... *184
Alunite, Research on..... 713
Amalgamation plates, Steaming. Pearce and Thomas. (N.)..... 711
American Association for the Advancement of Science, Research grants..... 342
American Association of the Baking Industry..... 199
American Association of Engineers' convention..... 813

AMERICAN CERAMIC SOCIETY:
——Joint committee on ceramic research. 104
——Philadelphia meeting. Announcement 104
—— Report..... *438
——Chicago meeting. Program..... 1217

AMERICAN CHEMICAL SOCIETY:
——Spring meeting. St. Louis. Program. *534
—— Report..... *768
—— Industrial excursions..... *858

AMERICAN ELECTROCHEMICAL SOCIETY:
——Spring meeting. Boston. Announcement 245, 442
—— Program..... 533
—— Report..... *725
American Engineering Standards Committee 294
——New bodies represented on..... 1218
American Foundrymen's Association to have new department..... 861
American Gas Association meeting..... 1090
American Institute of Baking..... 396

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS:
——Spring meeting. Canada. Itinerary and program..... *1089
——Reversing in and out ratio of members. Olsen..... 676

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS:
——Annual meeting, New York:
—— Program 104, 245
—— Report..... *343
American Metal Co. buys L. Vogelstein & Co..... 55
American Pharmaceutical Association research grant..... 536
American-Scandinavian Foundation fellowships..... 485
American Smelting & Refining Co. report.. 908

AMERICAN SOCIETY FOR TESTING MATERIALS:
——Asbury Park meeting. Report 1189
American Zinc Institute:
——Annual meeting, Chicago..... 999

AMMONIA:
——Absorption of, In spray system..... *124
——Catalyst for oxidation of. Perley.... 125
——Oxidation of. Thomson. (P.)..... 1127
——Oxidation of. Toniolo. (B.P.)..... 1129
——Synthesis of. Claude. (P.)..... 812
——Synthetic, Heat interchanger for. Greenwood. (P.)..... *812
——Synthetic. Gardiner. (P.)..... 661
Ammonia saturator. Roberts. (P.)..... 948
Ammonium nitrate, Mfr. of. (P.)..... 857
——Mfr. of. Partington. (B.P.)..... 992
Ammonium perchlorate, Mfr. of. Wang. (B.P.)..... 1040
Ammonium sulphate, Caking of. Atwater and Schulze..... 373
——Cost of mfr. from oil shale..... 21
——From gypsum. (S.)..... 424
——Mfr. using sodium bisulphate. Vis. (P.)..... 904
——Purifying. Sloss. (P.)..... 662

ANALYSIS:
——Analytical control of electrolytic zinc production. Bradley..... *651
——Arc images in. Mott. (N.)..... 728
——Automatic gas-analysis apparatus for Government helium plants..... 832
——Carbon in iron. Yensen. (N.)..... 728
——Chlorbenzenes. Bourion. (S.)..... 1084
——Determination of graphitic carbon. Selvig and Ratliff. (N.)..... 726
——Determining active strength of sulphate cooking liquor..... 462
——Gas, Determining light oil in. Bird.. *705

ANALYSIS—*Continued:*
——Gas, Spark coil for explosion pipettes. Taylor..... 1013
——Gas wash-bottle for referee's test for sulphur. Maze..... *1070
——Iron: (see Iron and Steel, Analysis)
——Limitations of Ledebur method for oxygen in steel. Cain and Pettijohn. (S.)..... *375
——Moisture determination apparatus... *946
——Monel metal, Rapid method. Covitz.. 31
—— Comment. Horner..... 436
—— Comment. Stausser..... 1144
——Of coal pyrite for sulphur..... 106
——Power hammer for pulverizing pig-iron samples..... 946
——Tin in brass or bronze. Raymond... 1056
Annapolis, Prominent chemists lecture at. 342
Anthracene press-cake, Treatment of. Andrews. (P.)..... 569
Anthranilic acid, Precipitating from aqueous solution. Potter. (P.)..... 378
Anthraquinone by catalytic oxidation. Andrews. (P.)..... 378
Anthraquinone, Purification of. Andrews. (P.)..... 569
Antimony compounds, Proposed tariff on. 664
Antimony pigments. Morris. (B.P.)..... 1175
Apparatus, Meeting of makers of scientific 860
——Scientific, Imports of..... 756
——Standardization of. Freas. (N.)..... 775
Arc images in chemical analysis. Mott. (N.)..... 728
Arc phenomena. Steinmetz..... 458
Argentina, Wood pulp manufacture..... 1030
Arizona Copper Co. mill, Dust exhaust system at. Hull..... *207
Arizona Copper Co., Stack losses at. Ambler..... *305
Arsem vacuum furnace..... *67
Asbestos paper, History of. Bowles..... 208
Asphalt industry, Miller..... *749
Assaying, Volatilization in, Dewey. (N.). 347
——Same paper in full..... 797
Association of Scientific Apparatus Makers 860
Atmospheric Nitrogen Corporation..... 1131
Atomic structure of metals in solid solution. Comment. Jeffries..... 100
——Comment Smith..... 340
——Reply. Feild..... 580
Atoms, Structure of. Langmuir. (N.).. *486
Australia, Electric steel furnaces in. (S.) 947
——Flax industry..... 988
——Foreign trade, 1918-1919..... 881
——Marking of imported goods..... 540
——Production of tin in. Lewis. (S.).. 903
Austrian engineers, Aid for..... 906
Auto-electrolysis..... 966

B

Babbitt: (see Bearing metal.)
Baking industry, Chemical engineer in. Lippert..... *893
Baking industry to be studied..... 199
Barium hydroxide from barium sulphide. Barnes. (P.)..... 89
Barium nitrate from barium sulphide. Davis. (P.)..... 378

BATTERIES:
——Primary:
—— Reserve dry cell. Batchelor. (P.). 856
——Secondary:
—— Reactions of lead accumulator. MacInnes. (N.)..... 727
—— Separators for. Rowson. (Aust.P.) 522
Bearing metal, Crystal growth in. Mahin. (N.)..... 775

BELGIUM:
——Artificial silk industry, Prosperity of 1144
——Industries one year after the armistice 645
——Penalties for commercial fraud..... 892
——Plate and window glass industry.... 487
——Steel cartel, Dissolution of..... 976
——Sugar production..... 1188
Belting, Leather, Measuring slip..... 255
Belt joining, Improved method..... 566
Benzaldehyde from toluene by catalytic oxidation. Weiss and Downs. (P.).. 522
Benzene, Catalytic oxidation of. Weiss. (N.)..... 102
Benzoic acid from toluene. Coblentz and Walker. (P.)..... 812

BIBLIOGRAPHIES:
——Nitrogen fixation..... 588
——Tungsten..... 16
Bismuth, Darling. (P.)..... 377
Bisulphite liquor manufacture. Baker. (N.)..... 781
Black ash, Extracting soda salts. Vrastel. (N.)..... 781
Black liquor from sulphate pulp, Treating. Olsson. (P.)..... 378
Blast-furnace: (see also Iron and Steel, Furnaces.)
Blast furnace, Comparative study of electrically and coke heated. Guédras. (S.)..... 990
Blast-furnace top, Rust. (P.)..... *377
Blast roasting at Port Pirie. Rigg..... 518
Bleaching powder, Mfr. of. Rudge. (P.).. 857
Bleaching with ozone..... 806

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

Bohemian glass industry 464
Bolivian petroleum deposits purchased... 910
Book Reviews....42, 185, 282, 331, 474, 570, 667, 817, 910, 1001, 1047, 1090

BOOK REVIEWS:
——Andros. The Petroleum Handbook... 817
——Classen. Quantitative Analysis by Electrolysis 185
——Darling. Inorganic Chemical Synonyms 667
——Davy and Farnham. Microscopic Determination of Ore Minerals 910
——Franke. A Handbook of Briquetting. 283
——Hatfield. Cast Iron in the Light of Recent Research..... 1001
——Hendricks' Commercial Register of the United States for Buyers and Sellers 474
——Hoyt. Metallography. Part I..... 1090
——Mahin. Quantitative Analysis..... 570
——Rideal. Industrial Electrometallurgy, Including Electrolytic and Electrothermal Processes..... 42
——Schenck. The Physical Chemistry of the Metals 1047
——Scott. The Journal of the Institute of Metals 474
——Slosson. Creative Chemistry 185
——Smith. James Cutbush, an American Chemist 283
——Twyford. Storing, Its Economic Aspects and Proper Methods..... 331
——VanKlooster. Lecture Demonstrations in Physical Chemistry 282
——Wein. Selenium Cells and How They Are Made 331
——Winslow and Pratt. Sewage Disposal 474
——Problems of Labor and Industry in Great Britain, France and Italy.... 185
Booth rotating furnace, Foundry test of.. 136
Borax in fertilizers..... 462
Bottle-blowing machine..... 859
Box-making course at Forest Products Laboratory 268
Box-testing machine, Drum..... *1126
Braden, Power development. Thomas. (N.) 101

BRASS:
——Booth rotating furnace vs. gas fired crucible for melting..... 136
——Determination of tin in. Raymond.. 1056
——Electric furnace, Evolution of. St. John. (N.)..... 733
——Heat treatment of beta brasses. Brayton *211
——Influence of cadmium on. Guillet. (S.) 947
——Naval, Physical properties, Campbell. (N.) 1191

BRIQUETTING:
——Experimental plant. Stillman..... *1035
——Mold for refractories..... *66
——Zinc ore..... *75
Brazil, Laboratory facilities for analysis of imports 754
Bread, Industrial research on..... 251
Brine corrosion of petroleum equipment. Mathews and Crosby..... 491
British: (see under England.)
British Chemical Industry....56, 200, 389, 628, 828, 1013

BRONZE:
——Cu-Al-Fe, Acid-resisting alloy. Kowalke 37
——Determination of tin in. Raymond.. 1056
——Elastic properties of bronze castings. Comstock *1113
Bronze plating. Mathers and Sowder. (N.) 728
Bronze powder industry in Japan..... 734
Brooklyn Polytechnic Institute, Annual alumni banquet of Chemical Society 1001
Bucher process, Improvement of. Mont. (P.) 709
Buenos Aires, Exposition of United States manufacturers in.....688, 713
——National hydraulic laboratory..... 1075
Budget bill..... 952
——Rejected 1132

BUREAU OF CHEMISTRY:
——Appropriation 448, 535
——Color laboratory. Gibbs..... *405

BUREAU OF MINES:
——Cottrell succeeds Manning as director *884
——Cryogenic laboratory to be established 1086
——Non-metals experiment station..... 1046
——Proposed consolidation with Geological Survey 952
——Tunnel ventilation problems..... 295

BUREAU OF STANDARDS:
——Appropriation 815
——Current activities of the stations.... 542
——Enamel investigations 810
——Plans increase in chemical activities. 56
——Standard samples. Comment. A.A.N. 964
——Standard samples, Present status of. 1047
Burma Corporation, Ltd., Report..... 197
Burns, Sag paste for..... 592
Business side of chemistry. Eisenschiml.. 53
Butyl alcohol by fermentation. Weizmann and Hamlyn 662

C

Cadmium, Influence on brass. Guillet. (S.) 947
Cadmium solder. Luckey. (P.)..... 1040
Caking of salts. Lowry and Hemmings. (N.) 976
Calcium arsenate insecticides..... 254
Calcium carbide and wood distillation products. Reid. (P.)..... 661
Calcium, Electrolytic production. Brace. (N.) 728
Calcium fluoride, Mfr. of. Chase. (P.)... 662
Calcium molybdate as an addition agent in steel making. Kissock..... 1018
Caliche deposits 656
California Fruit Growers Exchange research laboratory 876
California Institute of Technology..... 500
California, Power development in..... 876
California Section, A.C.S:
——February meeting..... 437
——March meeting..... 665
Calumet & Arizona Mining Co. report.... 908
Camphor from isoborneol. Andreau. (P.) 616
Camphor production in British Empire... 1030

CANADA:
——American glass in..... 423
——Chemical exports..... 210
——Exhibition in France..... 496
——Foreign trade for 1919..... 850
——Large chemical company organized.. 907
——Mineral production for 1919. (S.).. 855
——Productive power..... 975
——Pulp and paper combination formed.. 1176
——Pulp wood embargo may cause retaliation 1044
——Research bureau to be established.. 1046
——Special overseas trade commission... 902
——Ten commandments for trade..... 862
——Water-power development 1200
Canadian Institution of Chemistry..... 815
Carbazol, Purification of. (B. P.)..... 1216
Carbo-hydrogen gas. Rose. (P.)..... 1128
Carbon, Determining graphitic carbon. Selvig and Ratliff. (N.)..... 726
——In furnace refuse, Loss due to. Berry *179
Carbon black, Testing natural gas for. Neal *358
Carbon monoxide detector..... 906
Carborundum, Increasing uniformity of. Hutchins. (P.) 709
Carborundum refractories to be made at Perth Amboy 907
Carnegie Corporation aids National Academy of Sciences and National Research Council 198
Castner caustic soda-chlorine cell..... *206
Castor oil plant at Gainesville. Shrader and Goetz *833
Catalysis, Contact. Bancroft. (N.)..... 725
——Practical applications of. Bray. (N.) 437
——Theory and practice of..... 102
Catalyst for oxidation of ammonia. Perley 125
Catalysts for hydrogenation. Brochet. (B.P.) 948
Catalyzers in paint and varnish manufacture. Ingalls..... 590
Cat-tail as source of food..... 420
Caustic pot settings. Wheeler..... 373
Ceco spray system *174
Cellulose acetates. Zdanowitch. (B.P.).. 1175
Cellulose chemistry, Plea for scientific study of. Hibbert..... 838
Cellulose compounds. (B.P.)..... 1129
Cellulose ester solutions. Carlsson and Thall. (B.P.)..... 992
Cellulose symposium. Correction. Cohoe.. 244
Cellulose symposium, A.C.S. meeting..... 932

CEMENT:
——Electric drive in Victorville mill.... *292
——From low-grade carboniferous material. Lesley. (P.)..... 709
——Mfr. in electric furnace. Boillot and Daudignac. (P.) 708
——Olympic Portland Cement Co. plant.. 196
Cement drain tile, Durability in alkali soils 366
Central Foundry & Supply Co. at Nitro... 342

CERAMICS:
——Ceramic building for Rutgers College. Millen 410
——Ceramic processes and colloid phenomena. Bleininger. (N.)..... 779
——Commercial pottery of Japan..... 702
——Developments during 1919..... 4
——Feldspar as pottery material. Staley. (N.) 54
——Laclede-Christy Co. plant..... 858
——Properties of pottery bodies and glazes. Schurecht. (N.)..... 55
——Short course at Univ. of Illinois..... 864
Chamber of Commerce, New International 864
Chandler, Dr. Charles F., Receives Perkin Medal 103
——Full report of presentation..... *150
Chandler medal, Dr. Whitney to receive.. 666
——Presentation 863
Charcoal from walnut shells..... 1045

CHARTS:
——Alignment:
—— Loss due to carbon in furnace refuse. Berry *179
—— Vapor pressure-temperature relation for liquids. Savage..... *1155
——Viscosities in different systems. Nevitt *1171
Chemical and physical constants, Compendium of..... 247
Chemical engineer in baking industry. Lippert *893
Chemical engineering at Columbia University. Hendrick *162
Chemical engineering at University of Nebraska 665
Chemical engineers, Lessons for, In other industries. Marshall 218
Chemical Engineers, Reversing in and out ratio. Olsen 676
Chemical Foundation, German opinion of. 348

CHEMICAL INDUSTRY:
——Electrochemical industry in Scandinavia 1082
——Electrochemical industries in Sweden. Beckman 840
——Exposition of: (See National Exposition of Chemical Industries.)

CHEMICAL INDUSTRY—*Continued:*
——French, Development of..... 975
——In Holland..... 654
——In Sweden..... 464
—— Comment. Huitman 920
——In 1919..... 1
——Italian, Development of..... 791
——Need of co-operative educational work in. Cohen 509
—— Comment. Burr 724
——Of Southern States. Fairlie..... *307
—— Comment. Maher..... 724
Chemical market...44, 91, 141, 188, 236, 285, 332, 379, 426, 476, 524, 572, 619, 669, 716, 759, 819, 867, 912, 955, 1003, 1048, 1092, 1135, 1179, 1219
Chemical warfare. Fries. (N.)..... 773

CHEMICAL WARFARE SERVICE:
——Annual dinner *55
——Army reorganization bill reported to Senate 245
——Becomes a separate service..... 663
——Continues 1132
——General Sibert and. Wooton..... *755
——On peace basis 1217
——Progress of Army reorganization bill. 199
——Recruiting stopped..... 665
——Vocational school of 865
Chemistry for undertakers. Seyt..... 484
Chemists, Classification and salaries of. McBride *689
Chemists' Club elects officers..... 998
Chemists' Club will purchase German marks 508
Chemists' salaries, Government..... 488
Chestnut stumpage for sale..... 816
Chicago Chemists' Club..... 861
——Annual meeting 999
——Weekly luncheon inaugurated..... 1131
Chicago, John Crerar Library moves..... 1043
Chicago section, Amer. Ceramic Soc.:
——April meeting..... 861
——May meeting. Enameling..... 1107
Chicago section, A.C.S.:
——December (1919) meeting..... 53
——January meeting. Tungsten..... 248
——May meeting. Willard Gibbs medal.. 1086
Chicle gum in British Guiana..... 1017
Chilean nitrate, Ample supply assured.... 448
——Industry. Bertrand..... *655
—— Economic aspects..... 1207
——Output and shipments..... 1032
China, Awakened industrial..... 754
——Peanut and peanut oil exports..... 1173
——Rubber tires in..... 405
Chlorbenzenes, Analysis of. Bourion. (S.) 1084
Chlorhydrins from oil gas. Brooks..... *629
Chloride volatilization experiments at Eureka, Utah..... 52
Chloridization tests 879
Chlorination of aromatic compounds. Morris (B.P.) 1175
Chlorination, Vapor phase 406

CHLORINE:
——Chlorine's place in our daily life.... 509
——Electrolytic cell, McDorman. (P.).. *1216
——Liquefaction of. Henderson. (P.).. 1128
Chlorpicrin, Mfr. of. King. (P.)..... 661
Chrome alum. Hultman. (B.P.)..... 1129
Chromium, Electrolytic. Sargent. (N.).. 728
Chromium-nickel alloys. Gatward. (S.).. 661
——Comment. Fairchild 1144
Chromium sulphate, Mfr. of. Mooney. (P.) 857
Chuquicamata, Power development at. Thomas. (N.) 101
Cibucao wood for dye in Hongkong..... 888
Citric acid, Mfr. of. (B.P.)..... 1040
Civic Forum Medal awarded to Hoover .. 341
Civil Service examinations 247, 342, 437, 666, 816, 1090
Classification and salaries for chemists. McBride *689
Classification for chemical, physicochemical and physical phenomena 103
Clay, Colloidal, in soap. Weston. (S.) . 615
Clay, Classification, testing, storing and handling, etc. (N.) *439
Cleveland Section, A.C.S.:
——March meeting 665

COAL:
——Carbonization of Missouri cannel coal. Dunlap and Kershner. (N.) 774
——Low-temperature carbonization in England 692
——Powdered, In chemical and allied industries. Fitch. (S.) 183
——Pulverized, Explosion hazard in steel mills due to partly consumed 422
——Pulverizing plant at Nevada Consolidated Smelter. Pomeroy. (N.) .. 347
Coal ash from Eastern coals, Fusibility of. Selvig, Brown and Fieldner..... 80
Coal briquets, Mfr. at Swansea 1134
Coal pyrite, Chemical data on. Yancey... *105
Coal storage, Scoop conveyors for..... *182
Coal tar for fuel. Church. (N.) 296
Coal tar, Utilization of. Sharples. (S.).. *903
Cobalt, Recovering. Udy. (P.) 1174
Cobalt oxide, Use in ceramics. Davis. (N.) 439
Cobalt silver ore, Smelting and refining. Wright. (S.) 855
Coke plant at La Belle, Blackiston *561
Coke ovens, Robert type, at St. Louis Coke and Chemical Co..... 907
College of City of New York to give engineering degrees 860
Collinsville Zinc Corp., Lithopone plant. Jones *497
Colloidal clay soap. Weston. (S.)..... 615
Colloid symposium, A.C.S. meeting (N.) 778
Colloid symposium. Bancroft. (N.) 726
Colloid theory applied to asphalt 753
Colorado, Resources of 1100

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

Colorimeter for white paints..... 1192
Color laboratory, Bureau of Chemistry. Gibbs *405
Columbia University, Teaching chemical engineering in. Hendrick *162
Commercial organizations in the United States 711
Concentrating solutions, Process of. Walker. (P.) 709
Concrete, Test of water storage tanks .. 696
Condenser tubes, Corrosion of. Bengough, Jones and Pirret. (S.) 707
Constants, Compendium of chemical and physical 247
Construction and operation, 47, 95, 144, 192, 239, 288, 336, 383, 431, 479, 528, 575, 623, 672, 719, 763, 822, 871, 915, 959, 1006, 1052, 1095, 1139, 1183, 1224.
Contacts, Tungsten, Mfr. of 13
Converter and electric furnace. Sarron and Simon. (P.) 233
Conveyors, Pneumatic, At Aluminum Co. plant *566
Cooling liquids in spray systems and cooling towers. Baker *173
Co-operation during reconstruction 734
Co-operative associations Cohen 509

COPPER:

——And magnetite in copper smelter slags. Maier and Van Arsdale. I *1101
II. *1157
——Cost of production in 1918 38
——Hydrometallurgy and pyrometallurgy, 1919 6
——Hydrometallurgy of. Lyon. (N.) 1178
——Intercrystalline brittleness. Rawdon and Langdon. (N.) 346
——Operations at Ajo 388
——Precipitating from hot solutions. Laist. (P.) *1041
——Precipitating prior to flotation. Sulman and Picard. (P.) 991
——Precipitation on charcoal. Fleming. (Aust. P.) 904
——Production from secondary material. Addicks *119
——Relationship of chemical and physical properties of. Antisell. (N.) ... 344
——Requirements of refined copper. Addicks *449
Copper ores, Hydrometallurgical process for. Greenawalt. (P.) *473
Copper ores, Lixiviation with SO_2 solution. Christensen. (P.) 184
Copper-lead ores, Smelting. Johnson. (P.) 991
Cotton linters, Pulp from. Kress. (N.) 781
Cotton seed and cottonseed products. .906, 1081
Cottonseed mills import peanuts 1045
Cottonseed oil industry, Pictorial description of. Wesson *465
Cottrell receives Willard Gibbs medal.... 1086
Cottrell succeeds Manning as Director, Bureau of Mines *884

COTTRELL PRECIPITATOR:

——In Japan. Hirota and Shiga *276
——Motion of droplets and particles in field of corona discharge. Tolman and Karrer *1203
——Recovery of potash. Bradley. (N.) 756
Corona discharge, Motion of droplets and particles in field of. Tolman and Karrer *1203
Corporation patriotism 306
Corrosion: (see Metal protection and corrosion.)
Crescent belt fasteners 566
Crown-Willamette Paper Co. installs Jennsen system 1176

CRUCIBLES:

——For melting point determinations ..25, *66
——Graphite for 220
——Tungsten. Keyes. (P.) 184
Current Events 663, 710, 756, 813, 861, 905, 949, 993, 1042, 1086, 1131, 1176, 1217.
Cyanamide, Cyanides from. Landis 265
Cyanamide furnaces, Strawboard lining for. Middleton. (P.) 89

CYANIDES:

——From calcium carbide. Jacobs. (P.) 474
——Manufacture from cyanamide. Landis 265
——Manufacture, Review of developments in. Philipp 313
——Production of. Clancy. (P.) 856
——Production of. Lindblad. (P.) ... 617
——Production of. Mount. (P.) 709
Cymene sulphonic acids. Amber, Lubs and Gibbs. (P.) 42

D

Defects in steel: (see Iron and Steel, Defects.)
Dental cements, Development of..... 253
Denver, Industrial research at..... 1086

DETINNING PROCESSES:

——Electrolytic. Elkune. (B. P.) 1129
——Electrolytic. Tatro and Delius. (P.). 41
——Ferric salt process. Rumbold. (B. P.) 424
Detroit Engineering Society meeting..... 950
Diatomaceous earth, Phalen 981
Differential method for melting point.... *28
Dimethyl sulphate mfr. Durrans. (P.).. 41
Dinitrochlorbenzene, Mfr. of. Heyden. (P.) 709
Diphenyl from benzene 102
Dracco system at Armour Fertilizer Co... *182
Drain tile, Cement, Durability in alkali soils 366
Driers, Paint: (See Paint)
Dry cells: (see Batteries, Primary)
Dust exhaust system at Arizona Copper Co. mill, Hull *207
Dust hazard at Niagara Falls plants, Elimination of 348

DYE BILL:

——Licensing system, Controversy over... 101
——Substitute for dye licensing system.. 248
——Dye bill ready for Senate 294
——Senate debate on dye bill 390
——Moses amendment 584
——A. C. S. resolution in favor of Longworth bill 770
——Before Senate 905
——Fate of dyestuffs bill 951
——Moses automatic tariff amendment.. 998

DYES:

——British, Finer colors lacking 909
——Cibucao wood used in Hongkong.... 888
——Dye industry in Great Britain 535
——Dye section, A. C. S., Plans..... 390
—— Meeting. (N.) 776
——From halogenated hydroxynaphthoquinones. Wheeler. (P.)..... 569
——German, Allocation of 1218
——German dyes imported 1088
——German, Scarcity of 909
——Hongkong excludes American dyes.. 1133
——Production costs in dye industry.... 488
——Purple dye from shellfish..... 906
——Swiss dyes received..... 1133
Dyestuff industry, Dangers in. Cone 33

E

Earth's crust Chemistry of. Washington. (N.) 665
Eastern Potash Corporation 815
Eastman Kodak Co. work on organic chemicals 536

EDITORIALS:

——Acid fumes on Riverside Drive..... 339
——Alive to the situation! 723
——The alkali industry during the past year 2
——And the mountain labored and brought forth—Harding 1097
——Annual meeting of the Mining Engineers 49
——The annual report of the Steel Corporation 579
——Another case of secrecy 1010
——Are executives to join the labor turnover? 529
——Army reorganization and the Chemical Warfare Service 193
——Artistic imagination for engineering workers 627
——Availability of nitrate and ammonia nitrogen 827
——A balance nicely struck 626
——Boiler economy from distilled feedwater 918
——Bribery of dyers in textile mills..... 242
——Burning clay in Sanskrit 627
——Business men for exalted positions... 243
——Byproduct coke passes beehive..... 767
——Carbon and molybdenum as producers of flakes in steel 242
——A "Carnival of Greed and Imposition" 825
——Catalyst for the oxidation of ammonia 51
——Channels of steel consumption 875
——Chemicals in a smelter flue 98
——Chemistry and the Interstate Commerce Commission 625
——Chemistry conquering another industry. 1010
——Chemistry gone wrong 1011
——Chemistry, metallurgy and the Bureau of Standards 385
——Cleaning up Mexico—with soap.... 1099
——Cogitations on colloidal theories.... 767
——Colonel Fries heads Chemical Warfare Service 385
——Commercial ambassadors in Mexico City 387
——The compleat letter writer..... 1054
——Congress and the air nitrate projects. 961
——Congressional acts of omission..... 1097
——Conserving radium as a national asset. 626
——Co-ordinating scientific and industrial effort 433
——Creative engineering and theoretical science 290
——Developments in ceramics during 1919 4
——Developments in flotation litigation.. 1141
——Dewatering coal in the byproduct coke industry 146
——A dollar for war, a penny for progress 1009
——Do we need immigration? 529
——Economics or psychology..... 195
——Efficiency and morale of steel mill labor 51
——Electrometallurgy in 1919 and afterward 1
——Elimination examinations suit the mirror minds 1099
——Empirical equations in engineering calculations 530
——An engineer at the shrine 434
——Exit the National Laboratory Foundation 578
——Extrusion or diffusion? 766
——Fate of the dye bill..... 1011
——The Federated American Engineering Societies 1053
——Federation of engineering societies.. 193
——Food drafts for relief of Europe.... 433
——Fraudulent branding of imported articles 145
——Gold and silver metallurgy in 1919.. 3
——Government appropriation for the Forest Products Laboratory 385

EDITORIALS—*Continued:*

——Government nitrate plants should be operated 337
——A grand old man..... 145
——The greater circulation of chemists.. 766
——Professor Haber and the Nobel Prize 386
——The Haber process in the United States 1054
——Honorary degrees in chemistry..... 1054
——Mr. Hoover and the Presidency..... 49
——Hoover heads the A.I.M.E..... 337
——Horse thieves among chemists..... 1143
——How consulting chemists secure clientele 1143
——How is an invention invented?..... 531
——How shall the government nitrate plants be operated? 577
——How they do it out in Kansas..... 674
——Hydrometallurgy and pyrometallurgy of copper in 1919..... 6
——The ideal of national industrial independence 338
——Increased demand for laboratory facilities 337
——Index to current volume..... 1185
——Industrial patriotism and professional folks 98
——Industrial research and new technology 241
——Industrial value of the oxy-acetylene flame 194
——Inefficient distribution of labor..... 963
——Inquisitive ignorance in the foundry. 962
——In support of the Chemical Warfare Service 625
——An interpretation of coke statistics.. 338
——Iron castings in iron molds 721
——Is pearlite a special form of Widmanstättan structure? 577
——Just a little strike..... 1186
——Mr. Lane points the way..... 481
——Latest pronouncement on damage by smelter smoke 917
——Lessons from the last A. C. S. meeting 765
——Make it definite 1053
——Minerals Separation forestalled in contempt proceedings 1099
——The mission of Sir Oliver Lodge.... 289
——More power to the chemist..... 97
——The Muscle Shoals plant should be operated 674
——National organization of engineering societies 961
——New York Public Library combines science with technology..... 291
——The one and t'other..... 873
——Organized labor and the public..... 1143
——Organizing the steel workers..... 1187
——Our greatest chemical industry..... 578
——Patent royalties for Government employees 673
——Dr. Percy and the intellectual misers. 147
——Petroleum industry in 1919 4
——Political and commercial nitrogen.... 434
——Practicing industrial good-fellowship. 481
——President signs water-power bill.... 1141
——Proposed amalgamation of heat-treating societies 289
——A question of professional ethics.... 1185
——The railroad and you 146
——Railroad efficiency and steel requirements 627
——The railway administration and the quest of truth 194
——The relation of botany to chemistry.. 1098
——The report of the British Nitrogen Products Committee 241
——The report of the Industrial Conference 825
——Research among the bakers..... 827
——Research and imitation research.... 722
——Reversing the in and out ratio of the Chemical Engineers 290
——Review of the year's advance in rubber 5
——Ridiculous substitute for the metric system 434
——Rise and fall of the bessemer rail... 919
——The rule and its exceptions on the properties of lubricants..... 674
——Senate passes the water-power bill 97
——Senator Moses answers a question.. 874
——Sewage disposal and physical chemistry 433
——The simple life for some employers.. 1011
——Dr. Edgar F. Smith offers his resignation 339
——Something—but not enough..... 1187
——The Soviets at work 673
——Speaking of standard weights and measures 434
——The spirit of the West 1141
——Spring conventions of chemical societies 625
——The stable market for Chilean nitrate 1186
——Standardization that will work 918
——Standard samples to continue..... 721
——State of the milling art in 1919.... 50
——Steel Corporation does not violate the Sherman Law 435
——The steel industry can function.... 483
——The steel industry's growth..... 7
——The steel needs of the railroads..... 147
——Steel prices and other prices..... 723
——Steel prices and other prices..... 1055
——The steel strike officially called off.. 49
——Steel supplies recent and prospective.. 99
——Stop, look, listen, and keep a-looking. 1010
——Mr. Sulman's contribution to the study of flotation 387
——Summary dismissal of college professors 145
——A survey of the chemical industry... 1
——Synthesis and analysis of enginering formulæ 1142
——Technicalities concerning alcohol.... 482

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

EDITORIALS *Continued*

——Technically and commercially successful? 963
——Tests on high-speed steels in the small shop 826
——The tonnage output of the steel industry 675
——Wages and hours in steel industry 243
——What of breweries? 194
——What kind of an engineer are you? 19
——What to do with five million 294
——Where are the chemists? 1142
——Who knows about shale oil? 386
——Why not export helium? 559
——The woman and the serpent 195
——The Wilson Dam at Muscle Shoals 387
——Wood alcohol as a beverage 97

EDUCATION:

——Instruction in iron and steel at M. I. T. Hayward 1024
——Need of co-operative educational work in chemical industry. Cohen 509
—— Comment. Burr 724
——Technology plan for industrial co-operation. Walker 463
——Vocational school of C. W. S. 865
Elder nickel catalyzer 795
Electric arc phenomena. Steinmetz 458

ELECTRIC FURNACE:

——General:
—— Ferro-alloy manufacture in. Gibson. (N.) 730
—— Increasing use of. Smith. (N.) 714
—— Melting non-ferrous metals and alloys in. St. John 148
—— Problems in electric-furnace smelting. Holmgren *165
—— Regulator system for resistor furnaces. Lehr. (P.) *139
—— Smelting Montana manganese ores in. (Bardwell) 681
—— Step induction regulator for. Short. (N.) 733
—— Transformers for. Thomson. (S.) *616
——Various designs:
—— Arc melting furnace and central station. Smith. (N.) 731
—— Arsem graphite resistance vacuum furnace *67
—— Booth rotating. Booth. (P.) 991
—— Brass furnace. Evolution of. St. John 733
—— Car-type furnace for annealing aluminum sheet *699
—— Electric blast furnace. Transformer connections. Bibby and Boving. (P.) *1085
—— Foundry test of Booth rotating furnace 136
—— Inclined rotating furnace. Harvey. (P.) 1085
—— Induction furnace. Unger. (P.) *282
—— Laboratory metal furnace *231
—— Melting point furnace for metals and alloys *25
—— Melting point furnace for silicates and metals *64
—— Polyphase furnace. Shoeld. (P.) *184
—— Rennerfelt electric reverberatory furnace. De Fries *280
—— Resistance furnace for heating gases for blast furnace. Simon and Sarron. (P.) *1085
—— Resistance furnace for zinc ore briquets. Fulton. I. *73 II. *130
—— Resistance type. Bristol and Johnson. (P.) *569
—— Steel furnaces in Australia. (S.) 947

ELECTRIC FURNACE ASSOCIATION:

——Boston meeting. Announcement 534
—— Program 611
—— Report 711
Electric power. Public utility efficiency 997
Electric power symposium. (N.) 731
Electric truck with regenerative braking 374
Electrochemical colloquium 864
Elecrochemical industry: (see Chemical Industry.)
Electrochemical research. Colloquium on 390

ELECTRODES:

——Carbon. Mfr. of. (S.) 521
——Graphitized. Mfr. of. Hinckley. (P.) 41
——Increasing durability of rod electrodes for Schönherr type furnace. Heier. (P.) *138
——Manufacture of carbon electrodes. Morrison 741
——Söderberg self-baking continuous. Richards. (N.) 732
——Support for. In Heroult type furnace. Dyossen. (P.) *138
Electro-endosmosis. Briggs. (N.) 950
Electrolytic lightning arresters. Plates for. Coulson. (P.) 857
Electrometallurgy in 1919 1
Electron Society 780
Elmore process for zinc-lead ores 164
Emulsions, Soap-water, Separation of fixed oils from. Ayres *1057
Enamel investigations at Bureau of Standards 810
Enameling, Cleaning and pickling iron and steel for. Danielson. (N.) 32
——Of cast iron. Menne. (N.) 1107
——Preparation of steel for. Whitford. (N.) 1107
Enamels Division, Amer. Ceramic Soc. 440
Engineer in national affairs. Hoover 349
Engineering Advertisers' Association 584
Engineering and Mining Journal 863
Engineering Conference 861
Engineering Council Sixth monthly report 816
Engineering ethics. Code of 1042
Engineering practice. Resolution by house under date 1892 191
Engineering societies conference 910
——Correction. Richards 954
Engines. Tests on small engines at high back pressure. Fleming, Pepper and Field *318

ENGLAND:

——Alcohol from coal in 187
——Artificial silk mfr. in 853
——British blast furnace practice. Buckley. (S.) 650
——British chemical industry. 56 200 389 628 828 1013
——British officials to visit industrial centers 937
——British plans for trade information 686
——British research associations 462
——Dried flowers industry 1028
——Dye industry in 535
——Exports to U. S. 1919 389
——How British chemists are organizing. Hamer 597
——Industrial courts in 968
——Iron and steel production. 1919 744
——London metal prices for twenty years 1076
——Low temperature carbonization of coal 692
——Origin of British National Physical Laboratory 264
——Plate glass industry in 989
——Research associations in 264
——Touring exhibition for British industry 508
——Unique British advertising scheme 1075
Ether. Catalytic production of. Marble and de Godon. (S.) 329
——Continuous production of. Barbet. (P.) *617
Ethics, Engineering, Code of 1042
Ethyl alcohol: (See Alcohol.)
Ethylene, Compressed. Backhaus. (P.) 1216
——Electrolytic oxidation of. Curme. (P.) 40
Ethylene chlorhydrin from oil gas. Brooks *629
Explosion risks in dyestuff industry 34

EXPLOSIVES:

——Detonating fuse. Cope. (P.) 1174
——High explosives. Comey. (N.) 1000
——High explosives similar to dynamite. Bryan and Swint. (P.) 661
——Lead azide detonators. Stabilizing. Hudson. (P.) 856
——Nitrostarch, Stable. Anchors. (P.) 856
——Stabilizing nitrostarch. Snelling and Lams. (P.) 662

EXPORT STATISTICS:

——Chile:
—— Iodine. 1880-1918 659
—— Nitrate. 1880-1918 659
——Mexico.
—— Petroleum. 1919 932
——United States:
—— Caustic soda. Dec., 1919 348
—— Cement. 1919 704
—— Chemicals. Jan., 1920 650
—— Feb., 1920 736
—— March, 1920 952
—— Glycerine. Dec., 1919 348
—— 1919 226
—— Petroleum products 504
—— Phosphate rock. 1913-1917 308
—— Soda ash. Dec. 1919 348
—— Total value. Feb., 1920 734

F

Fansteel Products Co., Mfr. of tungsten at. Jones *9
Faraday Society thanked for war work 1043
Fatigue of metals. Investigation of 462
Fatigue research in tinplate manufacture 223
Federal Club 1218
Federal Reserve act. Revised text 536
Federal Trade Commission. Citations by 1131
Federated American Engineering Societies. Organization 1087
Feet. Sizes of 496
Feldspar as pottery material. Staley (N.) 54
Ferro-alloys:
——Electric furnace manufacture of. Gibson. (N.) 730
——Production of. Johnson. (P.) 184
Ferrocerium. Hirsch. (N.) 731

FERROMANGANESE:

——Mfr. in electric furnace at Great Falls. Bardwell 681
——Not covered by War Minerals Relief act 596
——Use of spiegeleisen in steel manufacture. Hibbard 209
Ferrosilicon. Raven. (N.) 730
Ferrosilicon. Mfr. of. Johnson. (P.) 184
Ferrovanadium metallurgy. Saklatwalla (N.) 730
Fertilizer industry in Southern States *311
Fertilizer regulations proposed 998
Fertilizer situation. Whitney 1021
Fiber. Vulcanized. Allison 1126
Fibers. Mfr. of. Weygan. (B.P.) 948
Filtering and Filters
——Classification of filter papers. Bowes. Searle *1005
——Continuous electrical metal filter. Merton. (P.) 1126
——Experimental filter 1
——Filtration and filters. Fabel 1
——Specific capacity of filter cloth. Wright I. 101; II. *10; III. *1119; IV. *1150; V. 1091
Fire brick. (See Refractories.)
Flax industry. Australian 988

FLOTATION:

——Contribution to the study of. 27
——Laboratory. Utah State School of Mines *878
——Precipitating copper sulphide pulp by. Sulman and Picard. (P.) 991
——Research on 135
——Use of sulphur soaps in. Tucker, Edset and M. S. Ltd. (E.P.) 991
Floor testing 891
Food stuffs for European relief. Hoover 430
Forest Products Laboratory. Co-operation Announcement 1045
——Appropriation 535
Formaldehyde from natural gas. Bailey. (P.) 317
Formic acid. Duty on 198
Fractures. Mechanism of. de Fleuriault *988
France. Chemical industries. Development of 975
——Duties on chemicals 804
——Hydro-electric power development in 1050
——Phosphate situation in 730
Freas system for laboratories 581
Freight car shortage. Relieving 816

FUELS:

——Liquid fuels *996
——New type 565
——Scarcity of fuel oil 1100
Fuel economy. Loss due to carbon in furnace refuse. Berry *179
Fuller's earth. Apparatus for treating spent. Husted. (P.) 41
Furfural from corncobs. Dunlap and Fischlowitz. (N.) 774
Furnace for testing firebrick under load at high temperatures. Lovejoy *109
Furnaces: (see Iron and Steel Furnaces. Electric Furnaces. Blast Furnaces etc.)
Gainesville castor oil plant. Shrader and Goetz *833
Gallic acid. (B.P.) 1216
Galvanizing large steel parts by hot process. (S.) 567
Galvanometers. Northrup *944
Garnet. Electric furnace reduction of. Thompson and Davenport 596

GAS AND GASES:

——Absorption of. In spray systems and towers. Baker *127
——Analyses. Automatic apparatus for. Government helium plants 832
——Apparatus for determining light oil in. Bird *705
——Blast-furnace. Cleaning. (S.) *423
——Coal. Influence of carburation on crystallization of naphthalene in pipes. Abder Halden. (S.) 990
——Industrial heating with. Lochell. (N.) 1044
——Liquefaction of. Brown. (S.) 1083
——Natural Gas Conservation Conference resolutions 1217
——Nitrous. Concentrating. Halvorsen. (P.) 137
——Poisonous. Storage of 1218
——Producer. Sulphur content of clean gas. Kaufmann 544
——Research opportunities in gas industry. Searle. (N.) 1044
——Supplementing natural gas supply with coke-oven gas. Ramsburg. (S.) 1114
——Testing natural gas for carbon black. Neal *358
Gas-fired furnaces. Surface vs. bunsen combustion in. Kowalke. (N.) 320
Gas industry. Crisis in 1090
Gas plants. Preventing accidents in. Comey 131
Gas wash bottle for referee's test for sulphur. Maze *1070
Gasoline. Casinghead. Blending with naphtha 884
Gasoline substitutes. Moore. (N.) 736
Gelatine. General chemistry of. Loeb. (N.) 940
Gelatine. Mfr. of. Turner. (Aust. P.) 527
Geological Survey. Proposed consolidation with Bureau of Mines 977
General Chemical Co. buys Western Chemical Mfg. Co. 197
General Briquetting Co. Experimental plant. Sullman *1033

GERMANY:

——Chemical works. Secret of success 341
——Dye companies pay big dividends 1090
——Dyes. Scarcity of 980
——Export and domestic prices for dyes 789
——German Works Councils Act 1127
——Marks. Chemists' Club will purchase 508
——Nitrate industry 600
——German Nitrogen Syndicate. Care 686
——No liquidation of American property in 666
——Opinion of Chemical Foundation 348
——Potash deposits of 945
——Potash production and price 341
——Potash situation 1125
——Prolongation of German patents. Zwingenberger 1056

*Illustrated; (P.), (B.P.), (Aust.P.), (Can.P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full

GLASS:
——American glass in Canada 423
——American glassware. Present status of. Sullivan 29
——Belgian industry. Condition of 487
——Bohemian glass industry 464
——British plate glass industry 989
——Chemical glassware, American 30
——Colored 29
——For cooking utensils 30
——For electric light bulbs 29
——Granulite used in British industry .. 1082
——Illinois Glass Co. plant *859
——Low-expansion 29
——Report of Glass Division, Amer. Ceramic Soc. 440
——Selective spectrum absorbing 30
——Welders' glasses 30
——X-ray shield 30
Glue, Inferiority of shellac as 360
Glue Mfr. of. Turner. (Aust. P.) .. 522
Gluten. Determination in flour 894
Glycerine by fermentation. (B. P.) 1129
Glycerine United States foreign trade in 225
Glycols from oil gas. Brooks *629

GOLD AND SILVER: (see also Silver.)
——Amalgamated aluminum plates for precipitating from cyanide solution. Gordon. (P.) 282
——Metallurgy of, In 1919 3
——Milling plant of Alaska-Gastineau Mining Co. Daveler *361
——Solubility of gold in cyanide solutions. White. (S.) 183

GOVERNMENT:
——Castor oil plant. Shrader and Goetz. *833
——Chemists' salaries 488
——Contracts, Liquidation of suspended . 341
——Employees' inventions 1045
——Kelp plant to continue.....357, 535, 776
——Officials organize club 1218
——Oil corporation proposed 1043
——Photosensitizing dyes 405
——Picric acid plant for sale..... 472
—— Plant sold 604
——Surplus supplies:
—— Disposal of, In 1919 200
—— Sulphuric acid 342
Grain unloaders. Use in chemical industry 219
Granulite. Use in British glass industry . 1082
Graphite. For crucibles 220
——Purifying. Turin. (B. P.) 424
Graphite ores. Ore-dressing methods for. Spearman. (S.) 521
Graphitic acid. Hulett and Nelson. (N.) 726
Graphitic carbon, Determining. Selvig and Ratliff. (N.) 726
Great Falls, Ferromanganese mfr. at. Bardwell 681
Great Falls smelter, Reminiscences of early years at. Repath *111
Great Western Sugar Co. to build new plant 1132
Gum copal, Export embargo in Sierra Leone 1213
Gutta-percha industry 792

H

Halogen substitution products. Koehler. (P.) 991
Heat interchanger for synthetic ammonia process. Greenwood. (P.) *812
Heat interchangers, Double pipe. Richter *551
Heatmeter, New compensated. Frey 100
Helium, Bill to prohibit export of 246
Hexanitrodiphenylamine. Marshall. (P.) 616
High-frequency coil, Artificially cooled. Northrup. (P.) 662
Holland, Chemical industry in 654
Hongkong shuts out American dyes 1133
Hongkong trade in chemicals 1122
Hoover and the Presidency. Engineer .. 484
Hoover awarded Civic Forum medal ... 341
Hoover for President. Snyder 245
Hull, Vegetable-oil industry of 1034
Hunt, Robert W., Receives Hunt medal.. 1046

HYDROCARBONS:
——Acetylene from. Curme. (P.) 40
——Cracking. (B. P.) 568
Hydrochloric acid. Sludge acid for mfr. of. Lasher. (P.) 1127
——From sulphur dioxide and chlorine. Tobler. (P.) *904
Hydrocyanic acid. Production of. Briner and Baerfuss. (S.) 329

HYDRO-ELECTRIC POWER:
——Canadian development 1200
——French developments 1070
——Muscle Shoals development. Jones... *417
Hydrofluoric acid. Mfr. of. Fickes. (P.) 90

HYDROGEN:
——Application in hydrogenation of oil. Barnitz *745
——Chemically active. Wendt and Grubb. (N.) 771
——Electrolytic production of. Barnitz. *201
——Reduction of tungstic oxide by *12
Hydrogen overvoltage, Effect of alternating current on. Goodwin. (N.) *727
Hydrogenation of oils. Barnitz *745
Hydrogenation, New catalyzer for Richardson 793
Hydrosulphite solutions, Preserving. MacIntyre. (P.) 1041
Hydroxynaphthoquinones, Dyes from halogenated. Wheeler. (P.) 569
Hypochlorite cell, Electrolytic. Gerstle. (P.) 1216
Hypochlorous acid. Mfr. of 631

I

Idaho phosphate rock for Orient 666
Illinois Glass Co. plant *859
Illinois, University of, Research graduate assistantships in engineering at . 199
Illinois, University of, Short ceramics course 864
Immigration conference 584
Import license, General, Extension of .. 110

IMPORT STATISTICS:
——United States:
—— Chemicals, Jan., 1920 650
—— Feb., 1920 736
—— Glycerine, 1884-1919 225
—— Petroleum products 504
Inagua, Bahamas, Revival of salt industry 706
India, Oilseed crop, 1919-20 forecast .. 1032
——Sandalwood oil industry 987
——1919-20 cotton crop 910
——1919-20 sugar crop 1026
Indigo and vegetable extract dye compound. Fries. (P.) 1174
Industrial Conference plan for labor disputes 813

INDUSTRIAL HYGIENE:
——Dangers in dyestuff industry. Cone.. 33
——Elimination of dust hazard at Niagara Falls plants 348
——Engineering and accident prevention . 667
——Explosion hazard in steel mills from partly consumed coal dust 422
——Industrial safety codes 437
——Pennsylvania Safety Congress 488
——Personal element in safety program for the foundry. Gartland 323
——Preventing accidents in gas plants. Conner 421
Industrial notes, 47, 95, 144, 192, 240, 384, 432, 480, 624, 720, 823, 872, 916, 960, 1007, 1140, 1184.
Industrial representation in Standard Oil Co. Hicks 607
Industrial research at Mellon Institute. Savage *249
Infusorial earth. Phalen 981
Infusorial earth industry. Bigot. (S.) 947
Insecticides, Nicodust 1045
Insecticides, Research on 253
Institution of Mining and Metallurgy awards medals 246
International Chamber of Commerce 864
International Joint Conference Council of printing industry 198
Inventions by Government employees 1045
Inverse-rate method for melting points .. *28
Iodine from kelp. Randall. (N.) 775
Iodine, Purification of. Carter. (P.) .. 378
Ionization of strong electrolytes. Kendall. (N.) 772
Iowa Section, A.C.S.:
——Officers 55
Iron, Cast, As chemical engineering material. Hoffer. (S.) 567
Iron alloys, Influence of chemical composition and thermal treatment upon properties of. Gunlich and Goerens. (S.) 376
Iron : nickel alloys, Magnetic properties of. Yensen. (S.) *1039
Iron oxides, Reduction by fuel gases. Eastman. (N.) 437
Iron and Steel Institute, Carnegie Research Fund 199
Iron and Steel market 43, 91, 140, 187, 235, 284, 332, 380, 428, 475, 523, 571, 618, 668, 715, 759, 818, 866, 911, 954, 1002, 1091, 1134, 1179, 1219

IRON AND STEEL:
——Analysis:
—— Limitations of Ledebur method for oxygen in steel. Cain and Pettijohn. (S.) *375
——Corrosion and protective coatings: (see Metal Protection and Corrosion.)
——Defects:
—— Effect of nitrogen on steel. Comstock and Ruder *399
—— Inclusions, Effect on stress distribution. McCance. (S.) 184
—— Nature of defects revealed by deep etching of transversely fissured rails. Rawdon *505
—— Rails, Shattered zones in 1190
—— Rails, Transverse fissures in 1190
—— Woody structures of fractures of transverse test pieces taken from certain special steels. Cohade... *259
——Effect of various elements:
—— Effect of copper in steel 281
—— Sulphur and phosphorus in 297
—— Contemporary foreign opinion. Rawdon 609
—— Investigations 952
—— Limits of 1189
——Foundry Practice:
—— Removing scale from steel. Marins. (P.) 185
——Furnaces:
—— Blast-furnace:
—— Blast-furnace flue dust. Atcherson. (N.) 391
—— British blast-furnace practice. Buckley. (S.) 660
—— Cleaning blast-furnace gas. (S.) *423
—— Electric steel furnaces in Australia. (S.) 947
——General:
—— Fifty years progress in iron and steel. Stead. (S.) 1130
—— Steel industry during 1919 7

IRON AND STEEL—*Continued:*
——Heat Treatment:
—— Cementation. Jones. (B.P.) 424
—— Distortion of alloy steels on hardening. Mathews.. (N.) 393
—— Elastic development of steel. Cornell *677
—— Hardening after long reheating. Van Oordt. (P.) 233
——Mechnical Work:
—— Forgeability of iron-nickel alloys. Yensen. (N.) 394
—— One-piece gun construction. Bridgman. (N.) 391
—— Physical properties of rolled rifle barrels. Moister *1025
—— Resistance of steels to machining. Fremont. (S.) 947
——Metallography:
—— Crystallography of alpha and beta iron. Giolitti *585
—— Effects of strain and heat treatment on metal structure. Nishikwa and Asahara. (S.) 1130
—— Ferrite, Genesis of. Giolitti *737
—— Magnetic analysis. Sanford and Kouwenhoven. (S.) 232
—— Microstructure at high temperatures. Rawdon and Scott. (N.) 394
—— Microstructure of iron and mild steel at high temperatures. Rawdon and Scott *787
—— Comment. Rawdon 1012
—— Modified Rosenhain furnace. Scott and Freeman. (S.) *811
—— Photographing etched sections at low magnifications. Monypenny. *882
—— Relation between mechanical hardness and grain size of carbon steels 786
—— Relationship between dendritic structure and ferrite mesh. Giolitti *921
—— Similarity of magnetic change in cementite and ferrite. Movius and Scott *1069
——Physical properties:
—— Lewis impact machine..... *325
—— Mechanism of fractures. de Freminville *983
—— Old rails with high internal strains contained no fissures. Cushing. (S.) 615
—— Physical changes below the thermal critical range. Jeffries. (N.)... 395
—— Strength of steel at high temperatures. McNiff. (S.) *660
—— Tensile strength of boiler plate. French. (N.) 392
——Processes:
—— Cast iron, Synthetic cast iron. Keller *83
—— Duplex:
—— Large mixer in new French steel plant. (S.) *855
—— Synthetic steel. Keller. (P.)..... 90
—— Electric pig:
—— Gray iron castings from magnetite in electric furnace..... 876
—— Scandanavian practice. Richards 61
—— Electric steel, Scandanavian practice. Richards..... 62
—— Malleable iron:
—— Graphitization of white cast iron. Archer. (N.) 392
—— Graphitization of white cast iron. Merica and Gurewich. (S.) *40
—— Open hearth, Acid:
—— Balanced reactions in steel mfr. McCance *634
—— Melting light scrap in acid open hearth. Hadfield. (P.) 233
—— Mfr. of high-grade steel by acid open-hearth process. de Maré. *1063
—— Pig iron, High phosphorus pig-iron from glauconite. Meadows. (P.) 569
—— Quadruplex:
—— Steel refining. Walker. (P.)... 89
—— Semi-steel, Manufacture of semi-steel for shells. Hall. (N.).... 391
—— Comment. Harrington..... 1188
——Special steels:
—— Comparative test upon high-speed steels. Langhammer I..... 829
II..... *889
III..... *939
IV..... 969
—— Distortion of alloy steels on hardening. Mathews. (N.)..... 393
—— High-speed steel. McKenna. (N.). 731
—— High-speed steel. Arnold's vanadium-molybdenum. Arnold. (S.) 1130
—— High-speed tool steel, crucible or electric steel for..... 172
—— Molybdenum. Sargent. (N.)..... 1190
—— Nickel steels, Critical ranges of. Scott. (N.)..... *394
—— Stainless steel, New uses for..... 1118
Isopropyl alcohol from Burton still gas.. 407
Italy, Chemical industry, Development of.. 791
——Seeks vegetable oil in Japan..... 1170
——To use explosives in agriculture.... 1014

J

JAPAN:
——Bronze powder and metal leaf industry in 734
——Commercial pottery of 702
——Cottrell precipitators in. Hirota and Shiga *276
——Encourages beet sugar in Manchuria. 786
——Foreign trade in chemicals, etc..... 376
——Lead and zinc industry 1198
——Rubber industry. (S.) 568
——Sulphuric acid industry in..... 1162
——Wages in 883

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

Japanning process, New 946
Java, German dyes in 206
Jennsen tower system 1176
Judge Mining & Smelting Co., Electrolytic zinc plant. Chapman *537
—— Methods for analytical control. Bradley *651
Judge Mining & Smelting Co. report 908

K

Kauri gum industry in New Zealand 937
Keller Leleux Co., Mfr. of synthetic cast iron at *85
Kelp plant to continue operations. 357, 535, 776

L

La Belle coke plant. Blackiston *561

LABORATORIES:

——California Fruit Growers Exchange .. 876
——Chemical engineering Columbia University. Hendrick *162
——Color laboratory, Bureau of Chemistry. Gibbs *405
——Cryogenic laboratory. Bureau of Mines 1086
——Fixed nitrogen research laboratory. Lamb *977
——Freas system for distributing apparatus, etc. 581
——Metallurgical research, Utah State School of Mines. Chapman *877
Laclede-Christy Co. plant 858
Lactic acid from corn-cobs 407
Lactose. Martin. (B.P.) 992
Land leasing bill 437
Langmuir receives the Nichols medal *486
Langmuir's new conceptions 863
Laundering research 252
Leaching copper-bearing sands with ammonia. Benedict and Kenny. (P.) 1174

LEAD:

——Corrosive action of soils on iron and. Stenger *965
——Influence of impurities on resistivity to acid 272
——Intercrystalline brittleness. Rawdon and Langdon. (N.) 346
——Japanese industry 1198
——Recovering from scrap iron. Rumbold. (B.P.) 424
——Reinforced lead. Baskerville and Wales *1081
Lead alloys, Melting in electric furnace. Winder. (N.) 734
Lead arsenate insecticides 254
Lead azide detonators, Stabilizing. Hudson. (P.) 856
Lead carbonate, Basic, Mfr. of 858
——White lead oil paste. Fletcher. (Aust.P.) 522
Lead plating. Shoemaker. (P.) 857
Lead-zinc ores, New Elmore process for. 164
Leather:
——Chemistry of leather manufacture. Wilson 938
——Leather section, A. C. S., Meeting. (N.) 777
Ledebur method for oxygen in steel. Limitations of. Cain and Pettijohn. (S.) *375
Legal notes...35, 81, 118, 180, 228, 272, 321, 368, 419, 453, 564, 613, 646, 703, 740, 803, 854, 898, 943, 980, 1032, 1076, 1124, 1163, 1193.

LEGAL NOTES: By Gustin

——Agreement to order as soon as "a car or two" has been used held valid.. 1193
——Armour Fertilizer Works not in contempt 1163
——The borderland of manufacturing—When mining is also manufacturing 1194
——Cherokee Fertilizer Co. wins judgment 803
——The Chute process for the manufacture of wood alcohol valid 1032
——Compliance with statute requiring license for sale of fertilizer 564
——Contract prohibiting presence of a given substance in ore does not imply exclusion of others 272
——Contract under war provision upheld. 980
——A controversy in pig iron sales 804
——Conveyance of property subject to mortgage 1076
——Damages awarded infant employee ... 454
——Damage during transit follows title to consignee 118
——Detroit Chemical Works wins case.. 803
——Duties and liabilities where wrong products are delivered—Express and implied warranties 613
——Egyptian Lacquer Manufacturing Co. vs. Chemical Co. of America 1193
——Exclusive license of a patented chemical process not a sale of business in a foreign country 35
——Factory refuse—What is held to be polluting matter—Public health paramount 272
——Fumes and gases from smelter 82
——Governmental power over manufacturers 703
——Held guilty of contempt for refusal to testify 898
——Injuries to workmen from noxious dust and gases—Employer's duties set forth 181

LEGAL NOTES—*Continued*:

——Inspection of potash crystals before payment and ex-dock New York construed 118
——International Forge Co. judgment affirmed by Pennsylvania Supreme Court 613
——Judgment for refusal to ship phosphate upheld 898
——Judgement to deliver in writing unwritten secret formulas is impossible of enforcement 322
——Law regulating contracts for an approximate amount such as the output for a season 749
——Legality of resale prices—Manufacturers' rights under the Sherman act 228
——A lesson on aluminum and sales contracts 419
——A lesson on filling orders 854
——Liability for guaranteed analyses .. 613
——Liability of stockholders—License to make and sell patented article construed 321
——Manufacturer and seller of tool steel warrants his product—"High-speed" steel not a trade name 368
——Measure of damages for failure to deliver acid under contract 36
——Measure of damages for failure to deliver specified quantity of goods.. 229
——Mutual releases in settlement of claims no bar to recovery of metals 564
——No liability if experienced employee chooses unsafe methods 943
——Notice to discontinue manufacture relieves buyer from responsibility for full purchase price 1194
——Oral evidence inadmissible to transform sale by description into one by sample 1163
——Pointers to inventors and users of secret processes 646
——Regulation upheld for computing drawback due exporters 1164
——Reliability of trade journal quotations in trade contracts 943
——Rockey vs. Moon Clay & Kaolin Co.. 854
——Rodman patent for method of making case-hardening material held valid. 1124
——Seller's representations amount to warranty 1164
——Unfair competition by use of trade mark—Extent of the use of trade mark 180
——What may be done under contract to purchase requirements 453
——Who has title to this benzyl chloride?—Matters of agency and title discussed 81
Legal notes. Physical conditions of workmen. Sherlock 612
Lewis impact machine *325
Liberty engine, Some metallurgical features of. Archer 176
Liberty Potash Co. in receiver's hands.... 1100
Libraries Directory of special 500
Library, John Crerar 1043
Lignite carbonization research plant 999
Lignite, Pulverized, In California. Buell.. *605
Lightning arresters. Electrolytic. Plates for. Coulson. (P.) 857
Linoleates as driers 102
Liquid mixtures, Homogeneous. Jolibois. (S.) *329
Liquids, Cooling in spray systems and cooling towers. Baker *173
Liquids, Vapor pressure-temperature relations for. Williamson 1151
——Calculations with Williamson formula. Savage *1155
Lithopone plant at Collinsville, Ill. Jones. *497
London metal prices for twenty years.... 1076
London, Proposed Efficiency Exhibition... 227
Lumber, Care of. In chemical plants 16

M

MAGNESITE:

——Hearings on tariff bill 604
——Industry in 1919 1026
——Refractories. MacDowell and Howe. (S.) 1214
Magnesium:
——Present status and outlook of industry. Rooney 60
——Properties of 60
Magnesium chloride, Anhydrous. Heap and Newberg 857
Magnesium chloride. Dow and Barstow. (P.) 1127
Magnesium oxychloride cement 604
Magnesium sulphate, Mfr. of. Dutt. (B.P.) 425
Maleic acid from benzene 102
Manganese and its alloys. (B.P.) 948
Manganese-aluminum alloy 549
Manganese dioxide depolarizer. Ellis and Wells. (P.) 856
Manganese ores, Smelting in electric furnace. Bardwell 681
Manganese silver ores, Treating. Austin. (P.) 920
Manila rope, Action of muriatic acid on.. 59
Manufacturers Catalogs 48, 96, 240, 384, 432, 480, 624, 824, 916, 960, 1008, 1096
Maple products industry in Quebec 1080
Markets, Current 43, 90, 140, 187, 234, 284, 332, 379, 426, 475, 523, 571, 618, 668, 715, 758, 818, 866, 911, 954, 1002, 1048, 1091, 1134, 1179 1219
Massachusetts Institute of Technology:
——Technology plan. Walker 403
——Reorganization of research in applied chemistry 905
——Instruction in iron and steel at. Hayward 1024
Materials Reliability of, de Freminville *661
Meetings Coming and Events 17, 95, 141, 192, 239, 288, 336, 384, 432, 480, 528, 575, 623, 672, 720, 764, 815, 872, 916, 960, 1007, 1052, 1096, 1140, 1181 1234
Mellon Institute of Industrial Research. Savage *249
Melting point methods at high temperatures. Dana and Foote. (P.) *23, 41, *63
Melting points of salts, alkalies, et. Table 64
Melting points of pure metals. Table 66
——of refractory oxides. Table 68
——of refractories. Table 70
Mercury Production, U. S., 1919 989

METAL PROTECTION AND CORROSION:

Corrosion of condenser tubes. Bengough, Jones and Pirret. (S.) ... 707
——Corrosion of copper bearing steel 1191
——Corrosion of petroleum equipment by brine. Mathews and Crosby 491
——Corrosion tests of sheet metal in atmosphere 1189
——Corrosive action of soils on iron and lead. Stenger *965
——Determining chemical corrosion. Shaw. (N.) 775
——Influence of slag and nitrogen on corrosion of iron. Richardson. (N.) *815
——Portable test set for galvanized coatings 1191
——Rust preventing solution. Allen. (P.) 856
——Rust prevention. Gravell. (P.) 377
——Tests for relative corrosion. Fenner *1197
Metallography Contributions to l'art nouveau. Lewis and Seyt 340
Metallurgical research Utah State School of Mines. Chapman *877

METALS:

——Apparatus for determining porosity of. Bezzenberger and Wilkins. ... *1031
——Atomic structure in solid solution. Jeffries 100
——Comment. Smith 340
——Reply. Feild 580
——Determining melting points of *23
——Investigation of fatigue of 462
——Melting and refining in vacuum. (B.P.) 1129
——Non-ferrous, Melting in electric furnace. St. John 148
Methyl alcohol: (see Alcohol)
Methylethylketone from normal butyl alcohol. Newman. (S.) 811
Methyl chloride and bromide from dimethyl sulphate. Boulin and Simon. (S.) 903
Metric system bill 448
Mexico, Commercial exposition in 1921.. 853
——Directory of industries 906
——Membership list of American Chamber of Commerce in 1172
——Petroleum production in 932
Micropyrometer *68
Microscope illuminator, "Pointolite" *281
Milk industry, Chemist in. Otting. (N.) 950
Milling plant, Alaska-Gastineau Mining Co. Daveler *361
Milling, State of art in 1919 50
Mineral oil: (see Petroleum)
Minerals Relief Commission awards 1178
Minerals Separation contempt proceedings against Butte & Superior dismissed 1131
Minerals Separation vs. Miami Copper Co:
——Hearing on contempt proceedings.... 1176
——Miami petition to reopen case denied 1176
Mohawk Valley Engineers' Club 199
Moisture determination apparatus *946

MOLYBDENUM:

——Norwegian process for mfr 229
——Recovery from ores. Doerner. (P.) 617
——Steels. Sargent. (N.) 1190
Monazite sand, Thorium from. Berndt (P.) 709
Monel metal for internal combustion engine valves. (S.) 1084
Monel metal, Rapid method of analysis. Covitz 41
——Comment. Horner 436
——Comment. Stausser 1144
Monsanto Chemical Co. plant *859
Montan wax. West 929
Mount Morgan Gold Mining Co. report 909
Muscle Shoals hydro-electric development. Jones *417
Mustard gas History of. West 541
——Comment. Zanetti 724
Myrabolans extract 1123

N

Naphthalene-β sulphonic acid. Dennis. (P.) 991
National Academy of Sciences-Engineering section 103

NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES:

——Preliminary announcement 1042
National Lead Co. Fire in Staten Island plant 906
National Lead Works, St. Louis 858

NATIONAL RESEARCH COUNCIL:

——Chemical division. Annual meeting 997
——Election of officers 1131
——Joint committee on ceramic research 104
Natural Gas Conservation Conference ... 1217
Nebraska lakes, Potash from. Correction 486
Nebraska University of, Chemical engineering at 665
Nevada Consolidated Smelter. Coal pulverizing plant at. Pomeroy. (N.) 347

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

New Cornelia Copper Co. Report . . . 908
New Haven Section, A. C. S.
——May meeting . . . 1133

NEW JERSEY CHEMICAL SOCIETY:
——Annual meeting. Apro. . . . 756
——May meeting . . . 950
——June meeting . . . 1178
——Year book . . . 1132
New Jersey Clay Workers Association:
——Annual meeting at New Brunswick, N. J. . . . 54
New Jersey Zinc Co. makes CP zinc . . . 92
New South Wales Growth of manufacturing industries in . . . 1017
New York Section, A. C. S.:
——January meeting. Catalysis . . . 102
——February meeting. Liquid fuels . . . *296
——March meeting. Nichols medal . . . *486
——April meeting. Shawinigan . . . 710
——May meeting . . . 949
New York Section, A. E. S.
——January meeting. Cyanides . . . 149
——February meeting. Liquid fuels . . . *296
——April meeting. Shawinigan . . . 710
New York Section, A. I. M. E.:
——January meeting . . . 101
——Election of officers . . . 248
New York Department of Health laboratory . . . 268
New Zealand. Kauri gum industry in . . . 937
Niagara District Industrial Association . . . 814
Nichols medal awarded to Dr. Langmuir . . . *486
Nickel catalyzer for hydrogenation. Richardson . . . 793
Nickel-chromium alloys. Gatward. (S.) . . . 661
——Comment. Fairchild . . . 1144
Nickelene . . . 1191
Nicodust insecticides . . . 1045
Niter cake: (see Sodium bisulphate)
Nitrate supply United States third in visible . . . 987

NITRIC ACID:
——From ammonia. Catalyst for. Perley. . . . 125
——From ammonia. Thomson. (P.) . . . 1127
——Nitric acid mfr. Banigan. (P.) . . . 991
Nitrides Production of. Lindblad. (P.) . . . 617
Nitro. First plant to locate at . . . 342
Nitrogen. Effect on steel. Comstock and Ruder . . . *399
Nitrogen. Chemically active. Wendt and Grubb. (N.) . . . 771
Nitrogen chloride. Noyes and Coleman. (N.) . . . 773

NITROGEN FIXATION:
——Articles and technical data on: . . . 558
—— Bibliography
—— By electric arc. Theoretical study of. Steinmetz . . . I. *299. II. *353. III. *411. IV. . . . *455
—— By silent discharge. Harding and McEachron. (N.) . . . 731
—— Concentrating nitrous gases. Halvorsen (P.) . . . 137
—— Data from Washburn's testimony . . . 862
—— Demand and supply of fixed inorganic nitrogen in the United States. White . . . *369
—— Fixed nitrogen research laboratory. Lamb . . . *977
—— German nitrate industry . . . 604
—— German Nitrogen Syndicate. Caro . . . 686
—— Haber process. Jones . . . *1071
—— Inorganic nitrogen in the United States. Gaillard.
Consumption . . . *783
Supply . . . *841
—— Muscle Shoals hydro-electric development. Jones . . . *417
—— Nitrogen fixation. Parsons. (N.) . . . 665
—— Nitrogen problem. Toniolo. (S.) . . . 424
—— Political and commercial control of nitrogen resources of world. Gilbert . . . I. *443. II. *501. III. . . . 557
—— Pre-war legislation affecting nitrate plants. Jones . . . 885
——Hearings and legislation relating to Muscle Shoals plants:
—— Congress investigates Muscle Shoals expenditures . . . 103
—— Criticism of Muscle Shoals expenditures . . . 246
—— Fixed Nitrogen Corporation Bill . . . 536, 582, 905, . . . 1088
—— Washburn's testimony before Senate Committee on Agriculture . . . 712
—— Further nitrate hearings . . . 757
—— War Department defends Government operation . . . 814
—— Offer to lease Muscle Shoals plants . . . 816
—— Recommendations of House committee . . . 993
Nitrogen hydrogen mixture. Ellis. (P.) . . . 569
Nitrogen oxides. Recovering. Guye. (P.) . . . 857
Nitrous gases. Concentrating. Halvorsen (P.) . . . 137
Non-Ferrous metal market . . . 43, 90, 140, 187, 234, 284, 332, 379, 426, 475, 523, 571, 618, 668, 715, 758, 818, 866, 911, 954, 1002, 1048, 1091, 1134, 1179, 1219
Nordstrom lubricated plug valve . . . *230
Northern Ohio section. Amer. Ceramic Soc. . . . 861
Northwestern Turpentine Co. . . . 853
Northwest Magnesite Co. not a monopoly . . . 638
Norway. Alcoholism in . . . 544
——Industrial growth in . . . 659
——Industry in . . . 1044

O

OBITUARY:
——Edgcumbe, Arthur Beresford . . . 953
——Bradbury, John A. . . . 817
——Chamberlain, Zear J. . . . 618
——Dwyer, William J. . . . 425
——Ebert, Oscar H. . . . 1179
——Elbert, J. J. . . . 570
——Fischer, Paolo . . . 284
——Flannery, Joseph M. . . . 475
——Gayley, James . . . 425
——Grierson, Edward S. . . . 523
——Hiorns, Arthur H. . . . 953
——Huntington, A. K. . . . 953
——Hyatt, John Wesley . . . 953
——Ingram, C. H. . . . 284
——Jeppson, John . . . 668
——Ketter, George W. . . . 866
——Kyle, David . . . 523
——Larkin, Eli Hilles . . . 866
——Levering, Richmond . . . 234
——Mackay, S. . . . 426
——MacLaurin, Richard Cockburn . . . 140
——McLean, James . . . 90
——Messel, Rudolph . . . 954
——Molenaar, Dirk Geijsbeek . . . 618
——Morgan, Samuel T. . . . 911
——Murphy, Franklin . . . 570
——Newcomb, Melvin B. . . . 618
——Ormay, Arthur L. . . . 714
——Phillips, Francis C. . . . 523
——Picher, Oliver Sheppard . . . 866
——Pond, George Gilbert . . . 1091
——Pratt, David S. . . . 379
——Pressinger, W. P. . . . 1179
——Procter, Harley T. . . . 1002
——Proctor, J. K. . . . 475
——Reilly, James P. . . . 426
——Spice, Robert Treat . . . 758
——Spilsbury, Edmund Gybbon . . . 1091
——Stone, I. Frank . . . 911
——Strong, Edwin A. . . . 426
——Surface, Henry E. . . . 1179
——Thomas, O. J. D. . . . 817
——Vail, Theodore N. . . . 758
——Ware, Ralston C. . . . 426
——Weeks, Charles A. . . . 475
——Wood, E. Fred . . . 186
——Woods, Herbert Spencer . . . 426
Oil pipe lines. Sulentic . . . 327

OIL SHALES:
——Cement from. Lesley. (P.) . . . 709
——Eventual retort plant for distillation of. Simpson . . . 71
—— Criticism. Franks . . . 244
—— Reply. Simpson . . . 244
——Investigations at Salt Lake City . . . 881
——Plant to locate at De Beque . . . 713
——Recovery of nitrogen contained in. Simpson . . . 20
——Scottish possibilities. Cadell. (N.) . . . 277
——Scottish shale oil industry. Conditions in . . . 1070
——Test of New Brunswick shales in Wallace retort . . . *809

OILS:
——Apparatus for determining light oil in gas. Bird . . . *705
——Cottonseed. Pictorial description of the industry. Wesson . . . *465
——Purifying. Calvert. (B. P.) . . . 948
——Vegetable, Freight rates . . . 910
——Vegetable oil industry of Hull . . . 1034
——Vegetable oils as fuel. Wesson . . . *296
——Vegetable. Refining. Schwartzkopf. (B.P.) . . . 1129
Oklahoma section. A. C. S. . . . 710
Olympic Portland Cement Co. plant . . . 196
Omaha Chemical Club . . . 198
Open tank leaf filters . . . 17
Optical pyrometers. Use of . . . *66
Optics. School of . . . 407
Ores. Mixed sulphide. Treating. (B.P.) . . . 992
Organic chemistry. Non-benzenoid hydrocarbon series. Brooks . . . 933
Organic compounds. Classifying by Prager-Jacobson system. MacArdle . . . 256
Organic research chemicals. Mees. (N.) . . . 536
Oxalic acid. Duty on . . . 198
Oxalic acid. Study of formate process for. Leslie and Carpenter . . . *1195
Oxidation. Vapor phase . . . 406
Oxy-acetylene welding. Kinsey . . . 221
——Comment. Johnson . . . 581
Oxyaldehydes. Mfr. of. Weiss. (B.P.) . . . 1175
Oxygen, Liquid. As explosive . . . 1150
Ozone and nitrogen oxides. Anderegg. (N.) . . . 773
Ozone in chemical industries. Jones . . . *805

P

PAINT:
——Drying with ozone . . . 807
——Driers. Ingalls . . . 590
——Catalytic action of driers. Ingalls. (N.) . . . 102
——Colorimeter for white . . . 1192
——Test for hiding power of . . . 1192

PAPER:
——Canadian pulp and paper combine . . . 1176
——Chem. & Met. to make its own . . . 953
——From fibrous plants. (B.P.) . . . 1175
——Paper pulp in Argentina . . . 1030
——Pulp from cotton linters. Kress. (N.) . . . 781
——Waste Saving . . . 780
Paper fibers. New . . . 492
Paper machine drive. Staege. (N.) . . . 781
Paper makers' strike. Status of . . . 1043
Paper mill. Publishers plan to buy . . . 1043
Paranitraniline. Use in standardizing sodium nitrite solutions. Bell . . . 1173
Patent Office. Better service demanded from . . . 198
Patent Office bill. Objections to . . . 1046
Patent Office bill. Section on inventions . . . 1045
Patent royalties for Government employees . . . 667
Patents, German, Prolongation of. Zwingenberger . . . 1056
Patents. Recent Chemical and Metallurgical. 40, 89, 137, 184, 232, 282, 330, 377, 424, 473, 522, 568, 616, 661, 708, 812, 856, 904, 948, 991, 1040, 1084, 1127, 1174 . . . 1215
Peanut and peanut oil exports from China . . . 1173
Peat as source of industrial power. Philipp . . . 693
Peat fiber and the textile industry . . . 1112
Pennsylvania Safety Congress . . . 488
Perkin Medal. Dr. Charles F. Chandler receives . . . 103
——Full report of presentation . . . *150

PETROLEUM:
——Alsatian industry . . . 1124
——Developments during 1919 . . . 4
——Mexican production . . . 932
——Mineral oil as factor in United States trade . . . 504
——Purifying. Grisard. (B.P.) . . . 992
——Specific heat at different temperatures. Bushong. (N.) . . . 775
—— Bailey and Edwards. (N.) . . . 776
Petroleum equipment. Brine corrosion of. Mathews and Crosby . . . 491
Pharmacoepia revision organized . . . 1000
Phenol-aldehyde condensation products. (B.P.) . . . 1175
Phenol-aldehyde condensation products. Robinson. (B.P.) . . . 992
Philadelphia. World's fair proposed for 1926 . . . 1044
Philosophical Society of Washington . . . 953
Phonograph as adjunct to research laboratory. Hillman . . . 436

PHOSPHATES:
——Deposits for lease . . . 1043
——Idaho phosphate rock for Orient . . . 666
——Manufacture of superphosphate at Anaconda . . . 388
——Phosphate deposits in the Netherlands . . . 416
——Phosphate reserves at Pacific islands . . . 416
——Phosphate rock industry . . . 307
——Portland, Ore., a shipping point for . . . 713
——Situation in France . . . 736
Phosphorus and sulphur in steel . . . 297
——Contemporary foreign opinion. Rawdon . . . 609
——Investigation . . . 952
——Limits of . . . 1189
Photographic chemicals made on Pacific Coast . . . 1100
Photographing etched sections at low magnifications. Monypenny . . . *882
Phthalic anhydride as indigo intermediate . . . 815
——By catalytic oxidation. Andrews. (P.) . . . 378
Pickling baths. Allen. (P.) . . . 331
Pickling solution. Regeneration of. Freenie and Rhodes. (P.) . . . 233
Picric acid plant for sale . . . 472
Picric acid plant sold . . . 604
Pipe lines, Oil. Sulentic . . . 327
Plant distribution. Wherry. (N.) . . . 773
Plastic composition. Devonshire and Ford. (B. P.) . . . 568
Plastometer, Improved . . . 1192
Platinum:
——At Goodsprings, Nevada . . . 536
——In 1919 . . . 135
Pneumatic conveyors at Aluminum Co. plant . . . *566
Pointolite illuminator for microscopes . . . *281
Polish courts to register American firms . . . 892
Porcelain. Vitrification of. Sherwood. (N.) . . . 442
Porosity of metals. Apparatus for determining. Bezzenberger and Wilkins . . . *1031
Portland, Ore., Shipping point for phosphate rock . . . 713
Portland Gold Mining Co. report . . . 909
Port Pirie, Blast roasting at. Rigg . . . 518

POTASH:
——Alsatian mines . . . 1206
——From Nebraska lakes. Correction. Beckman . . . 436
——From New Jersey green sands . . . 815
——German deposits . . . 945
——German potash situation . . . 1125
——German production and prices . . . 341
——Potash and reconstruction. Turrentine. (N.) . . . 776
——Recovery by Cottrell precipitator. Bradley. (N.) . . . 756
——Recovery from brines containing borax. McIlhiney. (P.) . . . 1084
——Spanish deposits to be operated by Germans . . . 1133
——Statistics . . . 366
Potassium chloride from blast-furnaces. Olander, Smith and Bambridge. (B.P.) . . . 425
Potassium permanganate. Manufacture of. Stringfield . . . *1027
Potentiometer in pyrometry. Frey . . . *1168
Pottery: (see Ceramics)
Powders, Properties of. Lowry and Hemmings. (N.) . . . 976
Power supply to be investigated . . . 1132
Prager-Jacobson system for classifying organic compounds. MacArdle . . . 256
Precipitator Electric: (see Cottrell precipitator)
Prickly pear. Industrial uses of . . . 520
Procter & Gamble to build soap plant in California . . . 1178

*Illustrated. (P.) (B.P.), (Aust.P.), (Can.P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Serapers; (N.)—Papers read at society meetings but not printed in full.

PRODUCTION STATISTICS:

——Canada:
—— Minerals, 1919 .. 855
——England:
—— Iron and steel, 1919 .. 744
——Italy:
—— Chemicals, 1914 and 1918 .. 791
——Mexico:
—— Metals, 1916-1919 .. 782
——Sweden:
—— Copper, 1918 .. 792
——United States:
—— Ammonium sulphate, 1902-1918. *903
—— Beet sugar, 1913-1920 .. 560
—— Copper, 1913-1918 .. 38
—— Cottonseed products .. 1081
—— Gold and silver, 1919 .. 217
—— Mercury, 1919 .. 989
—— Nitrogen compounds, 1900-1918 .. 444
—— Peat, 1908-1918 .. 693
—— Petroleum products .. 504
—— Phosphate rock 1913-1917 .. 308
——World:
—— Coal, 1910-1919 .. 1020
—— Glycerine, 1884-1917 .. 226
—— Nitrogen compounds, 1900-1918 .. 444
—— Sugar, Beet and cane 1916-1919 .. 312
—— Beet .. 560
Propylene chlorhydrin from oil gas, Brooks .. *629
Publications, new, 96, 384, 576, 1096, 1224
Public utility power efficiency .. 997
Public works, First step toward department of .. 1001
Pulverizing pig-iron samples with power hammer .. 946
Putrefaction and decomposition, Seyt .. 1188
Pumping acids with compressed air, Oliphant .. *408
Pyridine, Recovery from byproduct coke ovens, Dodge and Rhodes .. *274
Pyrite, Coal, Some chemical data on, Yancey .. *105
Pyrites industry .. 310
Pyrocatechin aldehyde, Schmidt, (P.) .. 616

PYROMETRY:

——Heatmeter, Compensated, Frey .. 100
——Melting point methods at high temperatures, Dana and Foote .. I, *23, II *63
——Nickel-chromium alloys in, Gatward, (S.) .. 661
—— Comment, Fairchild .. 1144
——Optical pyrometer, Calibration of, Forsythe .. 1211
——Potentiometer in, Frey .. *1168
——Simple pyrometer adjustment .. *367
——Treatise on pyrometric practice .. 1112
Pyroxylin, Chlorinated, Schwarzman, (P.) 522
Pyrrhotite industry .. 310

Q

Quantel, Langmuir, (N.) .. 863
Quantum theory, Application of, Rideal, (N.) .. 772
Quebec maple sugar crop .. 1044
Quebec, Maple-products industry in .. 1080
Quicksilver: (see Mercury)
Quinone from benzene by catalytic oxidation .. 102
Quinone from benzene by electrolytic oxidation, Kitchen, (P.) .. 331

R

Radium Conserving, Lind .. 920
Radium minerals .. 293
Radium scarcity .. 1020
Radium-uranium ratio, Lind and Roberts, (N.) .. 773
Rail defects .. 1190
Ramsay Memorial Fund .. 198
Recent Chemical and Metallurgical Patents, 40, 89, 137, 184, 232, 282, 330, 377, 424, 473, 522, 568, 616, 661, 708, 812, 856, 904, 948, 991, 1040, 1084, 1127, 1174, 1215

REFRACTORIES:

——Carborundum .. 907
——Cold and hot abrasion tests, (N.) .. 729
——Furnace for testing fire brick under load at high temperatures, Lovejoy *109
——Magnesite, Handy, (P.) .. 617
——Magnesite, MacDowell and Howe, (S.) .. 1214
——Melting point determinations .. *68
——Report of Refractories Division, Amer. Ceramic Soc .. 440
——Research work on .. 252
——Spalling losses, (N.) .. 729

RESEARCH:

——At Mellon Institute, Savage .. *249
——British research associations .. 462
——California Fruit Growers Exchange laboratory .. 876
——Canada to establish research bureau. 1046
——Ceramic research, Joint committee on. 104
——Ceramic research station at Rutgers College, Millen .. 410
——Fixed nitrogen, Lamb .. *977
——In applied chemistry at M. I. T .. 905
——In baking industry .. 396
——Incentive to, Hale .. 775
——Industrial research at Denver .. 1086
——Lignite carbonization .. 999
——Metallurgical, Utah State School of Mines, Chapman .. *877
——Opportunities in gas industry, Searle, (N.) .. 1044
——Organic, In non-benzenoid hydrocarbon series, Brooks .. 933
——Phonograph as adjunct to research laboratory, Hillman .. 436
——Problems in alloys research, Howe, (N.) .. 730
——Research grants of A. A. A. S .. 342
——Technology plan, Walker .. 463
——What does the General Electric get out of it? Seyt .. 1012
Resins, Oxidized, Purification of, Köhler, (P.) .. 89
Resinates as driers .. 102
Resistance thermometers, Use of .. 65
Riverside Drive, Acid fumes on, Mudge .. 676
Roof timbers, Added life for .. 396
Rope, Manila, Action of muriatic acid on .. 59
Rosenhain furnace, Modified, Scott and Freeman, (S.) .. *811
Rotary filter .. 18
Rotary hopper dewaterer .. 18

RUBBER:

——Developments during 1919 .. 5
——Exports from Brazil and Peru .. 1118
——Industry in Japan, (S.) .. 568
——Preserving, Stowe, (Aust. P.) .. 904
——Rubber division meeting, A. C. S. .. 930
Russia, Co-operative system in, Perkins, (N.) .. 101
Rutgers College, Ceramic research station at, Millen .. 410

S

Saccharimeters, Browne, (N.) .. 776
Sag paste for burns .. 592
Salaries for chemists, McBride .. *689
Salaries, Government chemists' .. 488
Salaries of chemists, Coney, (N.) .. 775
Salary increases for Government technical men contemplated .. 1132
Salt industry at Inagua, Bahamas .. 706
Salts, Determining melting points of .. *63
Salvarsan, Sodium compound of, Suzuki, (P.) .. 856
Sandalwood oil industry in India .. 987
Savannah Section of A. C. S. formed .. 1088
Saybolt viscosity of oil blends, Herschel .. *1109
Scale, Removing from steel, Marins, (P.) 185
Scandinavia, Economies of electric iron and steel production in, Richards .. 61
Scandinavia, Electrochemical notes from .. 1082
Scandinavian fellowships .. 485
Scoop conveyors for coal storage .. *182
Scottish oil-shale possibilities, Cadell, (N.) 277
Scottish shale oil industry, Conditions in .. 1070
Selenium, Lenher, (N.) .. 775
Selenium and tellurium, Lenher .. 1108
Selenium oxychloride, Lenher, (N.) .. 773
Selenium ruby glass .. 29
Settling problems, Deane, (N.) .. 726
Shale: (see Oil Shales.)
Shale Oil & Refining Co .. 713
Shawinigan Falls, Electrochemical industries at, Matheson, (N.) .. 710
Sheffield uses films to push steel trade .. 796
Shellac, Inferiority as glue .. 360
Shellac, Pure gum, Note, Chadwick .. 340
Sibert, General William L, Wooton .. *755
Silica gel, Adsorption of gases by, Patrick et al, (P.) .. 1127
Silica gel and its uses, Patrick, (N.) .. 949
Sillimanite, Commercial synthesis of, Malinovszky .. *851
Sillimanite development, Watts, (N.) .. 441
Silica, Fused, Commercial development of, Schari and Savage .. *593
Silicates, Determining melting points of .. *63
Silicon carbide, Increasing uniformity of, Hutchins, (P.) .. 709
Silk, Artificial, Belgians seek raw material here .. 1046
——Du Pont to manufacture .. 907
——Growth of industry .. 1024
——Mfr. in Great Britain .. 853

SILVER:

——Recovery from manganese silver ores, Austin, (P.) .. 282
——Volatilization process, Duschak, (N.) 665
Silver cobalt ore, Smelting and refining, Wright, (S.) .. 855

SLAG:

——Converter, Reverberatory furnace for treating Lanst and Maguire, (N.) 347
——Copper smelter, Copper and magnetite in, Mauer and Van Arsdale, I, *1101 II, *1157
——Reverberatory furnace for converter slag, Lanst and Maguire, (S.) .. *231
——Use in blast roasting at Port Pirie Rigg .. 518
Sloss-Sheffield Steel & Iron Co. byproduct coke oven plant .. 1132
Sludge acid, Recovering sulphonic acids from, Divine, (P.) .. 856
Smelters Steel Co .. 876
Smoke litigation in Salt Lake Valley, Thum .. *1145
Soap, Colloidal clay in, Weston, (S.) .. 615
Socialism a bankrupt philosophy .. 1112
Société de Chimie Industrielle
——May meeting, Announcement .. 905

SOCIETY OF CHEMICAL INDUSTRY:

——January meeting, Perkin medal .. *150
——February meeting, Liquid fuels .. *296
——March meeting .. 536
——April meeting, Shawinigan .. 710
——May meeting, Glue and gas .. 1044
Society of Cotton Products, Antidust-vention .. 848
Söderberg electrode, Richards, (N.) .. 732
Sodium, From sodium chloride and calcium carbide, Freeman, (P.) .. 457
Sodium, Metallic, Veazey, (P.) .. 1174
Sodium bisulphate, Use in diazotization, Bolton, (P.) .. 377
Sodium bisulphate, Use in mfr of ammonium sulphate, Vis, (P.) .. 904
Sodium carbonate from alkaline brines, Bacon, (P.) .. 570
Sodium ferricyanide, Mfr of, Williams, (P.) .. 667
Sodium ferrocyanide, Boberg, (P.) .. 377
Sodium formate, Factors in conversion to oxalate, Leslie and Carpenter .. *1195
Sodium fluoride as wood preservative .. 371
Sodium fluoride, Mfr of, Bowman, (P.) 474
Sodium nitrate: (see also Chilean nitrate)
——Effect of sodium chloride on solubility *658
——Freight rates on .. 666
——Released by Navy .. 666
——Senate approves sale .. 813
——War Department releases .. 713, 757
—— Reply to criticism .. 1043
—— Results of sales .. 1178
Sodium nitrite solutions, Standardizing with paranitraniline Bell .. 1173
Sodium permanganate, Mfr of, Wilson, (P.) .. 709
Sodium tungstate, Mfr of, Ekeley and Stoddard, (P.) .. 233
Soils, Alkali, Durability of cement drain tile in .. 366
Soils, Corrosive action on iron and lead, Stenger .. *965
Solder containing cadmium, Luckey, (P.) 1040
Solubility, Prediction of, Hildebrand, (N.) 771
South American markets for industrial supplies, Commissioner to study .. 206
Southern Agricultural Corp .. 907
Southern states, Developed mineral resources and chemical industries of, Fairlie .. *307
——Comment, Maher .. 724
Southwestern Portland Cement Co. plant .. *292
Spark coil for explosion pipettes, Taylor 1013
Specifications for chemical reagents, Collins, (N.) .. 774
Spelter: (see Zinc.)
Sponge bleaching with ozone .. 807
Spray systems, Absorption of gases in, Baker .. *122
Spray systems, Cooling liquids in, Baker *173
Stack losses at Arizona Copper Co, Ambler *305
Stainless steel, New uses for .. 1118
Stamford Chemical Society meeting .. 1000
Standard Oil Co., Industrial representation in, Hicks .. 607
Standard Oil Co., Wood River plant .. 858
Static discharges cause explosions .. 35
Static electricity explosions, Air conditioning prevents .. 614
Stellite, Haynes, (N.) .. 730
St. Louis as a steel center .. 197
St. Louis Coke and Chemical Co. plant .. 907
St. Louis district, Chemical resources of, Pierce, (N.) .. 773
Stopper, Grosvenor, (P.) .. 812
Storage batteries: (see Batteries, Secondary.)
Strontium peroxide, Pierce, (P.) .. 616

SUGAR:

——American beet sugar industry .. 560
——Belgian production .. 1188
——Crop estimates, 1918-19, for world .. 312
——Japan shipping to United States .. 1133
——Maple, Quebec's production .. 1044
——Purifying sugar solutions, Hood and Clark, (B.P.) .. 568
——Sugar division, A. C. S., Meeting .. 776
Sulphate cooking liquor, Determining active strength of .. 462
Sulphate of ammonia: (see Ammonium sulphate)
Sulphate pulp black liquor, Treating, Olsson, (P.) .. 378
Sulphite waste liquor, Reduced, Coombs, (P.) .. 662
Sulphite waste liquor, Sulphur dyes from, Robeson, (P.) .. 138
Sulphonation of aromatic compounds, Morris, (B.P.) .. 1175
Sulphonation, Vapor phase .. 406
Sulphonation with sulphur trioxide, Downs, (P.) .. 522
Sulphonic acids, Recovering from mineral oil sludge, Divine, (P.) .. 856

SULPHUR:

——Competes with iron pyrites .. 79
——Extracting from ores, Huff, (P.) .. 137
——Industry in United States .. 310
——Shipments from Sicily .. 1150
——Uses in agriculture, Lipman, (N.) .. 1178
Sulphur and phosphorus in steel .. 297
——Contemporary foreign opinion, Rawdon .. 609
——Investigation .. 957
Sulphur black from dinitrochlorbenzene
——Limits of .. 1189
Heyder, (P.) .. 709
Sulphur chloride, Gegenheimer and Maurau, (P.) .. 1128
Sulphur dioxide from slag, Diehl, (B.P.) 1175
Sulphur dioxide, Liquid, For solubilite pulp, Edwards, (N.) .. 787
Sulphur dyes from waste sulphite liquor, Robeson, (P.) .. 138
Sulphur retorts, Bezzaft and Genter Clifford and Green, (P.) .. 708

SULPHURIC ACID:

——Acid-proof masonry chambers, Larson, (P.) .. 1174
——Coal pyrite as source of sulphur for Yancey .. *105

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

SULPHURIC ACID—*Continued:*
——Concentration. Patten. (P.) 1216
——From sulphur dioxide and chlorine. Tobler. (P.) *904
——From sulphur dioxide and selenium dioxide. Haeseler. (P.) 1216
——Industry in Southern States *311
——Japanese industry 1162
——Mfr. of Welch. (P.) 662
——Nomenclature. Zeller 100
——Plant construction. Larison. (P.) ... 1127
Superphosphate, Mfr. at Anaconda 388
Surface vs. bunsen combustion in gas-fired furnaces. Kowalke. (N.) 320

SWEDEN:
——Chemical industry in 464
—— Comment. Huitman 920
——Copper production, 1918 792
——Electrochemical industries in. Beckman 840
——Market for American chemicals in .. 500
Switzerland factory statistics for 1918 .. 375
Synopsis of recent chemical and metallurgical literature ... 40, 183, 231, 281, 329, 375, 423, 521, 567, 615, 660, 707, 811, 855, 903, 947, 990, 1039, 1083, 1130, 1214

T

Tank cars, Movement of 491
Tannin extract from Indian myrabolans .. 1123
Tannin extract stumpage for sale 816
Tanning products, Synthetic. (B.P.) 1175
Tar, Coal, Utilization of. Sharples. (S.) *903
Tariff bills before Senate 488

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY:
——Fifth annual meeting, New York. Program 664
—— Report. Social activities *735
—— Technical sessions 781
Technology Clubs Associated 342
Technology plan. Walker 463
Tellurium. Lenher. (N.) 775
Tellurium and selenium. Lenher 1108
Temperature scale. C.p. zinc for fixation of Ashman 22
Tennessee Copper and Chemical Co. deficit 907
Texas, Regulation affecting transportation of denatured alcohol in 437
Thermal expansions, Stretched wire method of measuring. Correction 248
Thermit welding 88
Thermo-electric pyrometers, Use of *23
Thermometers, Resistance, Use of 65
Theta Tau Fraternity for engineering students 199
Thorium. Extraction from monazite sand. Berndt. (P.) 709
Throop College of Technology changes name 500
Thymol from para-cymene. Phillips. (P.) 948

TIN:
——Australian production. Lewis. (S.). 903
——Determination of, in brass or bronze. Raymond 1056
——Recovery from secondary copper 121
Tinplate manufacture. Fatigue research in 223
Tin scrap. Detinning: (see Detinning Processes.)
Titanium alloys, Electrical properties of. Hunter and Bacon. (N.) 731
Toluene from xylene. Brooks. (P.) 616
Toluene from xylene. Houlehan. (P.) 1127
Toluene sulphochlorides. Matthews and Strange. (B.P.) 992
Towers, Absorption of gases in. Baker .. *122
Towers, Cooling liquids in. Baker *173
Trademarks, Protection in foreign countries 665

TUNGSTEN:
——Bill reported to Senate 663
——Effects of impurities on metallurgy of. Balke. (N.) 774
——Extracting and recovering. de Golyer and Rund. (P.) 1040
——Manufacture at Fansteel Products Co. Jones *9
——Norwegian process for mfr. 229
——Process of recovery. Ekeley and Stoddard. (P.) 233
——Properties and uses of 14
Tungsten alloys 15
Tungsten crucible. Keyes. (P.) 184
Tungsten ores, Treatment of. Stannard. (B.P.) 424
Tungstic acid, Mfr. of *10
Tunnel ventilation investigation 295
Turpentine from Douglas fir pitch 853

U

Undertakers, Chemistry for. Seyt 484

UNITED STATES: (see also Government.)
——Balance of trade, 1919 550
——Foreign commerce for 1918 62
United States Pharmacopœia revision 1000
United States Nitrate Plant No. 1 ..... *1071
Utah State School of Mines, Metallurgical research department. Chapman *877
Utah, University of, Fellowships at 906

V

Vaccines. Thomson. (B.P.) 948
Valve, Plug, Nordstrom lubricated *230
Varnish driers. Ingalls 590
Varnish, Drying with ozone 808
Varnish plant purchased by du Pont 1043
Vaporphase chlorination, oxidation and sulphonation 406
Vapor pressure-temperature relations for liquids. Williamson 1151
——Calculations with Williamson formula. Savage *1155
Vegetable oils as fuel. Wesson *296
Vegetable-oil industry of Hull 1034
Virginia Polytechnic Institute, Wood distillation study at 137
Viscosity chart for different systems. Nevitt *1171
Viscosity of oil blends, Saybolt. Herschel. *1109
Vogelstein & Co., L., bought by American Metal Co. 55
Vulcanized fiber. Allison 1126

W

Wallace oil shale retort *809
War Department to use British units 1133
War Minerals Relief Act amendment fails 1133
War zone reconstruction 396
Washing filter cakes, Suggestions on 19
Washington Chemical Society meeting 1000
Waste sulphite liquor, Fuel from. Barsky and McKee. (N.) 781

WATER SOFTENING:
——Hot-process. Gibson *899
——Lime-soda ash process. Herrle and Gleeson *269
—— Criticism. Taylor 532
—— Reply. Chemical Engineer 920
Water sterilization by ultra-violet rays. Decker *639
Waterpower Bill delayed 667
——Conference report considered 951
——Signed by President 1177
Wax, Bleaching with ozone *806
Webb paper and box tester 254
Welding, Oxy-acetylene welding. Kinsey .. 221
——Comment. Johnson 581
Western Chemical & Metallurgical Field ... 52, 196, 292, 388, 876, 1100
Western Chemical Mfg. Co 197
Western Zinc Oxide Co 1218
West Point, Prominent chemists lecture at 342
White lead: (see Lead carbonate, Basic.)
Whitney, Dr. W. R., To receive Chandler medal 666
——Presentation 863
Williams moisture determination apparatus *946
Wire method for melting point of metals *65

WOOD:
——Care of lumber in chemical plants .. 16
——Destructive distillation of. Hanson. (P.) 857
——Inaccuracy of treating records due to moisture in. Bateman 57
——Pulp wood embargo by Canada 1044
——Pulp wood swept out to sea 1045
——Relation between viscosity and penetrance of creosote into. Bateman. *359
——Sodium fluoride as preservative 371
Wood alcohol: (see Alcohol.)
Wood distillation study at Virginia Polytechnic Institute 137
Wood distillation plant at Hattiesburg 1043
Woodine 321
Wood tars and pyroligneous acid, Separating. Clifford. (P.) 1128
Wool grease, New process for extracting. 16
Wool, Imitation, From vegetable fiber. (B.P.) 1216

Y

Yale University, Chemical activities at ... 713

Z

ZINC:
——C.p. For fixation of temperature scale. Ashman 22
——Electric furnace for distillation of. Fulton. I *73
II *130
——Electrolytic process. Gepp et al. (P.) 233
——Electrolytic process. Gepp. (Aust.P.) 522
——Electrolytic, Purification of solutions. Sulman and Field. (P.) 1084
——Electrolytic zinc plant of Judge Mining & Smelting Co. Chapman *537
—— Methods for analytical control. Bradley *651
——European vs. American practice. Stone. (N.) 999
——Hydrochemical extraction of. Stewart et al. (P.) *232
——Japanese industry 1198
——Purification of electrolytic solution. Field. (P.) 617
——Purifying electrolytic solutions. Field. (P.) 1040
——Tariff bill reported favorably 757
——Uses of zinc and zinc compounds 817
Zinc-lead ores, New Elmore process for .. 164
Zinc ores, Desulphurizing. Rigg. (Aust. P.) 522
Zinc ores, Electric resistance furnace for. Fulton. I *73
II *130
Zinc oxide, Production of. (P.) *330
Zinc sulphide ore, Roasting. Electrolytic Zinc Co. (Aust.P.) 522

*Illustrated; (P.), (B. P.), (Aust. P.), (Can. P.)—United States, British, Australian and Canadian patents, respectively; (S.)—Synopsis; (N.)—Papers read at society meetings but not printed in full.

AUTHORS' INDEX

ADDICKS, LAWRENCE. Production of copper from secondary material. 119
———The requirements of refined copper. 449
Allison, L. R. W. Vulcanized fiber 1126
Ambler, J. Owen. Stack losses at Arizona Copper Co. 305
Anderson, Marshall B. and Robert J. Anderson. Aluminum rolling-mill practice.
I—Commercial pig and scrap 489
II—Melting furnaces, Ingot pouring. 545
III—Ingot heating and mill calculations 599
IV—Slabbing 647
V—Finishing operations 697
Anderson, Robert J. and Marshall B. Anderson. Aluminum rolling-mill practice (see above)
Archer, R. S. Some metallurgical features of the liberty engine 176
Ashman, A. O. C.p. zinc for fixation of the temperature scale 22
Atwater, C. G. and J. F. W. Schulze. The caking of sulphate of ammonia. 373
Ayres, Eugene E. Jr. Separation of fixed oils from soap-water emulsions. 1057

BAKER, EDWIN M. The absorption of gases in spray systems and towers 122
———Cooling liquids in spray systems and cooling towers 173
Bardwell, E. S. Electric furnace smelting of Montana manganese ores.... 681
Barnitz Harry L. Electrolytic production of hydrogen 201
———Technical application of hydrogen in hydrogenation or hardening of oils 745
Baskerville, Charles, and C. M. Wales. Reinforced lead 1081
Bateman, Ernest. Inaccuracy of treating records due to moisture in wood.. 57
———Relation between viscosity and penetrance of creosote into wood. 359
Beckman, J. W. Electrochemical industries in Sweden 840
———Potash from lakes in Nebraska.... 436
Bell, William H. Use of paranitraniline to standardize solutions of sodium nitrite 1173
Berry, C. H. Loss due to carbon in furnace refuse 179
Bertrand, Alejandro. Nitrate industry in Chile 655
Bezzenberger, F. K., and R. A. Wilkins. Apparatus for the determination of the porosity of metals 1031
Bird, E. H. Improved apparatus for determining light oil in gas..... 705
Blackiston, G. P. LaBelle coke plant... 561
Bowles, Oliver. History of asbestos paper.. 208
Bradley, H. F. Methods for analytical control of electrolytic zinc production 651
Brayton, H. M. The heat treatment of beta brasses 211
Brooks, Benjamin T. Ethylene and propylene chlorhydrins and glycols from oil gas 629
———Research in the non-benzenoid hydrocarbon series 933
Brown, O. C., W. A. Selvig and A. C. Fieldner. Fusibility of coal ash from Eastern coals 80
Buell, Roy N. Pulverized lignite fuel in California 605
Burr, Freeman F. Need of co-operative educational work in the chemical industry 724

CARO, PROF. N. The German nitrogen syndicate 686
Carpenter, C. D., and E. H. Leslie. Factors in the conversion of sodium formate to oxalate 1195
Chadwick, D. T. Pure gum shellac 340
Chapman, L. W. Electrolytic zinc plant of the Judge Mining and Smelting Co. 537
———The metallurgical research department of the Utah State School of Mines 877
Chute, H. O. Dangers of denatured alcohol. 149
Cohade, J. J. Woody structures of fractures of transverse test-pieces taken from certain special steels. 259
Cohen, Jacob G. Need of co-operative educational work in the chemical industry 509
Cohoe, W. P. Cellulose symposium..... 244
Comstock, George F., and W. E. Ruder. The effect of nitrogen on steel... 399
Comstock, George F. Elastic properties of bronze castings 1113
Cone, Dr. L. C. Dangers in the dyestuff industry 33
Conner, J. F. Preventing accidents in gas plants 421
Cornell, Sidney. The elastic development of steel 677
Covitz, Philip. A rapid method for the analysis of monel metal 31
Crosby, Philip A. and Ralph R. Mathews. Brine corrosion of petroleum equipment 491

DANA, LEO. I. and Paul D. Foote. Melting point methods at high temperatures I 23
II 63
Daveler, E. V. Milling plant of the Alaska Gastineau Mining Co. 361
Davenport, John, and M. deKay Thompson. The electric furnace reduction of garnet 596
Decker, Walter L. The sterilization of water by means of ultra-violet rays 639
De Fremnville, Charles. Reliability of materials and mechanism of fractures 983
DeFries, H. A. Rennerfelt electric reverberatory furnace 280
deMare, B. E. L. The acid open hearth process for the manufacture of high grade steel 1063
Dewey, Frederic P. Volatilization in assaying 797
Dodge, F. E., and F. H. Rhodes. Recovery of pyridine from byproduct coke ovens 274

FABER, HENRY B. Filtration and filters 17
Fairchild, C. O. Effect of insulation on resistor temperatures 1144
Fairlie, Andrew M. Some developed mineral resources and chemical industries of the Southern States..... 307
Feild, Alex L. Atomic structure of metals in solid solution 580
Feuer, Bertram. Tests for relative corrosion 1197
Field, Crosby, Alan E. Flowers and R. J. Pepper. Tests on small engines at high back pressures 318
Fieldner, A. C., W. A. Selvig and O. C. Brown. Fusibility of coal ash from Eastern coals 80
Flowers, Alan E. R. J. Pepper and Crosby Field. Tests on small engines at high back pressures 318
Foote, Paul D., and Leo I. Dana. Melting point methods at high temperatures I 23
II 63
Forsythe, W. E. Calibration of an optical pyrometer 1211
Frey Charles P. A new compensated heatmeter 100
———The potentiometer in pyrometry .. 1163
Fulton, Charles H. Electric-resistance furnace of large capacity for zinc ores
I—Description of furnaces and process 73
II—Operation of furnaces and characteristics of process 130

GAILLARD, MAJOR D. P. Consumption of inorganic nitrogen in the United States 783
———Supply of inorganic nitrogen in the United States 841
Gartland, M. F. The personal element in a safety program for the foundry 323
Gibbs, H. D. Problems investigated at the Color Laboratory, Bureau of Chemistry 405
Gibson, George H. The hot-process water softener 899
Gilbert, Chester G. Political and commercial control of the nitrogen resources of the world
I 443
II 501
III 557
Giolitti, Federico. Crystallography of alpha and beta iron 585
———Genesis of ferrite 737
———Relationship between dentritic structure and ferrite mesh 921
Gleeson, Francis M., and Max R. Herrle. A study of the lime soda ash water softening process 269
Goetz, A. C., and J. H. Shrader. Operation of the Gainesville castor oil plant 833
Gustin, Wellington. Legal notes, 35, 81, 118, 180, 228, 272, 321, 368, 419, 453, 564, 613, 646, 703, 740, 803, 854, 898, 943, 980, 1022, 1076, 1124, 1163, 1193

HAMER, FREDERICK E. How the British chemists are organizing 597
Harrington, R. F. Air furnace vs. cupola semi steel 1178
Hayward, Carle R. Instruction in iron and steel at M. I. T. 1024
Hendrick, Ellwood. Teaching chemical engineering in Columbia University .. 162
Herrle, Max R., and Francis M. Gleeson. A study of the lime-soda ash water-softening process 269
Herschel, Winslow H. The Saybolt viscosity of oil blends 1109
Hibbard, Henry D. Use of spiegeleisen in steel manufacture 209
Hibbert, Harold. A plea for the scientific study of cellulose chemistry 838
Hicks, Clarence J. Lecturer of representation to the Standard Oil Co. 907
Hillman, V. E. The photograph as an aid used by a research laboratory 436
Hineta, Dr. Rikuro and Kyoshi Shiraki. Electrical precipitation in Japanese smelters 276
Holmgren, F. Problems in electric-furnace smelting 165
Hoover, Herbert C. The engineer in national affairs 349
———Food drafts for European relief .. 436
Horner, H. A. A rapid method for the analysis of monel metal 436
Hultman, G. H. Chemical industry in Sweden 920
Hull, M. R. Dust exhaust system at Arizona Copper Co. mill 207
Hutchins, Otis. A new aluminous abrasive 565

INGALLS, F. P. Observations on catalyzers in paint and varnish manufacture 590

JEFFRIES, ZAY. Atomic structure of metals in solid solution 109
Johnson, F. E. Jr. The technical engineer's judgment of the oxy-acetylene process 581
Jones, Chester H. Making lithopone at Collinsville, Ill. 497
———Manufacture of pure tungsten metal —operation at the Fansteel Products Company 9
———Muscle Shoals hydro-electric development 417
———Nitrogen fixation by the Haber method 1071
———Ozone in the chemical industries... 805
———Pre-war legislation affecting nitrate plants 885

KARRER, SEBASTIAN, and Richard C. Tolman. Motion of droplets and particles in the field of the corona discharge 1203
Kaufmann, Carl F. A test on sulphur content of clean, cold producer gas 544
Keller, Charles Albert. Synthetic cast iron 83
Kinsey, Alfred S. The technical engineer's judgment of the oxy-acetylene process 221
Kissock, Alan. Calcium molybdate as an addition agent in steel making... 1018
Kowalke, O. L. Copper-aluminum-iron bronze as an acid-resisting alloy 37

LAMB, ARTHUR B. The fixed nitrogen research laboratory 977
Landis, W. S. A new cyanide..... 265
Langhammer, A. J. A comparative test upon high-speed steels
I 829
II 889
III 939
IV 969
Leason, E. E. Air conditioning in the industries 279
Lenher, Victor. Selenium and tellurium 1108
Leslie, E. H., and C. D. Carpenter. Factors in the conversion of sodium formate to oxalate 1195
Lewis, F. B. Contributions by metallography to Tart nouveau 340
Lind, S. C. Conserving radium as a national asset 920
Lippert, O. C. F. The function of the chemical engineer in the biscuit and cracker baking industry ... 893
Lovejoy, C. H. Furnace for testing firebrick under load at high temperatures 109

MacARDLE, DONALD W. Classifying organic compounds by the Prager Jacobson system 256
Maher, Stuart W. Mineral resources and chemical industries of the Southern States 754
Maier, Charles G., and G. D. VanArsdale. Copper and magnetite in copper smelter slags—I 1101
II 1157
Mahnovszky, Andrew. The commercial synthesis of sillimanite 851
Marshall, A. E. Lessons for chemical engineers in other industries 218
Mathews, Ralph R., and Philip A. Crosby. Brine corrosion of petroleum equipment 491
McBride, R. S. Classification and salaries for chemists 689
McCance, Andrew. Balanced reactions in steel manufacture 634
Millen, E. C. New ceramic research station at Rutgers College 416
Miller, J. Strother, Jr. The lake asphalt industry 749
Moister, F. L. Physical properties in rolled rifle barrels 1025
Monypenny, J. H. G. Photographing etched sections at low magnifications ... 882
Morrison, Walter L. Manufacture of carbon electrodes for electric furnace purposes 741
Movius, Miss H. G., and Howard Scott. Similarity of the magnetic change in cementite and ferrite 1069
Mudge, H. S. Acid fumes on Riverside Drive 776

NEAL, ROY O. Testing natural gas for carbon black 358
Nevitt, H. G. Chart of viscosities in different systems 1171
Nolan, O. W. Wood alcohol as a beverage 533
Northrup, E. F. The galvanometer 944

OLIPHANT, JOHN. Pumping acid with compressed air 408
Olsen, J. C. Reversing the in and out ratio of the Chemical Engineers 676

PEPPER, R. J., Alan E. Flowers and Crosby Field. Tests on small engines at high back pressures .. 318
Perley, G. A. The catalyst for the oxidation of ammonia 125
Phalen, W. C. Diatomaceous or infusorial earth 981
Philipp, Herbert. Peat as a possible source of industrial power 693
———Some aspects of cheap cyanide processes 313

RAWDON, HENRY S. Contemporary foreign opinion on sulphur and phosphorus in steels 609
———Microstructure of iron and mild steel at high temperatures 1012
———The nature of the defects revealed by the deep etching of transversely fissured rails 505
———Microstructure of iron and mild steel at high temperature 787
Raymond, L. R. A rapid method for the determination of tin in brass and bronze 1056
Repath, Charles H. Reminiscences of early years at the Great Falls smelter 111
Rhodes, F. H., and F. E. Dodge. Recovery of pyridine from byproduct coke ovens 274
Richards, Joseph W. Economies of electric iron and steel production in Scandinavia 61
———Engineering conference on public service 964
Richardson, W. D. A new type of catalyzer for hydrogenation 793
Richter, George A. Double pipe heat inchangers 551
Rigg, Gilbert. Blast roasting at Port Pirie 518
Rooney, J. T. Present status and outlook of the magnesium industry 60
———Synthetic acetic acid and acetone... 847
Roush, G. A. Potash from lakes in Nebraska 436
Ruder, W. E., and George F. Comstock. The effect of nitrogen on steel..... 399

ST. JOHN, H. M. Melting non-ferrous metals and their alloys in the electric furnace 148
Savage, Wallace. Calculations with the Williamson formula 1155
———Industrial research at the Mellon Institute 249
Savage, Wallace, and John Scharl. Commercial development of fused silica . 593
Scharl, John, and Wallace Savage. Commercial development of fused silica 593
Schulze, J. F. W., and C. C. Atwater. The caking of sulphate of ammonia . 373
Scott, Howard, and Miss H. G. Movius. Similarity of the magnetic change in cementite and ferrite. 1069
Scott, Howard, and Henry S. Rawdon. Microstructure of iron and mild steel at high temperature 787
Selvig, W. A., O. C. Brown and A. C. Fieldner. Fusibility of coal ash from Eastern coals 80
Seyt, Martin. Chemistry for undertakers 484
———Contributions by metallography to l'art nouveau 340
———Putrefaction and decomposition .1188
———What does the General Electric get out of it? 1012
Sherlock, Chesla C. The physical condition of workmen 612
Shiga, Kyoshi, and Dr. Ritaro Hirota. Electrical precipitation in Japanese smelters 276
Shrader, J. H., and A. C. Goetz. Operation of the Gainesville castor oil plant 833
Simpson, Louis. The eventual retort plant for the distillation of oil shales 71, 244
———Recovery of the nitrogen contained in oil shales 20
Smith, Donald P. Atomic structure of metals in solid solution 340
Snyder, C. H. Hoover for President .. 245
Sperry, D. R. A classification of filter plates and frames and their general usage 493
Stausser, Paul W. C. A rapid method for the analysis of monel metal ...1144
Steinmetz, Charles P. Theoretical study of nitrogen fixation by the electric arc
I 299
II 353
III 411
IV 455
Stenger, L. A. Corrosive action of soils on iron and lead 965
Stillman, Albert L. Experimental briquetting plant 1035
Stringfield, Raymond B. Manufacture of potassium permanganate 1027
Sulentic, S. A. Oil pipe lines 327
Sullivan, E. C. Present status of American glassware 29

TAYLOR, GEORGE S. Spark coil for explosion pipettes 1013
Taylor, William M. A study of the lime-soda ash water-softening process. 532
Thompson, M. deKay, and John Davenport. The electric furnace reduction of garnet 596
Thum, Ernest E. Smoke litigation in Salt Lake Valley 1145
Tolman, Richard C., and Sebastian Karrer. Motion of droplets and particles in the field of the corona discharge.1203
Tunison, B. R. Industrial alcohol regulations 1056
———Industrial alcohol under the new law and regulations 513

VAN ARSDALE, G. D., and Charles G. Maier. Copper and magnetite in copper smelter slags, I.....1101
II.....1157

WALES, C. M., and Charles Baskerville. Reinforced lead.....1081
Walker, William H. The technology plan. 463
Wesson, David. Pictorial description of the cotton oil industry..... 465
West, Clarence J. The history of mustard gas 541
———Montan wax 929
Wheeler, F. G. Caustic pot settings..... 372
White, Alfred H. The demand and supply of fixed inorganic nitrogen in the United States 369
Whitney, Milton. The fertilizer situation..1021
Wilkins, R. A., and F. K. Bezzenberger. Apparatus for the determination of the porosity of metals.....1031
Williamson, P. B. Pressure and temperature relations for vapor of liquids....1151
Wilson, Dr. James A. The chemistry of leather manufacture..... 938
Wooton, Paul. General Sibert and the Chemical Warfare Service..... 755
Wright, Arthur. Scientific control of the filter station, I.....1015
II.....1077
III.....1119
IV.....1165
V.....1201

YANCEY, H. F. Some chemical data on coal pyrite 105

ZANETTI, J. E. The history of mustard gas 724
Zeisberg, Fred C. Resistance of absorption tower packing to gas flow..... 244
Zeller, R. Sulphuric acid nomenclature... 100
Zwingenberger, Otto K. Prolongation of German patents and useful models...1056

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

ALAN G. WIKOFF
Assistant Editor
L. W. CHAPMAN
Western Editor
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 22 — New York, January 7, 1920 — *Number* 1

A Survey of The Chemical Industry

THE chemical industry, as always, is in a state of transition. Roughly speaking, five years ago one would say that the chemical industry required about two dollars of capital invested for every dollar of annual turnover. Now capital requirements are almost doubled for the same turnover. Disregarding war contracts, which were largely made and enjoyed by men who are not ordinarily manufacturers of heavy chemicals, it is doubtful if any other essential industry has maintained so level a curve of prices as this.

The war has not produced new developments in chemical war materials, except, perhaps, in regard to sulphur. New sources chiefly in Texas promise cheaper sulphur, and for the first time in many years the element has been widely used in the place of pyrite and other metallic sulphides in the production of sulphuric acid. This, however, was rather due to shortage of iron pyrites than to competitive prices. It remains to be seen whether the sulphur producers can or will adjust their prices to compete with those ores under future normal conditions.

Muriatic, nitric and acetic acids were all used in very large quantities during the war, but the war did not perfect or revolutionize any process for them in this country.

Practically all the war plants built under Government auspices are closed. They were not planned for industrial use, and many of them unfortunately were not even happily designed for industrial advantage. Whether these plants can ever work themselves out of the category of junk aggregates is a serious question. At present they are incomplete and idle or in process of dismantling, and their prospects are not rosy.

No official effort has been made in this country toward the unification of chemical industry during or since the war, although in England there has been a marked tendency in this direction. In Germany all of their war developments were laid out with a view to improving the condition and co-ordination of chemical industries after the war. There is a curious psychology in this. Nobody enjoys making a dollar more than the typical American, but nobody cares so little for it after it is made or is less anxious to keep it than he. At the same time, if anyone has the courage to venture his wealth in an enterprise that has been organized by the Government, and succeeds in his venture, suspicion is immediately aroused. His profits are resented, and the officials of the Government who planned for just such industrial success are condemned. So it is fair to say that our Government has given substantially no consideration to permanent industrial development, and that the people of the country will therefore receive no benefits from it.

The Germans in the past have gone ahead faster than we have. This is not due to better chemists; it comes rather from better chemical understanding in high places, and greater concentration of resources.

Chemical research in the U. S. A. during the war period has been confined largely to the organic field, and since Germany was in control of a great part of that industry, it has consisted principally in trying to follow Germany. Otherwise the war has hindered rather than promoted true research.

As to markets and plant operations, the tremendous momentum of production at the time of the Armistice in November, 1918, was arrested by February, 1919, and in March and April of that year trade was very dull. By May and June it had picked up, and now everybody is busy. This is more than can be said of England and France, where, in neither country, are the peace plants operating at full load.

Industrial chemistry has made a big forward stride during the past year, not so much through the development of new processes or through any remarkable improvement of established processes, but rather through a silent and unspectacular invasion of industries that have heretofore gotten along with but little assistance from the chemist or without an intensive application of the principles of chemical engineering. There has also been evidenced an extension and broadening of the scope of the work performed by the chemist and physicist in chemically controlled industries and an added importance placed upon the technical positions in industrial organizations. Thus we note an expansion of the personnel of research departments and an extension of their investigations to cover the whole field of industrial activity, and also find the chemist employed in the smaller plants as an addition to the operating staff.

That this should take place during a year in which industry as a whole has marked time awaiting a more favorable opportunity for expansion and development augurs well for the future position of the industrial chemist and of the chemical industries.

Electrometallurgy In 1919 and Afterward

THE year just passed was an active one for the electrometallurgical industries. The beginnings of large improvements were numerous and important. In fact, one feels that the electrometallurgical processes are "coming into their own."

In the iron and steel industry the introduction of electric melting and refining furnaces in steel plants was more active than ever before. This industry has already far outstripped the crucible steel process, and if it was not so well fitted to work duplex or triplex with the bessemer converter or open-hearth furnace, or both, we might say that it was a potential successor to these

standard steel apparatuses. Works experience with the electric steel furnace is certainly short and limited in comparison with other processes, yet it is the most rapidly developing improvement in the whole steel industry.

In Scandinavia the electric reduction of iron ores to pig iron is on a sound commercial basis, and large extensions are already under way, such as at Lulea, where six of the largest size (2500 kw.) furnaces are being erected. It looks as if the knell of the iron blast furnace is about to sound in Sweden, and the situation is likely to spread to other countries similarly situated as to power and fuel cost.

The electrolytic refining of iron, for the commercial production of very pure iron, made its commercial début in France in 1919. Details are not yet published, but the plant is invaluable for producing the basic material for the highest quality of special alloy steels.

The synthetic production of cast iron of carefully controlled quality from the superabundance of steel scrap from munition machine shops was a war development in which electric furnaces were the necessary apparatus. A description of several fine plants erected for this purpose in France has just been distributed by the American Electrochemical Society, written by the chief director of this industry in France, CHARLES A. KELLER. How much of this industry will survive under post-war conditions is not certain; we believe that a considerable part of it is bound to survive as a stable industry.

Automatic heating, hardening and tempering furnaces electrically heated and controlled have attracted great attention in the past year. The leading American designer and constructor of these apparatuses has rapidly devised one type of furnace after another, designed to replace the trained and experienced workman by the impeccable machine with its superhuman electric control, and served by a common laborer. The steel industry stands to benefit largely in the near future from these innovations, and other metal industries will likewise share the advantages of these electrical improvements.

In the non-ferrous metal industries 1919 was characterized by the rapid introduction of electric melting furnaces in place of melting in crucibles or open-combustion furnaces. Crucibles cost twice as much and are not half as lasting as they once were; the electric furnace had a great opportunity, and it was grasped. It is hardly conceivable that the industry can or will back-track. Fifty or more electric furnaces were erected in a single brass-producing city (Bridgeport, Conn.), and all the other brass makers in the country are either looking on with interest or have determined to follow suit. America is leading the world in this development, and the brass and other related industries of other countries cannot do otherwise than imitate our methods and follow our lead.

Altogether, just from this fragmentary review of what is only a part and not the whole field of electrometallurgy, the advocates of this branch of science and industry must feel proud of the rapid progress made and the innovations introduced in 1919. It is only a fraction of the progress which will be recorded in this line for this year, for the door is just opening, and the general introduction of electrometallurgical methods bids fair to work revolutions in many of the metal industries in 1920.

The Alkali Industry During the Past Year

IN REGARD to alkalis there is substantially nothing new in technology. Before the war $12 a ton was a more or less standard price for soda ash, and Europe could not compete with domestic manufacture in this territory. Now labor and steam power have become very uncertain factors both here and abroad, but it hardly seems likely that we need fear foreign competition in the home market for soda. Business in soda ash and caustic has been very similar to that of sulphuric acid: great demand during the war, followed by a heavy slump after the Armistice, and now plants are running nearly to capacity again. It should be remembered that many big caustic plants have lately doubled and some even trebled their capacity, but in spite of that they are running nearly full time.

This is partly explained by exports to the Scandinavian countries, which are the natural customers of Germany; to South America, formerly supplied by England and Germany; and to France and Spain and elsewhere. These markets have been obtained by American producers, not by low prices or cheap production, but because there has been no competition. Germany does not seem to have soda for export as yet, which may be due to labor troubles, or coal shortage, or to difficulties in transportation. The same may be said of England, so that when European manufacturers start to go after that trade, to get back what was formerly theirs, it may be that production will have to be curtailed. It will be largely a question of manufacturing costs.

There is considerable talk of a combination of the Haber process for making ammonia with the Solvay process in Europe. For the Solvay process it will be recalled that brine, ammonia and limestone are needed, and by this combination of processes the ammonia would come direct from the Haber plant, enter with CO_2 and water as ammonium bicarbonate into reaction with salt in which acid radicals are exchanged. Then sodium bicarbonate precipitates from the ammonium chloride solution, and this liquor, on treatment with caustic lime, sets the ammonia free. The ammonia may then be treated with sulphuric acid to form ammonium sulphate and sold as fertilizer.

We fail to see any very great advantage, because in the Solvay process the ammonia is mostly recovered so that the total amount required for renewals is not very great. Then, too, the two products are respectively an industrial and a fertilizer material, and the demands for the two are not adjusted to joint manufacture.

Occasionally there are rumors of a reintroduction of the Leblanc process. Some three years ago there were two or three such plants still in operation in England, and a very few similar works along the Rhine in Germany. There is none in this country, but the gossip usually arises from the fact that there are great deposits of sodium sulphate in Arizona, New Mexico and California. As thenardite, which is anhydrous Na_2SO_4, it is sometimes 98 per cent pure. When a cheerful promoter sees the deposits and reads the price of Glauber's salt as a drug or as a chemical need in the dye baths of the textile mills or in glass works he usually has visions of great wealth. These industries being all far away from the source of supply, to encourage production his next thought is the Leblanc process for soda! For this the materials

are brine, sulphuric acid, limestone and coke. While limestone is sometimes available it is the absence of coke and the problem of freights that usually kills the propositition. Such an undertaking, however, is a possibility.

In regard to potash, we have now a producing capacity of nearly 100,000 tons K_2O per year, or a little less than half of our requirements before the war. This can be extended, provided there is profit enough in the business, or provided technical research advances rapidly enough. It is likely to be two or three years before some establishments are shaken down to economic production. In addition to this, the problems of fuel, labor and freight are all in a state of flux.

The most promising prospects are certain California and Nebraska lakes; the greater deposits being in California. Here we have very strong natural brines in a hot, dry region. This is as rich as German or Alsatian products, dug out and brought up from many hundred feet underground. Now it is up to American technologists to get this salt by the aid of the sun and artificial evaporation as cheap as Germans can mine it, and it seems as though this were possible. It is also up to American producers to refine it at the same costs as Europeans can. The chemistry of the refining, including the separation of borax, and all other ingredients, is all worked out.

From 1000 to 5000 tons each are coming in from other sources, some of which may be materially increased. For lack of space we shall merely mention them: Dust from cement mills, beet sugar waste, molasses alcohol waste, Utah alunite, and Wyoming leucite. Two iron blast-furnaces are making potash recovery at present. This source may have considerable development in a couple of years. Working over the green sands of New Jersey may also become an important factor in the future, but they are not producing as yet. Kelp is practically dead for the present. The trouble was the cost of handling 90 per cent water which it contains when harvested, and the large amount of unprofitable organic matter to treat before the potash could be produced. The United States Government has an experimental plant in operation, with a view to developing enough useful byproducts from the kelp and thus to put the industry upon a commercial basis.

Gold and Silver Metallurgy in 1919

THE conditions that have prevailed in the gold industry during the past year have approximated stagnation. Probably not a mine operated throughout 1919 at full capacity, and all have faced increased costs. It is true that some reduction in the cost of many mining and milling staples has been experienced, but the benefit which might have been derived from these has been offset by the shortage of labor and its falling efficiency.

Naturally, the result has been retrenchment. Metallurgical developments have been such as have been dictated by the necessity of paring expenses to the bone; generally speaking, they have been refinements of existing practice rather than additions to known methods or to underlying principles. This condition, and the state of mind it inevitably produces, has also been in evidence in the technical press and the publications of the national societies. Passing these in review, we recall few of more than ordinary interest.

CROWE and LENNOX have described work done with Chilean mills at the Portland. It would appear that they have developed a mill that is superior to earlier designs, but it is not so clear that it has merit enough to threaten either the stamp- or the ball-mill. Ball-milling has contributed nothing new during the year, other than a steady improvement in technique and a more general understanding of the limitations of this type of machine. The stamp-mill operators have had an unsatisfactory experience with alloy steels, forced on them by war conditions as a substitute for hammered iron in such parts as camshafts. We understand that the steels have failed dismally, but feel that the failure may be redeemed when the manufacturers take time to give intelligent study to the exacting requirements of the stamp-mill. Several new screening devices, as the Mitchell and the Maxton, have been offered during the year.

ALLEN, in the *Engineering and Mining Journal*, discussing general tendencies in metallurgical practice, interested us in his insistence that this country has not wholly appreciated the advantage of gravity-leaching of finely crushed sand, suggesting by inference that our "all-sliming" work has been carried to an unwarranted extreme. We think there is much good sense in his argument. Sand-leaching is cheap; it is effective. Moreover, its possibilities have not been exhausted.

As an illustration, a single point may be instanced. For effective extraction, one of two conditions is essential. Usually, ample time must be allowed; sometimes it is sufficient that a certain minimum quantity of solution be applied. When the first condition prevails, the question of leachable depth of sand becomes of interest. Given clean classification, the depth may cover a considerable range without affecting leaching rates. Leaving out of consideration such factors as saving in cost of installation, increased washing time, etc., there remains the fact that, if 10 per cent more sand can be treated in a vat, extraction will be effected with 10 per cent less solution, and consequently with enrichment of effluent solution and reduction of all losses except the cyanide actually destroyed by the ore. Close attention of the problem is warranted.

The work of the copper men in leaching is of increasing interest to cyanide operators. The large scale of operations, the mechanical devices used, the manipulation of solutions, all carry valuable suggestions to practitioners in the older branch of hydrometallurgy.

CROWE'S process is a success, proclaimed as such not only by its continued introduction but also by criticism of the merits of its claim to letters patent. Of the soundness of the points raised against these claims we are not convinced, but that they should be made at all is excellent indorsement of the value of the process.

Of collateral interest is the publication by WHITE, in South Africa, of a method for the determination of oxygen in cyanide solutions. He apparently overlooked Sir WILLIAM RAMSAY'S work on the same subject, published eighteen years ago. Indeed, RAMSAY seems not only to have originated but to have pointed out the weaknesses of the method, which impresses one as being of rather limited application, too readily influenced by slight irregularities in the sampling and subsequent manipulation.

South Africa has been sharing our experience with unrest and disorganization of business; technical matters are for the moment of secondary importance. A new wage scale, with provision for a six-day week, has recently been negotiated on the Rand.

The great demand for silver has stimulated production everywhere, subject, of course, to the universal limitations imposed by unsatisfactory business conditions. BRYAN is again the prophet, and we have wondered at times, with the metal quotations before us, whether he may not have been, after all, an unduly modest conservative.

This reviving interest is being evinced by the reopening of old mines and camps, and interesting metallurgical problems may arise from these. Cyanidation will no doubt be the most favored method, as it has been almost the only one practiced in recent years and wider margins will extend its economic field. But in the bonanza days of the last century many ingenious processes were developed. In addition to the old Patio process, the Washoe, Von Patera, Augustine and Russell processes may be mentioned, to name but a few. Exhaustion of rich ores or falling prices of bullion led to the complete elimination of these methods. It is of interest to speculate whether the current market will bring back any of the old processes, rehabilitated with the machinery and equipment of the present day, and drawing on the experience of cyanide operators for supervision.

Then, too, the experiments in volatilization, quoted by LYON and RALSTON, and the work in this field by the staff of the Chief Consolidated, suggest that this radical innovation has possibilities. If the vagaries of the chloridizing furnace can be controlled, there may be a future for these methods.

Developments in Ceramics During 1919

ALMOST without exception ceramists have confined their efforts to adapting their technology to the available types of clays. They have never, except in a few individual cases, attempted to do much chemically with their raw material. Before the war great quantities of foreign clays were imported into this country. Little real effort was made to obtain them from among the vast and varied domestic deposits until the foreign supply was cut off. How successful were the clay geologist and ceramist has been frequently reported and is undoubtedly familiar to all.

However, the accomplishments of the clay chemist have been extolled with a weak voice indeed! It has almost become a dying one, for the work of our analytical friends in ceramics has furnished insufficient as well as only indirect guidance in this industry, where physical properties are mainly wanted and which can be controlled directly by physical tests.

Some valuable chemical developments in ceramics appear to have been accomplished during the past year in a laboratory located almost within hearing distance of the din from the narrow streets of the New York financial area. A practical process has been developed here for making a lean clay fat—a bond clay out of pure kaolin, which gives promise of a new era in refractories and the many industries depending upon them. The technical details cannot be described at present, but will be during the coming year.

In the fused silica industry progress can be noted at home as well as abroad. Since 1901 the variety of products has increased simultaneously with a decrease in prices. Large acid plant installations were made during the war and two domestic concerns are now operating on a small scale. The bulk of this material has been imported from England, but with the impending prohibitive duty once enacted, we will soon be fusing our own sand and use more fused silica equipment than can even be anticipated under present conditions.

Petroleum Industry In 1919

BUT a few years ago the low valuation of that undesirable by-product of the petroleum refinery, gasoline, gave impetus to the development of the internal combustion engine. The latter in turn was to create markets of inconceivable magnitude for the many petroleum products then practically unknown, ranging all the way from gas to pitch, surely a desirable substitute for the market of lighter products, ever becoming more circumscribed by the displacement of the candle and oil lamp with more modern methods of lighting.

In the past year the major products of the petroleum refineries—gasoline, lubricating oils, asphaltic residues, and coke—have largely been utilized so as to get more miles of transportation out of our several million motor cars and trucks. Just as it was the function of the lubricating oils to reduce the power lost by friction within the machine, so it was that of the asphaltic residue to produce less resistant roads and that of the coke to reduce alumina to aluminum for use in the fabrication of bodies and motor parts of less weight. All three of these factors helped to reduce the tractive energy required and therefore actually have a gasoline equivalent of considerable magnitude. An improvement in the technology of any one of these four products can be said to have a bearing second to none in regard to public convenience and pleasure.

Gasoline made by the cracking process is not stable and upon standing partly polymerizes into products which clog the carburetor, unless a considerable proportion of saturated hydrocarbon is mixed with the destructively distilled product. It has consequently been thought that the new cracking processes were of limited application. Some investigators have anticipated this difficulty by working out hydrogenation processes for building up the saturated hydrocarbon content. However, it has been found that by making prompt delivery of the destructively distilled gasolines, they will usually be consumed before sufficient time is given for the polymerization to take place.

None of the cracking processes gives the most desirable conditions for getting maximum yields. Temperature, heat input and pressure are not so difficult to control, but they must now be maintained below the ideal, due to the safety limitations of the equipment used. Considerable work along these lines is being done which gives promise of development of great importance. The oil fraction to be cracked is passed through a bath of molten lead. Evidently, the pressure is easily controlled by the head of metal maintained above the oil inlet. Very great pressures can thus be obtained without danger of ruptured containers and conflagrations. The temperature is controlled by regulating the heat applied to the container of the metal in conjunction with which the rate of the oil feed and its dispersion governs the flow of heat into the oil.

Asphaltic residues are usually brought to the required specifications of melting point, penetration, or tempera-

ture susceptibility by proper mixing of bases and blowing with air. It has been found that a better product is made by using a very high rate of air input and shorter heating periods than has generally been adopted hitherto.

In one of the large Eastern refineries, a segmental still-head has been designed so that the coke zone can be readily exposed and the deposit removed mechanically. Stills thus equipped will not have to stand idle for days to be cooled down to a temperature at which men can enter to clean them. Many asphalt and other stills containing bituminous solids will eventually be equipped with some such type of segmental plate and mechanical cleaner in preference to carrying excess equipment for peak operation.

During the year the petroleum refining companies formed a Petroleum Institute which will undoubtedly have considerable influence in many aspects, legislative, technical or economic. At the present time new specifications governing the use of fuel oil are being discussed. The Institute keeps its members informed as well as obtains and makes known their opinions on points at issue. It is planned to organize a technical section which will afford men the long and much needed opportunity to meet, swap ideas and return to their plants with their minds opened and stimulated.

Review of the Year's Advance in Rubber

THE shifting from a war to a peace basis has been accomplished by the rubber industry with no great difficulty. This was due chiefly to the fact that rubber has a wider range of application in the arts of peace than in war. In 1917 and 1918 the rubber factories were running at minimum production and every effort was put forth to aid our Government. Peace brought a decrease of production in some lines, but the effect was just the opposite in rubber. The stocks of all the major companies began to rise. Production organizations were expanded, and since then practically all companies have been hard pressed to fill their orders. This is particularly true in the tire business, which had been considerably under the ban due to the restriction of crude rubber imports.

One of the most gratifying results of the war has been the better appreciation of the value of the chemist and chemical engineer. This lesson has apparently been well learned by the rubber industry. During the past year practically every company has either installed or enlarged its laboratory, and the tendency is to give more weight to the opinions of its chemists. The day of the rule-of-thumb compounder is nearly over. His place is being taken by the rubber chemist, whose duty it is so to combine science and common sense that products may be improved and cheapened, while at the same time production may be increased and a uniform quality maintained.

Another achievement of the year has been the reduction in the number of tire sizes for pleasure cars. Through co-operation between the Society of Automotive Engineers and the tire makers many unnecessary sizes have been eliminated. The resultant saving in cores and molds has been enormous.

There is a marked tendency for a wider application of the cord principle in tire construction. There are now no 5-in. tires which are not cords. It is predicted that before long all sizes, even down to 3 in., will be made in this way. While cord tires have a higher initial cost than fabric, they do give a lower cost per mile and more comfortable riding, which is due to the greater pliability of cord casings over those of fabric. This increased pliability has permitted the development of pneumatic truck tires, which are now past the experimental stage and are being manufactured in quantity by several large companies. There is a growing tendency to equip all long-haul trucks with pneumatics and to use solid tires only on very good roads and for short hauls. This is due to the fact that trucks so equipped can average 30 to 35 miles per hour over a long trip.

Because of the failure of electrically driven street cars adequately to care for the traffic in many large cities, more and more attention is being paid to the operation of buses which are simply large trucks with special bodies in which seats are provided for from 25 to 75 persons. Such buses, equipped with pneumatic tires, are comfortable and make very good time. Since no tracks or trolley wires are required, they are free to operate on any street. There is a great saving in initial expense and upkeep, and since only one man is required to operate most of them, there is a saving in labor as well. Keen students of the traction problem say that the street car is doomed.

The growing of long staple cotton equal to the best Egyptian or sea island varieties in Arizona is of particular interest to American tire manufacturers. The success of the project is now assured and many thousand more acres of former desert land will soon become productive.

In tubes the consensus of opinion seems to favor increased pole size. It has been found that if the diameter of the tube more nearly equals that of the casing its life is longer. In other words, the lower the strain the tube is under when the car is still the better it will age.

American tube makers are showing great interest in antimony sulphuret. It is admitted by most rubber chemists that a properly compounded antimony tube made with rightly prepared sulphuret is absolutely the best tube that has been made to date. The American branch of a French rubber company enjoys a national reputation because of the high quality and long life of its tubes. There are now approximately six firms in this country making antimony sulphuret, and antimony tubes are being manufactured by quite a number of rubber companies.

The pioneer work of EATON, GRANTHAM, DE VRIES and others in producing fast-curing rubber of high quality is now bearing fruit. At least two of the large rubber companies are producing it on their own plantations and using it in their compounds. There is an increasing tendency among rubber growers to pay more attention to selective breeding and like problems with a view to making the *Hevea* tree more productive.

In the accelerator field hexamethylene tetramine is now almost as extensively used as thiocarbanilide was a few years ago. Another accelerator that has recently come into general knowledge is the reaction product of dimethylamine and carbon disulphide, dimethylamine-dimethyl-dithiocarbamate, which is the most powerful curing agent known to date. A quarter of 1 per cent of this substance will give a good cure in three minutes heating to 140 deg. C. If this same stock is made into a cement and the accelerator added in benzol solution, the whole mass will

set to a very stiff vibrant jelly in about a week's time at room temperature. There are as yet no practical applications of this accelerator, but one may reasonably expect the development of a line of self-curing cements and patches at no very distant date.

There has been very little labor trouble in this industry, chiefly because rubber workers are well paid and the large majority of them are home-owning Americans. Several firms require their foreign-born workmen to become American citizens or quit. In many factories there is a healthy spirit of co-operation between the men and the management which has brought about a good appreciation of each other's responsibilities. There is no room for Bolshevism here.

The coming year should be a very fruitful one for the rubber industry. The demand for rubber goods of all kinds was never greater, not only at home but abroad. Materials are available in quantity and labor is willing. These are certainly the principal factors necessary for prosperity.

Hydrometallurgy and Pyrometallurgy Of Copper in 1919

NEW smelter construction appears to be centered in South America, and the Andes Mountains bid fair to witness a building boom such as occurred ten years ago in Arizona. Strangely enough, each one of the four leading copper producers is engaged in the design, if not in actual construction, of new and larger plants. Braden has completed plans for a new blast-furnace plant some five miles below its present mill site, concentrates to be transported by rail or aërial tram. Cerro de Pasco has started on the construction of a new smelter at Oroya, some distance below La Fundicion, the site of its present one, planned and built some 15 years ago. Its new plant (which will probably not operate before 1922) will have two blast and two reverberatory furnaces, and will make about 100 million pounds of copper annually—somewhat more than the present installation gets with nine smaller smelting units. Chuquicamata is engaged on a project which calls for doubling its present output—the same leaching system will be utilized, and the extension will be on the same site. Andes Copper has its preliminary work on its property at Potrerillos well in hand, the metallurgical details having been carefully worked out by LAIST at Anaconda and the mechanical design for a 12,500-ton unit nearly complete in all respects. Briefly the scheme for the oxidized capping will consist of crushing to ½ in., leaching by downward percolation in rectangular concrete tanks containing one day's ore receipts, precipitation by pig iron or SO_2 and refining by melting down under bone ash.

Of this new construction it is seen that over half is devoted to leaching—to hydrometallurgy—and the conclusion is safe that from now on the sulphuric acid leach will be given careful consideration by those contemplating treatment of low-grade oxidized ores. As a process for roasted sulphides it is not so attractive. For instance, ROGERS at Anaconda has found that table tailings from old dumps containing 0.7 per cent copper can be reground and reduced to a 0.2 per cent tail by flotation as cheaply as the same material can be roasted and dissolved in its leaching plant, and the former method is now practiced using either one section exclusively or distributing the available sands throughout the mill.

But there is a range between straight sulphide ores and straight oxide ores where the losses in either process may be too much to countenance—in fact much work is being done, particularly in Arizona, on combined methods which will catch the oxidized copper comprising the bulk of the tailings values. If the ore contains few acid-consuming materials—a point impossible to determine from the usual chemical analysis—it would obviously be good engineering to leach coarse material, then grind and float the cleaned sulphides, a scheme which ALDRICH is now operating at Inspiration in a 30-ton experimental mill. On the other hand, the Miami Copper Company, in co-operation with VAN BARNEVELT of the Bureau of Mines, is investigating a scheme for handling mixed ores which entails fine grinding followed by flotation. The pulp is then passed through a large wooden drum against a current of SO_2, which leaches soluble copper out as sulphite, changing rapidly into sulphate, however. The whole mass then goes through a very long ball mill, acting not as a grinder but as a precipitator, after which the cement copper is to be recovered by flotation.

Precipitation of copper sulphate presents the most interesting problem in leaching. Some ores may be so fortunately constituted that any contained iron is insoluble; then the solutions may be electrolyzed almost completely without precautions to lower the ferric content and with the simultaneous production of little or no cement copper. On the other hand, manipulation may change the ratio of cement to electrolytic copper. Thus, at New Cornelia, during curtailed production TOBLEMAN found that the longer the time of leach and the lower the corresponding acid concentration, the less would be the amount of impurities dissolved and consequently the greater the proportion of electrolytic copper to cement copper produced, a very desirable condition. On some ores, solutions may become so foul that only a small percentage of copper is removed in one passage through the tanks and that at a low ampere efficiency; this condition, coupled with a high cost of electricity and acid, would make some clean method of chemical precipitation quite attractive. FRICK at Anaconda has therefore worked out the details of precipitation by SO_2 for the new Andes plant. In this scheme, leaching solutions, thoroughly reduced by liquid SO_2, pass through heat interchangers into lead-lined autoclaves, there to be heated to 150 deg. C. under 125-lb. pressure for 4 hours, when half of the metal is thrown out as bright red copper crystals with the generation of sulphuric acid according to the formula

$$CuSo_4 + SO_2 + 2H_2O \rightarrow Cu + 2H_2SO_4$$

The hot mixture is then discharged through interchangers and thickened; the liquid returned to circuit and the copper dried and furnace refined.

Reverberatory and blast furnace still maintain supremacy in their individual bailiwicks, despite rumors of the latter's demise. Anaconda has cut one of the 51-ft. units into the two 15-ft. stacks from which it sprang, and runs the small one only intermittently, while KUZELL has just doubled the capacity at Clarkedale by a battery of new reverberatories, and other Southern plants have hung up wonderful records for long campaigns. Thus, CLARK at Calumet & Arizona, by widening furnace, raising verb and enlarging uptake, has been able to smelt regularly 700 tons of dry charge daily plus 100 tons of converter slag, with an oil consumption of 0.7 barrel of oil per ton. Large modern

reverberatories are doubtless pre-eminent for smelting fusible fine charges, especially where fuel and silica brick are cheap. On the other hand, a blast furnace has all the best of the argument with refractory, coarse ores, high in sulphur, especially in places where power is relatively cheap and cost of coke not prohibitive. Even fines may be smelted to advantage after sintering or nodulizing, as will be done in Braden's new plant, and introduction of powdered coal through tuyeres bids fair to remove the disability caused by expensive coke.

The soundness of the latter idea seems definitely established. Early in 1918, CAVERS ran a blast furnace at Tennessee Copper for a fortnight, blowing pulverized coal through ten tuyeres on one side of the furnace. But very little coke was charged occasionally, it being replaced by two-thirds its weight in fine coal. This practice was discontinued because of unburned carbon discoloring the acid; but later experiments at International Nickel have shown beyond question that pulverized fuel can replace a considerable percentage of coke, a result confirmed at Cerro de Pasco, by RICHARDS at Garfield and by HAMILTON at Midvale.

VAN ARSDALE and MAIER have published a most important contribution as to the exact condition of copper in furnace slags. To a certain small extent copper sulphide is held as a true solution, but the balance occurs as globules of white metal, floated by attached bubbles of SO_2, the latter gas formed by reduction of iron sulphide by ferric iron in the slag. Continued settling would not recover either the dissolved or the buoyed metal, and this can only be done by changing the composition of the slag so as to practically eliminate the occurrence of ferric oxide. In the light of this information, data on the operation of the large slag furnace at Anaconda are interesting. Here liquid converter slag is poured through a side door of a reverberatory, banked by high-sulphur calcine and siliceous tailings. Reaction with this material melting along the sides of the bath reduces the magnetite in the converter slag and tailings are dissolved so that whereas the incoming slag carries 4 per cent copper, 63 per cent iron reported as FeO, and 23 per cent silica, the outgoing slag has been reduced to 0.6 per cent copper, 53 per cent FeO and 34 per cent silica.

Anaconda's new Cottrell plant started during the summer, giving good clearance of very fine fume. The relative difficulty and expense of catching fume and dust are vividly exhibited by a comparison of this monumental plant with a little plate treater tucked away in a short section of gas flue at Tooele. In comparison it is only a toy, yet it gets 90 per cent of the dust passing a dust chamber, even when handling gas from twelve McDougalls at 20 ft. per sec. With the problem of how to catch solids now solved, the next to appear in the near future will be how to get rid of the unusual substances which will accumulate and finally saturate the smelter system. How to do it at a profit will at times be subordinated to the compulsion to do it in some way which will create no nuisance or positive danger.

Refineries were left with much war-time excess capacity as well as war-time copper on hand, and it is hardly probable that any considerable plant extension will occur for some years. An interesting possibility for the future is the casting of large ingots to be rolled direct without cooling into rods or sheets in mills built closely adjacent to the furnace refinery, a practice long standard for blooming mills in steel plants. ANTISELL, at Raritan, has been able to use a high-sulphur Mexican topped oil of high specific gravity in cathode-melting furnaces, without any harmful effects from high sulphur in the resulting wire bars. If electroyltic copper, notoriously sensitive to minute impurities, can thus be melted without slag protection and with impunity with what is commonly regarded as dangerously impure fuel, the harmful effects of SO_2 in furnace gases in other metallurgical operations are possibly overdrawn. It may be remembered that high ash pulverized coal was not suitable for reverberatory smelting on account of an "insulating blanket of fine ash settling upon the slag," until some ignorant person went and used it!

Even in rock-ribbed Michigan are signs of change visible. Needs must, for the Federal Trade Commission's reports show that as a group, Lake copper costs more than that from deep mines or porphyries in the West, even the biggest Michigan companies returning costs of from 16.2 to 16.6 cents per pound, while at the same time the price differential between Lake and electrolytic copper has definitely vanished. Deep mining, low-grade ores and fine concentrates point to a certain revision of Lake practice to that more modern; at least some simple labor-saving devices are necessary purely on account of the continual decrease in number of laborers of the broad-back, narrow-forehead type. The cheapest copper coming from Michigan is probably that reclaimed from regrinding tailings, and it is even possible that the old slag dumps can be made to yield metal more economically than can an ore body 5,000 feet below.

The Steel Industry's Growth

THE actual commercial capacity of the United States for producing steel ingots crossed the 50,000,000-ton mark in 1919. To secure a basis for computation one must go back to the year 1916, for in none of the three years intervening has there been opportunity to test the industry under fair working conditions. In 1917 and 1918 there were transportation difficulties curtailing the output at one time or another, and in 1919 there was a lack of orders for a large part of the year. The steel ingot production in 1916 was 41,401,917 gross tons. Deducting the estimated production of new capacity installed during 1916, and adding about 80 per cent, to be conservative, of the rated capacities of new installations from January 1, 1916, to January 1, 1920, one reaches a figure slightly in excess of 50,000,000 tons. It seems perfectly safe to assert that given the same operating conditions as obtained in 1916 such a tonnage can be produced.

On the whole, there has always been sufficient rolling capacity to take care of ingot production. The sum total of rolling capacity is always well in excess, as provision must be made for variations in the distribution of demand. Except for the dislocation produced by the rolling of shell steel, with heavy discards, the production of finished rolled steel, in rods, skelp, sheets, plates and shapes, has always run approximately 76 per cent of the ingot output. Hence the capacity in finished rolled steel may be taken at fully 37,500,000 gross tons a year, or 725,000 tons a week. The year 1920 opens with a conspicuous shortage of steel, and with production at 550,000 or 600,000 tons a week, and thus it may be seen readily that making up the shortage is chiefly a case of

bringing production as nearly up to the capacity rate as may be.

Electric steel has made a magnificent record in the past four years. Previously the statistics had given it a little bit of a black eye. It looked bad that production of electric steel ingots and castings should jump from 13,762 tons in 1909 to 52,141 tons in 1910, and then show a lower production in each of the four years following. The excess production in 1910 was chiefly of rails, made for experimental purposes. For many, if not all, other uses the production of electric steel increased in the four years following 1910, with the exception, of course, of 1914, which was an "off" year in practically all respects. The remarkable growth of the electric steel industry is shown by the following production statistics, the figures referring to gross tons:

	Ingots	Castings	Total
1909	13,456	306	13,762
1910	50,821	1,320	52,141
1911	27,227	1,878	29,105
1912	14,147	4,162	18,309
1913	20,973	9,207	30,180
1914	15,458	8,551	24,009
1915	46,348	23,064	69,412
1916	126,048	42,870	168,918
1917	239,632	64,911	304,543
1918	403,068	108,296	511,364

While the war was largely responsible for the rapid increase in the production of electric steel, there has been no retrogression since hostilities ended. Instead there has been much new construction, at a rate not far below that which obtained during the war. The half-million ton output of 1918 is large in itself, but the tonnage is made the more impressive as the output of a young industry when it is observed that the steel industry of the U. S. was regarded as very large at the time the United States Steel Corporation was formed, early in 1901, and that the 1918 output of electric steel is 5 per cent of the output of the entire steel industry just before the formation of the Steel Corporation.

The pig iron producing capacity of the United States, on a fair estimate of actual production under normal operating conditions, not a summation of rated capacities of stacks, is about 45,000,000 tons a year, with a dozen furnaces being built, to add about 2,000,000 tons to production. Output for years past has grown not merely by the erection of new stacks but by the remodeling of old stacks and by apparently slight changes in equipment and methods whereby individual furnaces have materially increased their output.

Statistics have now accumulated for a number of years of the consumption of iron ore, fuel and limestone by blast-furnaces, so that some comparisons may be made. Beginning with 1909 there are complete statistics of the quantities of iron ore, mill cinder, scale, etc., and limestone consumed by the furnaces, while the fuel consumption figures are complete since 1912.

The average iron content of the Lake Superior ores has been going down more or less steadily for about 20 years, partly by reason of the exhaustion of the choicest deposits and partly because expanding requirements necessitated the opening of lower-grade deposits. One might suppose, therefore, that the average ore consumption of the whole industry, per ton of iron made, would increase. The ore consumption was 1.886 tons per ton of pig iron in 1909 and 1.895 tons in 1910, since which year it has been less, and 1918, with 1.853 tons, was almost the lowest year of the ten for which statistics are available. The statistics, however, furnish a plain offset to this, in that while the consumption of mill cinder, scale, etc., was 0.098 ton in 1909 and 0.102 ton in 1910, it was 0.130 ton in 1918. The total of the two was almost constant in the ten years, the maximum being 2.018 tons, in 1911, the minimum being 1.937 tons, in 1917.

Scale is much richer in metallic iron than any of the iron ores available, and scrap is nearly all metallic iron. Taking the industry as a whole, there was practically no choice as to the consumption of scale. Presumably the blast-furnaces consumed nearly all the scale that was produced in rolling steel. As the production of the steel has increased more rapidly than the production of pig iron, a smaller percentage of the total pig iron output being used in foundries, the relative supply of scale has increased at least slightly. The proportions of the charge in 1909 were 95 per cent iron ore and 5 per cent cinder, scale, scrap, etc., while in 1918 the proportions were 93.4 per cent and 6.6 per cent. The increase in the material other than ore may be attributed entirely to an increase in the scale available, which would mean that the blast-furnaces are not using larger quantities of scrap.

Seeing the uniformity of the figures, one might possibly incline to the notion that blast-furnace managers have endeavored to regulate this matter for themselves, using scrap as necessary to get out certain tonnages. It is interesting that in ten years the amount of ferrous material has deviated only slightly from a mean of about two tons per ton of pig iron.

It should be noted that in statistics like these, where simply the totals for the whole country are considered, the declining iron content of Lake Superior ores is balanced, to some extent at least, by two other influences. One is that rich ores have lately been imported to a greater extent than formerly, while another is that the proportion of Lake Superior ore to total ore has increased, and the Lake Superior ore remains of higher iron content than the Southern ores. The total production of iron ore in the United States increased from 51,155,437 tons in 1909 to 69,658,278 tons in 1918, but the production of all ore outside the Lake Superior region was practically stationary, being 9,291,802 tons in 1909 and 9,878,484 tons in 1918.

The fuel statistics are complete only for 1912 and subsequent years. They show, as to the coke furnaces, 2436.5 pounds per ton of iron for 1912 and 2375.2 pounds for 1918. Very small quantities of bituminous coal were used, and weighed in with the coke, the quantities being so small as not to affect sensibly the showing of fuel consumption. Comparing 1912 and 1918, there was a slight decrease in the quantity of ferrous material used, and these two changes are almost precisely in proportion. There is a larger decrease in the consumption of limestone than in the consumption of coke, but very precise comparisons cannot be made because the limestone statistics are not separately given for coke furnaces, the anthracite totals being included.

The general conclusion one may draw from the statistics is that no great change has been occurring in these matters, taking the industry as a whole. At individual plants furnace managers may effect important changes, but the industry as a whole is operating much the same now as ten years ago.

Actual production in 1919, which was distinctly an "off" year, was approximately 30,500,000 tons in pig iron, 33,000,000 tons in steel ingots and 25,000,000 in finished rolled steel, or in the neighborhood of two-thirds of capacity.

Manufacture of Pure Tungsten Metal—Operations at the Fansteel Products Company

Smelting and Leaching the Ore—Production of Ammonium Paratungstate, Tungstic Acid, and Oxides—Reduction Operations and Design of Furnaces Used to Secure Pure Metal—Working Qualities of Product—Future Markets

BY CHESTER H. JONES

FROM comparative obscurity and classification with the rare elements twenty years ago, tungsten has come to take a place among everyday substances in the metallurgical world. It has largely received prominence through use in the steel industry and later in the incandescent electric lamp manufacture. Automobile ignition equipments have also consumed large quantities of tungsten metal for contact points.

We have been accustomed until recent months to think of these substances in the metallic state as powders of varying impurity. The steel industry has called for only a crude refining of the ore; the lamp manufacturers have kept the processes secret and made little attempt to market the fine wire they produce; and makers of tungsten contact points have made no effort to market the pure metals for general application.

It is hoped that by a description of the process of producing pure metal from the crude ore and an outline of the properties of the final and intermediate products the chemical industries may find particular application to supply needs hitherto unfilled.

TREATING THE REFINED ORE

The wolframite ore is received in 100-lb. bags at the plant of the Fansteel Products Co., North Chicago, the present supply coming from Korea. It is a hand-picked product about pea size (Fe,Mn) WO_4, heavy dark gray to black, sub-metallic crystals, orthorhombic in appearance, but actually monoclinic. The material has a hardness of 5 to 5.5; specific gravity 7.1 to 7.55; streak, dark brown to black; opaque, brittle and slightly magnetic. The chemical analysis is about as follows: WO_3, 73 per cent; tin, 1 per cent; copper, 0.05 per cent; manganese oxides, silicon oxides and iron oxides, 25.95 per cent.

This ore is first crushed in a small jaw crusher and subsequently ground to a coarse brown powder in a Braun planetary disk crusher. It is then mixed with commercial soda ash in a ratio of one part of WO_3 content to one part of Na_2CO_3, plus a 15 per cent excess of soda ash. This mixture is placed in a belt-driven Abbé pebble mill, about 1-in. diameter pebbles, and reduced to pass 100-mesh screen.

FIG. 1. REVERBERATORY FURNACE—OUTLET SIDE

ROASTING

The fine mixture is shoveled by hand into a small reverberatory furnace in charges consisting of about 200 lb. of ore to 100 lb. of soda ash. It is hand-rabbled

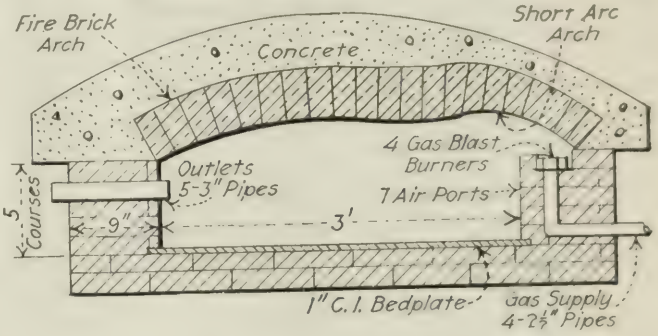


FIG. 2. TRANSVERSE SECTION OF REVERBERATORY FURNACE

at a temperature of about 800 deg. C., just sufficient to convert all the manganese oxide to dioxide during the following main reaction:

$$2FeWO_4 + O + 2Na_2CO_3 = 2Na_2WO_4 + Fe_2O_3 + 2CO_2$$

The operation requires about 2 hr. per charge. Care must be taken that the temperature does not mount high enough to fuse the mass, which must be kept in a pasty condition. When the reaction is complete the hot material is raked out in cast iron pans to cool.

DESIGN OF THE FURNACE

The furnace is located out of doors and its general appearance may be noted in Fig. 1. This view shows the five fume outlet holes and the single door, used for charging, discharging and as a rabbling port; with flat pan before the opening ready to receive the finished roast.

The structure is erected on concrete base with concrete roof to protect the brick work from the weather. Length of inside is 5 ft., with 3 ft. width of hearth and five brick courses from floor to point where arch intersects. Fig. 2 shows sectional sketch of furnace. Ordinary fire brick is employed as a refractory, but is unsatisfactory because of rapid deterioration, especially on the floor and side walls where the charge comes in contact with the brick. For this reason a 1-in. cast iron bed plate is inserted over the floor. This resists

FIG. 3. REVERBERATORY FURNACE. GAS FEED SIDE ON RIGHT

the chemical action of the charge, but is not suitable, as its continual warping and crawling under the temperature changes break up the walls, as can be seen in Fig. 3. In the construction of a new furnace magnesite or dolomite brick should be used.

The gas supply system appears on the right in Fig. 3. Gas is furnished at about 3-lb. pressure and the air blast is maintained by a small positive-pressure blower. The Zander blast burners furnished by the Chicago Pulley & Shafting Co. are imbedded in the brickwork to protect from heat in the main chamber, and the flame near this point is directed downward by the small arch constructed in the main roof.

Leaching the Roasted Ore

The cooled matter from the furnace is crushed to pea size in a jaw crusher and taken to the leaching room. Here it is shoveled into wooden tanks 4 ft. in diameter and 4 ft. high, where solution with process water is agitated by wooden mechanical stirrer. The sodium tungstate goes into solution quite rapidly, but the liquor is usually agitated over night to assure complete dissolving. A 2-in. pipe line near the bottom of the tank connects up with a small centrifugal pump, which forces the slurry into a 36-in. Sweetland filter press made by the United Filter Corporation.

The clear filtrate, Na_2WO_4, is discharged through a 2-in. hose to the precipitating tanks. The sludge, consisting of MnO_2, Fe_2O_3 and other oxides, is washed in the press and washings returned to mixing tank. When thoroughly cleansed of all tungstate the residue is thrown away. In testing the first solution in the mixing tanks a hydrometer is employed. If a 50 deg. Baumé reading is secured the solution is saturated. It is not allowed to go below 30 deg. Baumé.

Commercial Tungstic Acid

The precipitating tanks are wooden or stoneware tubs about 3 ft. in diameter by 3 ft. high. The clear liquor is heated by live steam jet from hose bubbled directly into the solution. When brought to a boiling temperature the hose is removed and a 20 deg. Baumé solution of $CaCl_2$ is added in excess. A white flour-like precipitate of $CaWO_4$ is thrown down. This is washed with process water, by decantation, until all the excess chlorides are removed.

$$Na_2WO_4 + CaCl_2 = CaWO_4 + 2NaCl.$$

The calcium tungstate is baled over to glazed-ware bowls about 3 ft. in diameter and 2.5 ft. deep and a 20-gal. carboy (120 lb.) of commercial hydrochloric acid is added to excess. A stoneware pipe is inserted in the solution to supply the live steam for boiling. The reaction

$$CaWO_4 + 2HCl = CaCl_2 + H_2WO_4$$

is continued over a period of about 1 hr. The yellow precipitate of tungstic acid is allowed to settle and the excess $CaCl_2$ and HCl are siphoned off. This acid and chloride solution is treated with lime to obtain $CaCl_2$ for the preceding operation.

The yellow precipitate is shoveled to a General Ceramic Co. suction filter, operating under about a 20-in. vacuum, and is repeatedly washed with process water. The resulting product has the following average analysis:

H_2WO_4	99.53 per cent
FeO	.02 per cent
Al_2O_3	.05 per cent
CaO	.20 per cent
SiO_2	.20 per cent

This is the ordinary commercial tungstic acid known on the market as Grade A. It is seen to be impure as compared with the required acid.

Purification of Tungstic Acid

The washed precipitate is removed from the suction filters to the ammonium paratungstate room by hand and dumped into a high enamel-lined steel tank 3 ft. in diameter by 5 ft. This tank is painted on the outside with aluminum paint to resist ammonia fumes. Sufficient distilled water, together with about 5 gal. of concentrated ammonium hydroxide, is added to nearly fill the tank and obtain a 7 per cent solution of ammonium paratungstate.

A 1-in. jet of live steam is added through the hose to bring the solution to boiling. Fig. 4 shows this tank with the steam hose hanging down between the windows.

The hose on the right-hand edge of the tank is connected to a centrifugal pump which decants the liquor to a 12-in. wood-leaf Sperry filter press shown in the foreground. This press is equipped with filter paper between the leaves and the spigots are replaced by glass tubes inserted in rubber corks, as shown emptying into the wooden trough in Fig. 5. The clear filtrate of paratungstate is carried by 2-in. hose shown at the lower right hand of Fig. 4 to 150-gal. enameled, steam-jacketed Elyria kettles. The second ammonia room mentioned later is equipped with Pfaudler kettles.

Reference to the kettle in Fig. 5 will show the steam piping, the liquor hose across the floor from tank to pump and the wooden hood over the evaporating kettles,

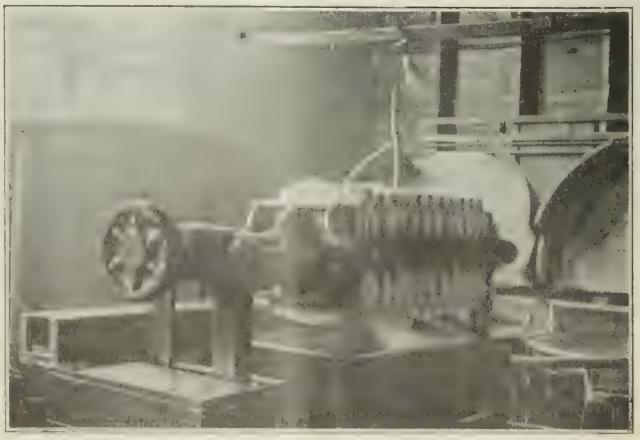


FIG. 4. AMMONIA ROOM, WHERE AMMONIUM PARATUNGSTATE IS MADE

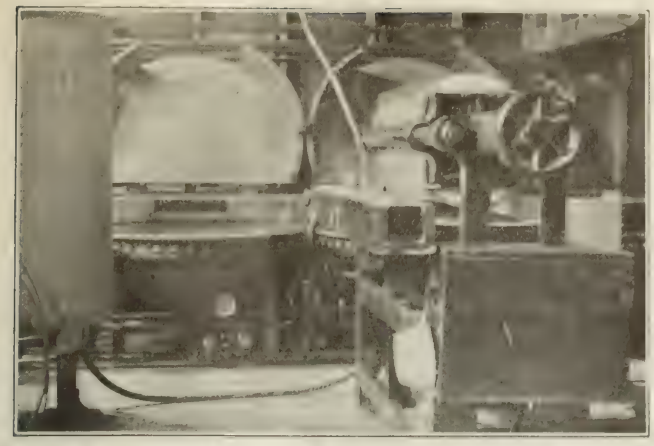


FIG. 5. AMMONIA ROOM SHOWING TANK, KETTLES AND FILTER PRESS

lifted out of place. This hood collects the ammonia fumes during evaporation, which are carried off by an exhaust fan. The rectangular exhaust opening is shown in the wood housing directly back of kettle.

The filtrate is evaporated to a small volume in the pans and dried to a mud in stoneware suction filters and is washed with distilled water. The sludge from the filter press consists of impurities and some quantity of blue mud, ammonium metatungstate. This, together with the filter paper, is saved for the scrap salvage mentioned further in this article.

The white mud, ammonium paratungstate, is removed to the nitric acid room, where 40-lb. batches are placed in the 7-gal. steam-jacketed enamel-lined bowls shown in Fig. 6.

C.P. nitric acid, about 40 per cent solution, is added. The white precipitate is slowly changed to the yellow tungstic acid H_2WO_4 as the liquor is heated. The color of this product is a much brighter yellow than the original commercial tungstic acid noted at the beginning of the purification process.

The nitric acid fumes collected in the hood shown over the kettles in Fig. 6 are exhausted from the room by a 6-in. General Ceramic Co. stoneware fan direct-connected to a 2-hp. General Electric motor running at 1800 r.p.m. Considerable trouble with the handling of these fumes was experienced until the installation of this apparatus, which has been giving perfect 24-hr. service for a year.

The contents of the kettles are removed on completion of the reaction to two 10-gal. stoneware suction filters, where they are washed repeatedly with distilled water. In spite of the processes through which the tungsten compound has passed it is not yet of sufficient purity for production of the metal, and is therefore taken from these filters and returned to the ammonia room, redissolved as paratungstate, filtered in a Sperry press, evaporated, filtered and washed with distilled water in suction filters and returned to the nitric acid room.

It is again treated with C.P. nitric acid solution, filtered and washed repeatedly in suction filters and dried to give the pure tungstic acid needed for metal production.

Pure Tungstic Oxide

The next operation consists in placing the yellow tungstic acid in No. 6 fused silica crucibles, 44 crucibles per heat, and placing in a gas-fired oven. The temperature is raised to about 1000 deg. C. and the following reaction occurs:

$$H_2WO_4 + \text{heat} = WO_3 + H_2O$$

The resulting tungstic oxide is a light green color due to mixture of WO_3, yellow, and lower oxides of tungsten, which are blue. The following analyses give some idea of the purity of this product:

SAMPLE NO. 1

WO_3	99.94 per cent
Fe_2O_3	.024 per cent
Al_2O_3	.018 per cent
CaO	.009 per cent
P	Trace
SiO_2	.010 per cent
S	none

SAMPLE NO. 2

WO_3	99.96 per cent
Fe_2O_3	.0075 per cent
Al_2O_3	.016 per cent
CaO	.028 per cent
P	none
SiO_2	none
S	none

A very pure tungstic oxide has been produced in small quantities for special purposes with the following analysis:

WO_3	99.995 per cent
CaO	.005 per cent

The metal tungsten is of higher purity than the foregoing analyses because of volatilization of the impurities. All oxides produced are analyzed and if a content above 0.02 per cent Fe_2O_3 is present they are returned to the process for further purification.

Raw Materials Used

The process water enters two Hygeia Filter Co.'s Steward non-agitator filters connected in parallel and is distilled in a 55-gal. Barstead automatic still. A 750-gal. storage tank supplies the requirements for the pure water.

About 40 per cent of the output at the present time consumes scrap tungsten for the raw material. All scrap metal, filter paper, sludge from ammonia rooms, sweepings, etc., is reconverted by ignition in a small gas-fired brass-melting furnace with sodium nitrate to get the soluble sodium tungstate. Thirty lb. of sodium nitrate and 25 lb. of scrap constitute the usual charge. The powdered metal and sludge may be thrown in with a reverberatory charge. The process on scrap then continues as described for the ore.

Difficulties in Chemical Process

The over-all efficiency of the chemical process is 90 per cent, that is, 90 per cent of the tungsten in the ore

FIG. 6. NITRIC ACID ROOM—STEAM-JACKETED EVAPORATING BOWLS

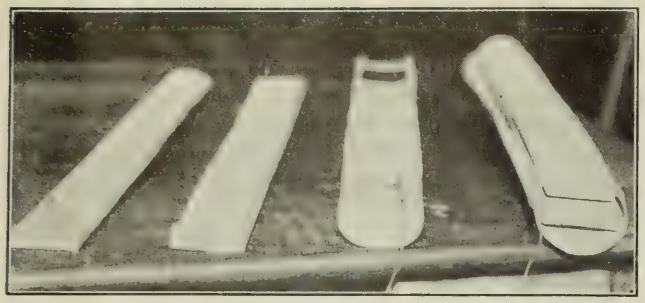


FIG. 7. NICKEL BOATS AND TRAYS FOR FURNACE

is recovered. The greatest difficulty in the work is to maintain absolute cleanliness in each step of the operations. The item that has given the most trouble in this connection is the refractory containers, especially the enamel linings in tanks and evaporating kettles. No enamel lining has been found that will remain perfectly intact under the action of hot acids and alkalis. Alkaline conditions cause chipping of linings, resulting in the presence of iron, silica and silicates in the process. The linings become de-vitrified. These impurities occur in actual combination with the product and not as mechanical inclusions.

When the impurity is carried through to the metal product the physical structure of the sintered bar is weakened to a marked extent. Continual supervision is necessary to prevent this condition.

Reduction of WO_3 to Tungsten Powder

Until recent years the only commercial methods of reduction were (1) by hydrogen and (2) by use of carbon. The latter was generally employed because of difficulty in control and of completion of reaction with hydrogen. As a result it was impossible to secure pure tungsten. The hydrogen method has been improved upon so that it is now entirely used in the Fansteel Products Co. plant to secure the purest metal obtainable. Ten thousand cu.ft. of hydrogen are consumed daily in the process.

The WO_3 powder is placed in small nickel trays about 18 in. long, which are stacked in pairs in nickel boats as shown in Fig. 7. The two trays appear on the left; the third object is the nickel boat empty, showing cross-wire supports and wire for pulling out of furnace, and on the extreme right is the boat containing two loaded trays. This charge is placed in a closed-tube type electric furnace, heated to about 1200 deg. at completion of exothermic reaction, through which passes a stream of pure hydrogen. The reaction is as follows:

$$WO_3 + 3H_2 = W + 3H_2O$$

The tungsten is withdrawn as a gray powder. The excess hydrogen passing out is dried from water content and re-enters the system.

Design of Reduction Furnace (Old Type)

The older type of furnace, still in continuous operation at this plant, is well illustrated in Fig. 8. Each set consists of four tubes with three in operation, the fourth one a spare. Each tube is composed of a quartz member about 5 ft. long, around which is formed the heating element, a coil of nichrome or molybdenum wire. About this element a heat insulating jacket of Sil-o-cel is held in place by a galvanized iron jacket. The quartz tube is attached to water-cooled, cast fittings at each end which are provided with connections to the hydrogen supply and exhaust system.

Single phase current is supplied to each tube at 220 volts, a set of three consuming about 50 amp. on tungsten reduction and 30 amp. on molybdenum reduction. This difference is due to necessity of getting 1200 deg. C. on tungsten and 900 deg. C. on molybdenum. Two sets of the old type furnace consume about 3000 cu.ft. of hydrogen per 24 hours.

When starting up with a new charge the heat must be applied very slowly to prevent fusion of the WO_3 powder before the exothermic reaction starts. Should this fusion occur, the reduction would be accomplished only on the surface of the mass.

New Type Reduction Furnace

The Fansteel Products Co. has just completed and placed in operation a four-tube tungsten reduction furnace set of entirely new design and larger than those previously operated. The complete outfit consists of the furnace proper, assembly drawing of which is shown in Fig. 9, the water chest beneath the tubes; three calcium chloride towers about 1 ft. in diameter and 8 ft. high for drying the hydrogen from the furnace; complete pyrometer equipment for noting temperature of hydrogen in the jacket of each tube; three glass tubes packed with absorbent cotton to purify hydrogen; one hydrogen pump oil type, manufactured by C. Crowell, and hydrogen pressure tank; together with complete switchboard and control equipment for the heating coils.

The hydrogen supply enters the annular space between the 3-in. and 1½-in. pipe and is preheated prior to entering the furnace by the exhaust in the 1½-in. pipe as seen in Fig. 9. Passing into the space between the quartz tube and the jacket, it is further heated, and finally enters the main tube, passing out near the point of entrance.

The tube is equipped with an additional preheater coil at the right of the drawing with connection terminals as shown on extreme right. Fig. 10 shows the feed end of the furnace with the hydrogen apparatus in the rear. The picture was taken before all the lower piping connections had been made. Peepholes are evident in the doors. Glass-absorbing tube appears in the background beyond door of rear tube. The whole equipment is excellent in design and shows careful workmanship. The operating record should prove a distinct advance in reduction furnace efficiency.

The gray tungsten powder is removed from the furnace after a period of about 7 hr., when it has been reduced to a high state of purity. Analyses are given under tungstic oxide. This powder is then placed under a hydraulic pressure of 300 tons and formed into a bar

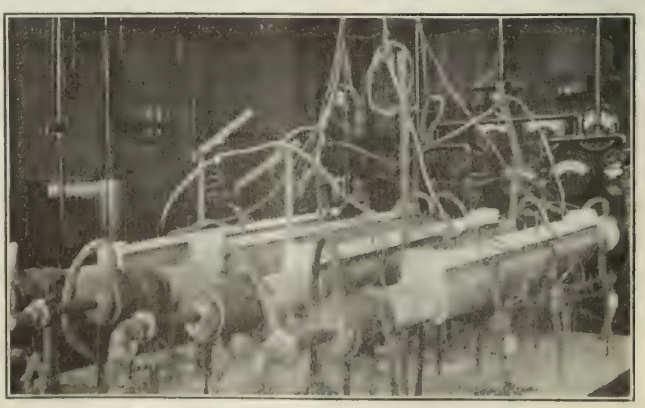


FIG. 8. OLD TYPE REDUCTION FURNACE

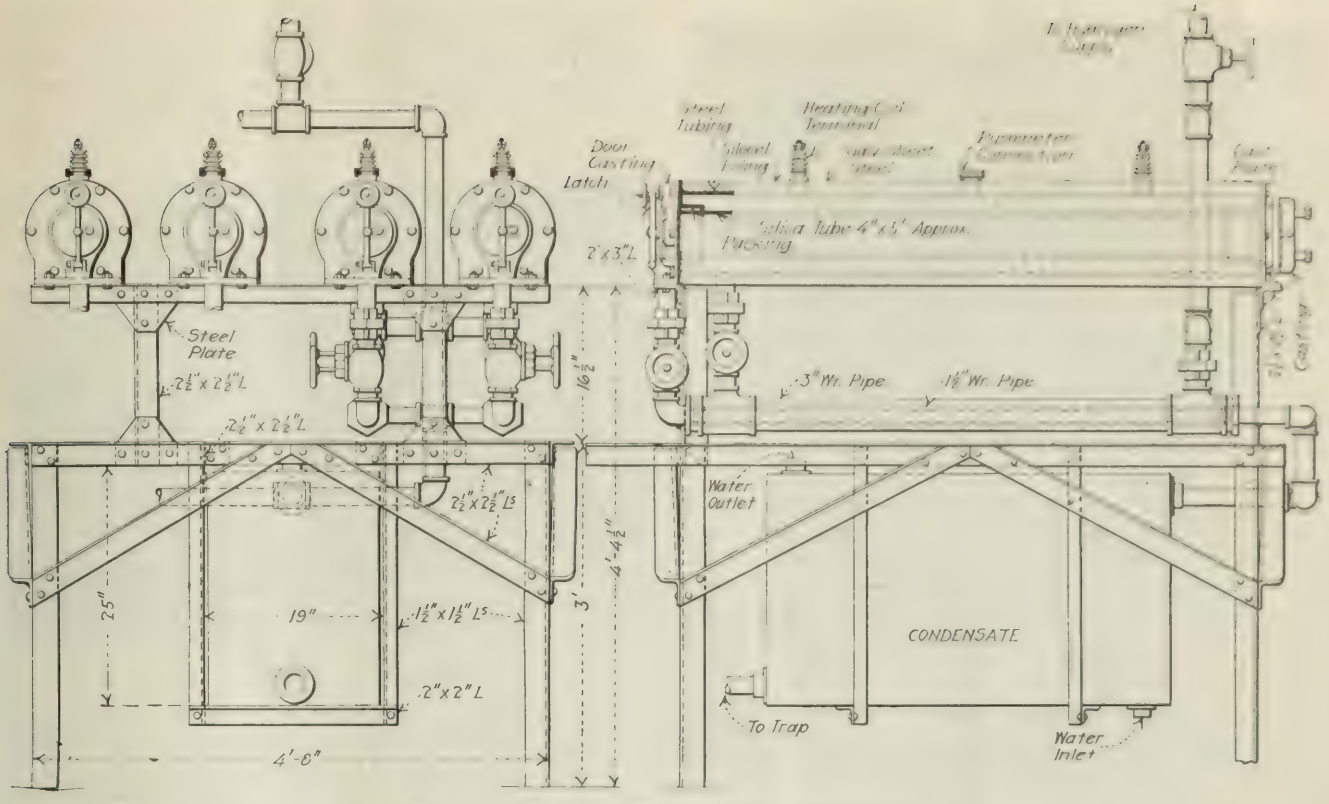


FIG. 9. NEW TYPE OF REDUCTION FURNACE

which might properly be termed cast tungsten. The bars vary in size as desired according to die used. The average bar is 1 in. square and 8 in. long.

Sintering Furnaces

These bars are placed between contacts as shown in the sintering furnace, Fig. 12, where they are subjected to a current of 2750 amp. at 220 volts single phase. The temperature is maintained in an atmosphere of dry hydrogen and the body of the furnace is water cooled. The large bottle on the right contains calcium chloride for drying the hydrogen.

Fig. 11 shows the furnace closed and in operation, while Fig. 12 illustrates a bar just finished and in place in the furnace. This process causes considerable shrinkage in size, as may be noted by comparing with the unsintered bar on the table directly below the one between the contacts.

Swaging and Drawing

The sintered bars are taken to the swaging room, where 14 specially designed furnaces are in operation. Each furnace consists essentially of a refractory tube surrounded by a jacket at a distance from the tube to form an annular space. The hydrogen is introduced into this space, permeates the walls of the refractory alundum and enters the center of the tube where the metal bar is placed. The hydrogen then passes out the opening through which the bar has been placed and burns in contact with the air.

Each furnace is heated, by a coil wrapped around the refractory tube, to a temperature of from 1100 deg. to 1500 deg. C. The fourteen furnaces consume 185 amp. at 220 volts single phase. The alundum tubes burn out in from 3 to 6 weeks, operating at 14 hr. per day.

The bars are heated and one end is drawn in an Excelsior Needle Co. machine appearing on right of furnace (Fig. 13). The opposite end is then placed in the furnace first, heated, and the drawing operation repeated. This continues until the bar is brought down to the required size, either as bar or heavy wire. It is then ready for the market or for cutting into fine contact buttons.

Contact Manufacture

The wheels for cutting tungsten are about 0.016 in. thick, 3 in. in diameter and made of an abrasive material with rubber as a binder. A cooling mixture is continually sprayed over the point of contact during the cutting operation. The small tungsten contact button is attached to the steel screw stud in an interesting manner. Buttons are placed in a jig with a thin sheet of copper on top of each button. Over this the screw studs are inverted so that the copper sheets lie at the surface of contact between tungsten and steel. The

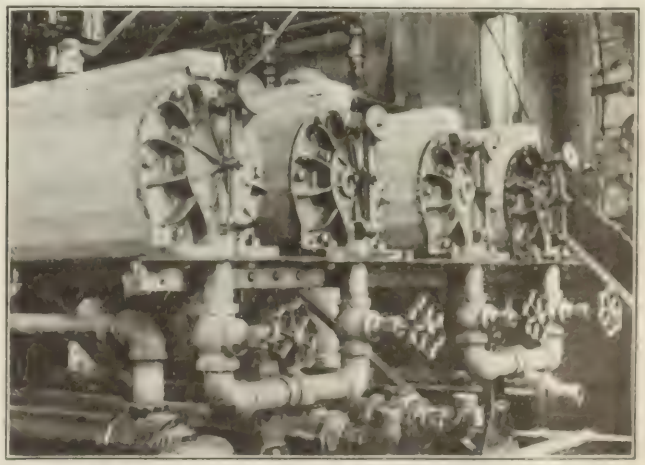


FIG. 10. FEED END OF FURNACE, WITH HYDROGEN APPARATUS IN REAR

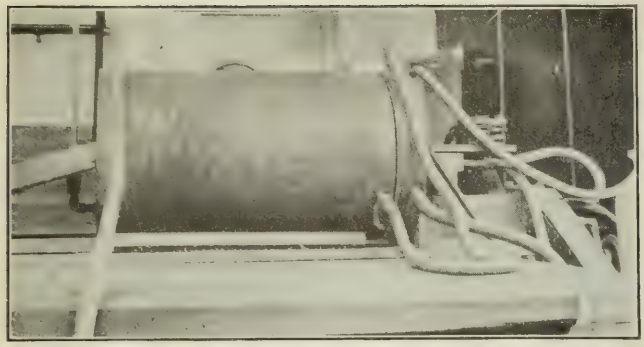


FIG. 11. SINTERING FURNACE CLOSED

whole is then placed in a hydrogen atmosphere furnace battery illustrated in Fig. 14 and of design similar to swaging furnaces.

The temperature is brought up to a point where the copper volatilizes, permeating both the steel and tungsten to a sufficient extent to braze the two firmly. This covers the entire contact with a copper plating, which is removed in a Hanson-Van Winkle deplating bath. The point is then polished on an oiled abrasive wheel and is ready for the market.

Rolling Sheets

The rolling operation is somewhat more difficult and requires expert attention. The swaged bar about $\frac{3}{8}$ in. by $\frac{3}{4}$ in. in section is heated in a small furnace shown in

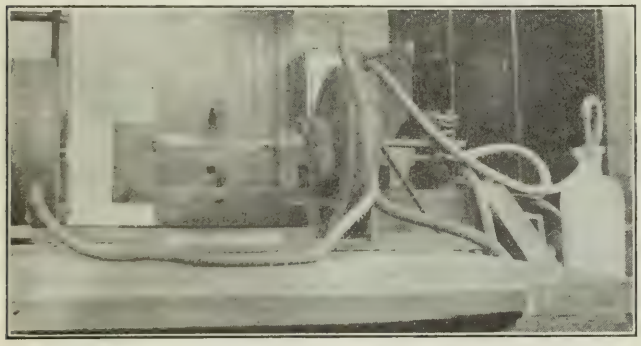


FIG. 12. SINTERING FURNACE OPEN

Fig. 14 to about 1200 deg. to 1400 deg. C. The furnace consumes 45 amp. at 220 volts single phase.

With continued heating and rolling in the preliminary rolls shown in Fig. 15 the bar is brought to a thick strip. As the strip grows thinner care must be exercised during the heat to prevent excess heat resintering the metal. The strip is then removed to finishing rolls and furnace (Fig. 16), where it is brought down to required thickness by continued heating and rolling.

It will be noted in the background of several of these illustrations that a quantity of electrical apparatus is in evidence. All the transformers, furnaces and regulators were designed and made by the Fansteel Products Co. This was necessary owing to the special nature of the work involved.

Properties of Pure Metallic Tungsten

The company produces tungsten wire in round shapes from 0.080 wire up to $\frac{1}{2}$-in. rods and sheets for special purposes as desired. The metal is a pure wrought, ductile, fibrous substance as shown in the foregoing processes. It is rolled into thin sheets and it may be welded at yellow heat. The melting point is about 3080 deg. C. and the specific gravity 18.8.

The tensile strength in a 5-mm. diameter wire is 460,000 lb. per sq.in. and in a 1.2-mm. diameter is 580,000 lb. per sq.in. Rolled sheets have a tensile strength of 500,000 lb. per sq.in. It is not affected by air or water at temperatures below red heat.

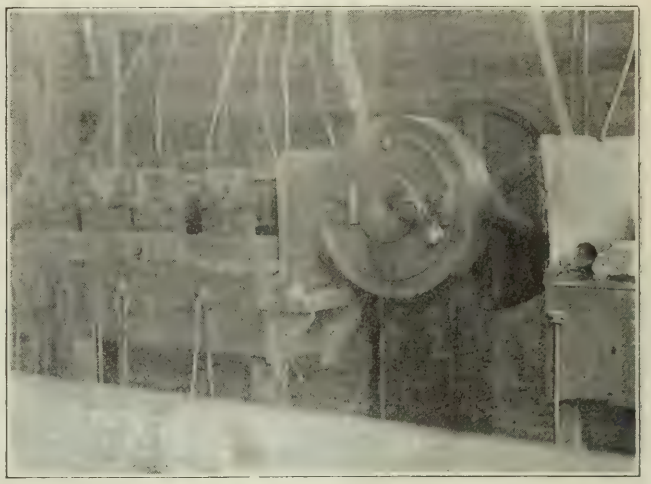


FIG. 13. SWAGING ROOM

While fused nitrates, peroxides, potassium bisulphate, alkali carbonates and caustic alkalis attack the metal, it remains unaffected by solutions of these chemicals.

Reactions With Acids

Sulphuric acid, boiling, dilute, has no effect.

Sulphuric acid, boiling, concentrated, attacks very slowly.

Hydrochloric acid, boiling, concentrated, attacks slowly, but neither strong nor dilute affect at ordinary temperatures.

Nitric acid, concentrated or dilute, has no effect.

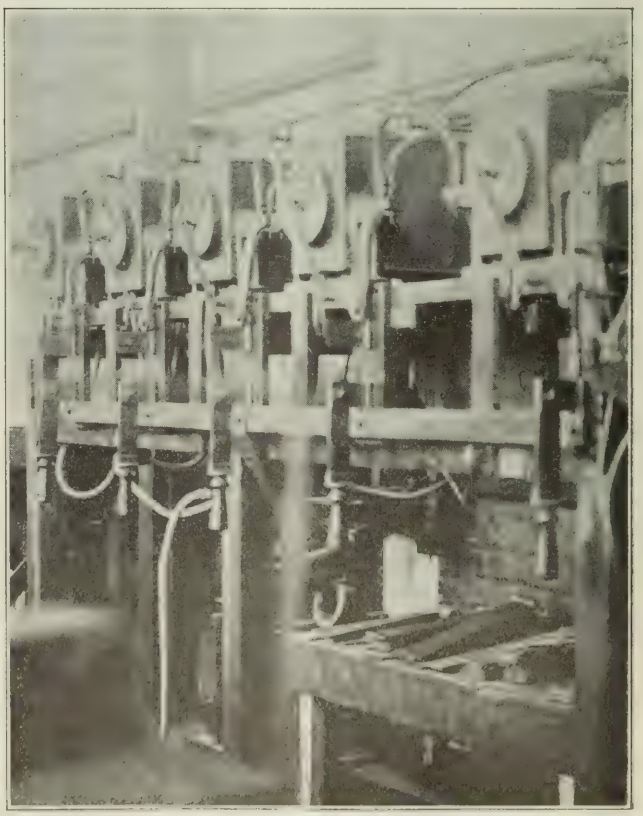


FIG. 14. BRAZING FURNACES

Hydrofluoric, concentrated or dilute, has no effect. Mixture of concentrated HCl and HF attack rapidly.

Uses of Tungsten Aside From Steel Industry

In the electrical industry the use of tungsten is well known, being superior to platinum for contact points on account of its hardness and having a heat conductivity equal to twice that of platinum. It is employed as a target for Röntgen Rays in electrophysical work.

Tungsten bronzes are produced by fusing with pure tin. These are resistant to ordinary acid action.

The dye industry employs tungsten for fireproofing cloth, and as a mordant for silks the salt has the added feature of serving as a weighting material.

In the ceramic industry the tungstic oxide is used for producing yellows in glass and porcelain. (A. Granger, *Compt. rend.*, 1905, pp. 140–935.)

Sodium tungstate decolorizes acetic acid.

In the chemical industry the wire and sheet, being impervious to alkali solutions and to cold and hot acids to the extent described above, should find many practical applications, such as binding cloth on filter wheels, wire gauze for filtering acids; wire mesh for supporting filter cloths; as a support for asbestos packing at Duriron connections; in utensils for nitric and hydrofluoric acids in the laboratory; heating elements in laboratory ovens; as electrodes in certain electrochemical processes; in instrument parts where subjected to fumes from the processes; and as supports for incandescent gas mantles. A thermocouple of tungsten-molybdenum gives an increase in electromotive force with the increase in temperature up to 540 deg. C. and passes through zero millivolts at 1300 deg. C.

Non-Ferrous Alloys

Many alloys useful to the chemical industry have been made, and research will prove that the field in this regard is far from exhausted. Following are some of the better known metal compounds.

Aluminum (metallic) can be hardened with tungsten. Its resistance to oxidization makes it much superior to copper. See "Tungsten, Its Uses and Value," *Mining and Sci. Press*, Dec. 17, 1904.

Partinium ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec. 3, 1904) is an alloy of aluminum and tungsten. It is used by the French in automobile construction because of its lightness and strength.

Sideraphite ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec. 3, 1904) is an alloy containing a large proportion of iron, some nickel, aluminum and copper, and 4 per cent of tungsten. It resembles silver in appearance, is very ductile, malleable and not easily attacked by acids.

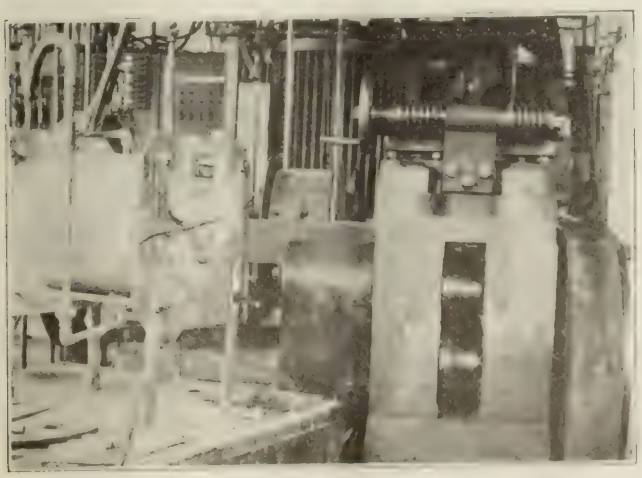


FIG. 15. ROLLING EQUIPMENT. PRELIMINARY ROLLS

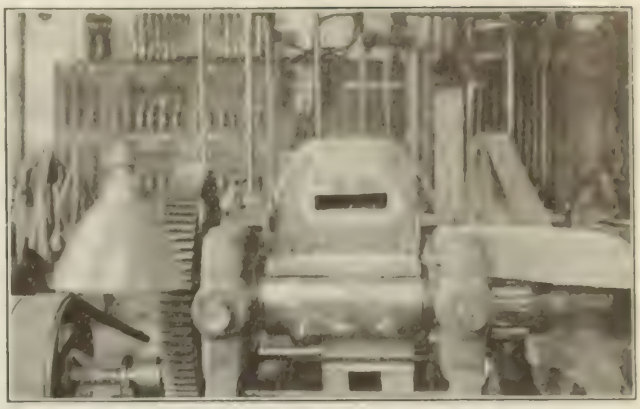


FIG. 16. ROLLING EQUIPMENT. FINISHING ROLLS

Minargent ("Tungsten," J. H. Pratt, *Min. Wld.*, Dec 3, 1904) is an alloy of copper, nickel and tungsten.

Backford, or Britannia metal, is an alloy of copper, tin and tungsten (Hadfield).

The Blackwell Company manufactures a tungsten-nickel alloy which consists of 73 to 75 per cent tungsten, 23 to 25 per cent nickel, and 2 to 2½ per cent iron, 0.75 to 1 per cent carbon, and 0.25 to 0.50 per cent silicon (Pratt).

Platinoid consists of 60 per cent copper, 25 per cent zinc, 14 per cent nickel and 1 to 2 per cent tungsten. It has a high electrical resistance, which does not decrease with heat (Hadfield).

An alloy of tungsten, aluminum and copper is used in the manufacture of propeller blades. (See "Tungsten," Min. Res. U. S. G. S., 1901.)

A series of unnamed alloys has been made by L. P. Hamilton and Edgar F. Smith, *J. Am. Chem. Soc.*, March, 1901, p. 151, which consists of tungsten and copper and aluminum, tungsten-iron-titanium-carbon, and tungsten-iron-columbium-tantalum.

Technical Characteristics

A table of physical and chemical constants for ductile tungsten has been prepared by C. G. Fink of the General Electric Co. as follows:

Density 19.3 to 21.4.
Tensile strength 322 to 427 kg. per sq.mm.
Young's modulus of elasticity is 42,200 kg. per sq.mm. (steel 20,000), i.e., twice that of steel.
Melting point, 3177 deg. C.
Boiling point, 3700 deg. C. (?)
Thermal conductivity 0.35 g. cal. per sq.cm. per sec. per 1 deg. C. (Pt is 0.166). Calculated.
Expansion coefficient 4.3×10^{-6}.
Specific heat 0.0358 (Weiss).
Resistivity (25 deg.) hard, 6.2 microhms per cu.cm.; annealed, 5.0 microhms per cu.cm.
Temperature coefficient of resistance 0.0051 (0-170 deg. C.).
Hardness 4.5 to 8.0 (Mohs scale).
Insoluble in HCl, H_2SO_4, HNO_3, NaOH, KOH (aqueous), $K_2Cr_2O_7 + H_2SO_4$.
Soluble in mixtures of HF and HNO_3 and in fused nitrates, nitrites and peroxides.

Ductile tungsten and molybdenum are available in quantities for commercial consumption; the purity is such as to give metals with properties greatly needed by the chemical and electrochemical markets; new uses are being developed by research; and it would therefore appear that the increase in consumption must of necessity continue.

We wish to acknowledge the courtesy of the Fansteel Products Co. in furnishing facilities and information for the preparation of this article.

BIBLIOGRAPHY

The Rare Earth Industry, Johnstone.
Treatise on Rare Metals, Herman Fleck.
Tungsten in Colorado, H. R. Van Wagenen.
Ductile Tungsten, C. G. Fink.
Atomic Weight of Tungsten, T. M. Taylor.
Other references as given in the text.

Care of the Lumber Pile in Chemical Plants*

THE chemical plants in this country are in a continual state of development, which means that there is always a supply of lumber on hand for repairs and expansion of various projects. As in other lines of industry, this material is usually handled carelessly, where by the expenditure of a small amount of time and money the companies might save considerable sums each year.

One of the simple methods which may be used is the coating of the ends of timber, logs, etc., to prevent splitting and checking, which occurs especially in dry climates, due to the fact that timber dries much more rapidly from the ends than from exposure to the atmosphere on the sides. The rule for end coating in simple terms is that the harder and greener the wood, the more effective must be the coating. Paint is convenient to handle, but is of low effectiveness. White lead is convenient to handle, and is of medium effectiveness. Lorac, a commercial compound, is convenient to handle and also of considerable effectiveness, but the best application is rosin-lampblack, which is inconvenient to handle, but is of high effectiveness.

Rosin-lampblack is made according to the following formula:

Clear grade rosin	60 parts by weight
Lampblack	1 part by weight

The mixture is prepared by melting the rosin but not allowing it to boil or froth, and when in a thoroughly molten condition the lampblack is thoroughly stirred in.

This coating is applied where feasible by dipping the ends of the sticks in the molten mixture to a distance of about one-half inch, which when hardening gives a smooth, shiny coating free from bubbles and about an eighth of an inch thick over the ends. Where large timbers are to be coated the mixture may be applied with a brush or paddle.

If the stock is to be subjected to rough handling which might cause the coating to chip when cool, linseed oil may be added in the proportion of 1 to 15 by weight. This, however, will have a tendency to make the coating excessively soft at temperatures which are higher than 130 deg. F.

STORAGE

Many serious losses from decay in wooden structures are caused by the fact that the timbers used were infected with wood-destroying fungi while in storage. These losses may be greatly reduced by keeping the storage yard in a sanitary condition.

Strong efforts should be made to store the product on well-drained ground removed from possible danger of floods, high tides and standing water. All rotting debris scattered about yards should be collected and burned, no matter whether it be decayed formations and timbers or stored lumber which has become infected. In the case of yards already filled in to considerable depths with sawdust and other woody debris the situation can be improved by heavy surfacing with soil, slag or similar material. Weeds should be cut away from the piles to allow good ventilation.

Solid foundations should never be used for supporting timbers. In damp climates the stock should not be piled less than 18 to 20 inches from the ground. Wood blocking used in direct contact with the wet ground should be protected by the application of creosote or other antiseptic oils or else replaced by concrete, brick or other durable materials. Treated skid timbers would be highly advantageous.

Foundations should be built so that the piles will slope approximately one inch to every foot of length. In most regions lumber should not be close piled in the open, but should be set with crossers at least one inch thick. Lateral spacing is also very desirable. Roofing or cover boards should be placed over the piles and extend for several inches in front and back.

Instead of throwing the crossers about on the ground to become infected with decay, they should be handled carefully, and when not in use piled on sound foundations and kept as dry as possible. If pine saturated with resin or the hard wood of such durable species as white oak or red gum be employed, the danger of possible infection will be greatly decreased.

Where lumber is stored in sheds the necessity of piling higher from the ground is very apparent in many cases. The same remedies apply here as for pile foundations in the open. The sheds should be tightly roofed and the siding should not be run down below the bottom of the foundation sill. Free air circulation is very necessary and only thoroughly dry stock should be stored in close piles under cover.

Should fungous outbreak occur in the storage sheds, the infected foundation timbers should all be torn out and be replaced with wood soaked in an antiseptic solution, or by concrete or brick. In all cases the new foundation should be so constructed as to keep the lumber well off the ground and the soil and timber immediately adjoining the infected areas should be sprayed or painted with an antiseptic solution of water, soluble salt, like sodium chloride, mercury chloride, zinc chloride, or copper sulphate.

*Abstracts from Forest Products Laboratory *Technical Notes*.

New Process for Extracting Wool Grease

A company has been formed in Melbourne for the purpose of exploiting a new process for extracting grease (adeps lanæ, the base of lanolin) from wool, and for the manufacture of special neutral wool-scouring and other soaps. The principal supply of lanolin in pre-war times, it is stated, was drawn from Belgium and Germany. The method of treatment was a trade secret, and no public description is in existence, but it is known that sulphuric acid was used in the final process of refining. In the new Australian process no sulphuric or other acid is used, and the product of the process is wholly animal and pure. A small plant has already been erected and the process tested sufficiently to prove that by it adeps lanæ can be produced in commercial quantities at a very low cost.

(Persons interested can obtain the address of the inventor of the process from the Bureau of Foreign and Domestic Commerce, or its district or co-operative offices, by referring to file No. 40859.)

Filtration and Filters*

By Henry B. Faber

THE importance of filtration in industrial work has during the past three or four years been emphasized particularly in those chemical and industrial lines dealing directly and indirectly with products necessary for war. As we are approaching an era of expansion in all industries, and particularly so in the chemical industry, research and development will call for new methods of manufacture. A note of caution may properly be sounded at this time. Too often the technical man, carried up to too great an altitude by his chemical research, flies too high and neglects to give proper emphasis to the simpler operations, such as filtration, which act as the Scylla and Charybdis to wreck the chemical mariner.

From experience in the handling of a large number and variety of filtering problems, I am inclined to classify them in two major groups.

First, those problems in which the slurries contain suspensions of a colloidal nature. These can hardly be dealt with except by highly specialized forms of apparatus and might even be regarded as a class not applicable to simple filtration. This group will, therefore, be passed over.

Second, those problems in which the solid suspensions may be separated from the liquid by the simple expedient of a filter medium. This latter group may be divided as follows:

Class A, which embraces those slurries in which the suspensions are fine, but not of a colloidal character. This group includes those slurries which contain slow filtering suspensions in large or small bulk, and those slurries which by reason of a relatively small amount of suspended matter require merely clarification.

Class B embraces those slurries containing relatively free filtering suspensions, which permit the liquid content to be separated readily from the solids, where the solid content is of considerable bulk, crystalline or definite in its form.

Class C embraces those slurries which are principally mother liquors, containing relatively large crystals, in which the liquid content can be drained readily, the crystals washed easily, the principal problem being the automatic and easy handling of the solids.

The filtration engineer has designed various types of filtering equipment to be applied to these various groups. A description of their types and their limitations as applied to the various groups will, I believe, be of interest, together with a short sketch of the development of these various types.

Filters for Class A Problems

In class A of group II, in which the suspensions are fine and the slurries slow in filtering, the engineer has two problems confronting him—the problem of large area of filter surface and that of keeping the filter surface clean.

The Filter Press

The filter press is probably the best known type of filter equipment in use. The press consists of a series of shallow frames separated one from another by plates and nested together, forming a series of shallow chambers. Against the plates, which are channeled or scored with shallow galleries, are placed filter cloths, which act as the filtering medium. The slurry to be filtered is pumped into the chambers, the liquid forcing its way through the medium and making its exit by means of the galleries or grooves, leaving the solids deposited upon the medium and gradually filling up the chambers.

Open Tank Leaf Filter

It remained to one George Moore, a metallurgist, to invent a process of filtration in the mining field which has had world-wide acceptance and renown. This process employed the use of filter leaves, operating in an open tank. These leaves were frames of pipe, usually rectangular in shape, over which was sewn filter cloth completely incasing the frames and forming a hollow shallow chamber with ribs spaced equidistant across the face of the leaf for the purpose of preventing the two faces of the cloth from touching. The pipe constituting the lower edge of the frame was perforated. When the leaf was submerged in the slurry to be filtered and suction applied, this suction was translated throughout the entire space within the leaf, causing the liquid to pass rapidly through the cloth, leaving deposited upon the outside surface the solids, in the form of an adhering cake. Many of these leaves were attached to a common header and in this form was called a "basket." The simplicity of this construction permitted the operator to throw into use very large areas of filtering surface at a relatively low cost.

Self-Dumping Filter

At the time of this invention, George Moore anticipated that many problems would be encountered where a greater force than that exerted by a vacuum pull would be necessary to make the separations of solids from liquids. His original patents also called for the incasing of these filter leaves in some simple form of container for use by either suction or pressure. The self-dumping filters, so called, in which the container may be parted from the leaves, shortly made its appearance on the field, and met with wide acceptance in both the mining and industrial world. These filters, in which the basket of filter leaves is completely incased by a container permitting either suction or pressure to be applied to force the liquid through the medium, have a wide application in the many filtering problems of to-day.

Comparison of the Various Types of Filter

To sum up the virtues of these various types, the press, by reason of the fact that the filter cloths can be replaced readily, at a relatively low cost, protects the operator from serious curtailment in his filtering operations by reason of accidental damage to the cloths.

The open tank leaf filter has the advantage of large area of filtering surface and extremely low initial cost.

The self-dumping types of filters, by reason of the fact that they can use pressure as well as suction, have a wider latitude of use, but the same argument applies to them as applies to the open tank leaf type in that time is lost in re-covering the leaves, and repair and renewal are costly.

Filters for Class B Problems

In reference to the handling of problems in class B, viz.: those slurries which are relatively free filtering and build a substantial firm filter cake quickly, the rotary filter is the most desirable type to use.

*Extract from address before the Fifth National Exposition of Chemical Industries, Chicago, Sept. 25, 1919.

The rotary filter made its first appearance in Belgium about 50 years ago or thereabouts, and consisted of a headed barrel rotating about its long axis. The face of the drum was perforated and a filtering medium was stretched around, completely encircling the drum, and held in place by winding cords. This machine was used for the filtration of salts and proved very effective. A gooseneck entered through the head of the drum, dipping down to within an inch of the bottom, and was the means through which suction was applied to the interior of the drum. The drum rotated in a shallow container, dipping into the slurry through an arc of about 40 deg. Later this type of machine was built of sturdy metal construction. The perforated surface was replaced by bars of iron, forming a grating so that the drum had the appearance of a heroic-sized squirrel cage. In all cases, a gooseneck dipping within the drum downward to within a few inches of the bottom served as an exhaust and also to carry the liquid from the inside of the drum.

When rotating, the filter cake, which adhered to the surface of the drum, passed upward and over beyond the zenith, and was removed by means of a scraper.

It remained to the same George Moore who invented the Moore process of filtration to invent a multiple compartment or revolvable filter, which is the rotary filter of today. This filter, instead of being of the squirrel-cage type with a gooseneck outlet, has the peripheral surface of the drum composed of a number of shallow hollow compartments, over which is stretched the filtering medium. Each of these hollow compartments has its own separate pipe line connected to a valve hub by means of which suction or pressure may be applied at will, through any desired arc.

These machines have had wide usage in the mining field for the handling of concentrates and are extensively used in the industrial chemical field, where automatic and continuous filtration is rapidly replacing the batch or intermittent method.

Filters for Class C Problems

In handling slurries of the character mentioned as class C, viz.: crystals from mother liquid or coarse granular suspensions, the centrifugal or draining boards have been widely used.

Rotary Hopper Dewaterer

The rotary filter has failed in many cases by reason of the fact that the solids will form too heavy a cake and will not adhere firmly enough to prevent the cake breaking away from the drum and thickening in the container. The rotary hopper dewaterer is a type of filter machine built especially for this class of work, and consists of a series of elongated hoppers arranged radially about a central axis, each hopper having a filter bed, below which a pipe line connects with the central valve hub, similar in design to that used in the construction of the rotary filter. As the filter beds are set quite a distance below the rim of the hoppers, they form in reality a series of filter trays, revolving slowly about a central axis. The slurry is fed into these trays at a point about 30 deg. from the zenith and dewatered by means of suction as they rotate through an arc of about 40 deg. Suction is then automatically cut off and the product discharged either by gravity or by a puff of air, making the operation continuous and automatic.

Practical Suggestions for the Engineer

Settling Should Precede Filtering

In a great number of the ordinary filtering problems, settling should precede the operation of filtering, or the slurries should be thickened by some means until the amount of suspension has reached the maximum permissible for easy handling. Suspensions will settle at a relatively uniform rate of fall until they thicken to such an extent that they begin to clump. It is usual to consider the rate of settling as uniform until the particles approach one another by a distance less than five times their diameter, at which point the settling rate begins to slow down very rapidly. A simple test that is often made in the laboratory is to permit the slurry to settle freely and plot a curve, showing the widening of the clear supernatant liquor. A point will be noticed in the large majority of problems where the curve shows a marked slowing down of the rate. It is at this point that we find it desirable to complete the separation by filtration. Too often the engineer attempts either to settle completely his slurries or to filter completely his slurries, where a combination of settling and filtering will give a much more efficient operation. This is a general statement, but one which will bear emphasis.

Experimental Filter for Classifying Filtration Problems

The class in which a particular filtration problem belongs may be determined easily by using a small experimental filter leaf constructed as follows:

Bend a small piece of $\frac{1}{8}$-in. brass pipe in the form of a square paddle with sides approximately $3\frac{1}{4}$-in., perforate the lower side and stitch over the frame either unbleached muslin, No. 10 duck or other suitable filtering medium. Strips of wood about the thickness of a lead pencil are inserted between the faces of the cloth in order to prevent collapsing. The filter leaf is now complete. By vacuum rubber pipe 2 or 3 ft. in length, the leaf may be attached to a graduated Woulff bottle, which in turn should be connected up to the suction line. Introduce into a battery jar or large beaker the slurry and submerge the filter leaf. When the suction is turned on, the liquid will pass through the leaf into the Woulff bottle, leaving deposited upon the face of the leaf the solids. Note the time, quantity and character of the liquid constituting the filtrate and the thickness and character of the filter cake produced for the given period of time. The filter leaf with the adhering cake when withdrawn from the slurry may be introduced into a receiver containing wash water, and the wash water drawn through in the same manner as the filtrate. The amount of water necessary to wash the cake can be readily measured, the period of time necessary for washing obtained, and the dryness of the cake determined by allowing the filter leaf with adhering cake after being withdrawn from the wash water to be held suspended in the air until the occluded liquid has been sucked out of its pores. A filter leaf of the above-mentioned size will have approximately one-sixth of a square foot of active filtering surface, and when a ratio is struck between the volume of filtrate or weight of cake to one-sixth of a square foot for the particular period of time employed, the operator can readily calculate the number of square feet of active filtering surface he will need for an installation capable of handling a given quantity of liquid or solid. He will

also be able to determine the amount of wash water, the purity of his cake and moisture content of the latter, which will closely approximate the results he will obtain on a commercial installation.

Deductions From Experimental Tests

From these tests a few general deductions can be made. If it takes a longer time than ten minutes to form a filter cake of at least ¼ in. in thickness, in all probabilities the problem falls into class A, in which are included the filter press, open tank leaf filter and the self-dumping filters. If a firm cake of from ¼ in. to upwards of 2 or 3 in. in thickness can be formed in less than ten minutes, and if the cake frees itself readily from the filter leaf, a rotary filter will very likely handle the problem. In determining the size of the rotary filter by this simple test required for any problem, it must be borne in mind that any point on the peripheral surface on the filter drum will require from one to ten minutes to pass through the full 360 deg. according as the machine makes one r.p.m. or one-tenth r.p.m. Consequently, as frequently less than one-half of the surface of the drum is submerged continuously in the slurry through which it rotates, the requirements for filter surface for continuous operation must be multiplied by approximately two, as less than one-half of the drum is active for cake building. If in making the tests a cake builds so rapidly on the filter leaf and the product is of such a granular nature that in attempting to withdraw the leaf from the slurry the cake will not adhere, but slough off, the centrifugal or the rotary hopper dewaterer will most likely be the type of machine for use.

Suggestions on Washing

Often it is as important to wash the solids as it is to filter them, and a few suggestions along this line may be in order. Irrespective of the type of filter used, the one important factor to provide against is the channeling of the filter cake. In the filter press as well as the self-dumping type it is difficult to provide against a classification of the solids, as the heavier particles will often settle away from the lighter, forming areas of less resistance to the passage of the filtrate. This classification is not met with to any noticeable extent in the open tank leaf type of filter, as the slurries may be kept in constant and thorough agitation during the process of filtration, thus insuring a homogeneous slurry. Consequently, it has been my experience that washing on the open tank leaf type of filter can be accomplished with less wash water and a more thoroughly cleansed product obtained than by either the press or self-dumping type. It seems to be a prevailing custom among engineers to determine the degree of wash that a filter cake has been subjected to by merely testing the wash water coming from the filter. Let me suggest to those who are operating different types of filters, to sample the filter cake itself. Without a doubt, in many instances surprisingly curious results will be obtained. In sampling I do not mean the ordinary grab sample, but a number of samples taken from different parts in the chamber or on the filter leaf. In many cases it will be found that the most astonishing results are due to channeling.

Another important point on the subject of washing is that we do not get the advantages of diffusion to the extent desired by passing our wash water through the cake, and it has been my practice to recommend wherever it is possible where extreme degrees of washing are required with a minimum amount of wash water to discharge the cake after the mother liquor has been replaced to a reasonable extent by wash water, and to churn up or cream the product, thus getting the advantages of diffusion and refilter. I wish to emphasize this method of washing, particularly in the case of the rotary filter, where the period of washing is relatively short, and where much is left to be desired where filtering and washing and automatic discharge are accomplished in one revolution of the filter drum. Most gratifying and surprising results have been obtained on difficult problems of washing where only a sufficient amount of wash water is sprayed upon the cake to replace the mother liquor held by the cake volume for volume, and the cake discharged into some form of agitating tank in which it is creamed up with wash water in sufficient amount to permit of easy handling of the slurry and refiltered.

One other important point before closing the subject of washing is, in dealing with free alkalis, the passage of steam through the cake prior to washing with water will often show very beneficial results.

Importance of Ample Pump Capacity

Why it is that the engineer after recommending the purchase of expensive installation will suddenly take it into his head to economize on the size of the pump, and particularly the size of the pump lines in connection with vacuum filtration, has always been a mystery to me, and yet it is a fact. Allow me to emphasize the need of ample pump capacity. In the filtration of bicarbonate of soda the pump displacement should be from 10 to 15 cu.ft. per minute of free air per sq.ft. of active filtering surface unsubmerged. This amount of free air per sq.ft. decreases rapidly as the porosity of the cake decreases. Carbonate of lime or caustic lime mud from the ordinary soda-lime process requires only from 3 to 5 cu.ft. per unit square area of filtering surface. Another point that the engineer seems to neglect to take into consideration is that short suction lines are preferable to long lines. In one instance I have in mind a 500-ft. suction line, which, although of adequate diameter, failed completely to function, due to its extreme length.

Conclusion

In concluding, allow me to offer a few suggestions to the manufacturers and chemists who have filtering problems to solve.

Filtration is too important a factor in the operation of any plant, where the separation of solids from liquids is a step in the operations, to neglect careful, faithful research on the most practical means of obtaining the separation. These problems cannot be brushed hastily aside or decided hurriedly, but should entail the same thoroughness in research that any technical chemical operation deserves. One of the most important points to emphasize is that in many cases filtration will not be as difficult an operation if more care and attention are given to the form in which the solids appear at the time that filtration is to be attempted. In other words, the chemical reactions should have run their course and the suspensions should have been allowed to form themselves in a physical condition as far as practical, giving the best separation possible in consideration of their nature and crystalline structure.

Recovery of the Nitrogen Contained In Oil Shales

By Louis Simpson

THE question of the economic retorting of oil-yielding shales will be governed by the results of the retort controversy. Whether the oil shale operators of this continent decide to use the "dual purpose" retort of Scotland, with its elaborate attempt to secure as large a yield of nitrogen as may be possible, or whether they will elect to use a "single purpose" retort, which will give them the largest possible yield of high-grade oil, with a small yield of recovered nitrogen, remains to be seen.

It is a pity that the governments, which are so greatly interested, have not as yet seen their way to aid the operators to solve this question. The proof can be gained only at the risk of a considerable expenditure, much of which would be common to all the tests that would have to be made, hence much duplication of expense would be avoided, were any one or more of the governments interested to arrange for comparative trial runs of the several classes of retorts.

Economic Comparison of the "Dual Purpose" and "Single Purpose" Retorts

The first question that has to be decided is whether the "dual purpose" retort or the "single purpose" retort is the more economic when operating under the special conditions existing in different parts of the North American continent.

The "dual purpose" retort has been perfected to educe the oil contained in the shale and at the same time to recover to the greatest possible extent the nitrogen contents of the shale. Owing to certain peculiar conditions present in Scotland years ago, this retort was perfected so that the nitrogen contents might be recovered and were recovered even at the expense of the oil contents. The "single purpose" retort is designed so as to make the utmost recovery of the oil contents and so to make such recovery that the risk of cracking the educed oil is lessened. The "double purpose" retort with its necessary accessories is very expensive to build, while the best examples of "single purpose" retorts can be constructed for very much less money. In Scotland, years ago, when the selling price of oil was very low, when gasoline was almost unsalable and when sulphate of ammonia was selling at prices very much higher than pre-war prices, the operators solved the question, so far as they themselves, then, were concerned, by perfecting the "dual purpose" retort. The operations of this retort in Scotland have certainly proved to be very profitable, but it was the local conditions that made the operations of the retort profitable and given other and widely different local and unfavorable conditions, the results would have been very different. The local conditions now existing on the North American continent are nearly, in every item, the opposite to those existing in Scotland when the "dual purpose" retort was perfected, and on this account it is not safe to accept the results obtained in Scotland from the operations of the "dual purpose" retort as the results likely to be obtained by the use of that retort when operated on this continent.

To make this point clear, the conditions that existed in Scotland and the conditions that exist at many, probably at the majority of locations on this continent, are given in Table I, placed side by side for comparison. It is, however, admitted that locations are to be found where the conditions as stated are not present.

TABLE I—COMPARISON OF CONDITIONS IN SCOTLAND AND IN NORTH AMERICA

	As they existed in Scotland	As existing in North America
Shale, quality	Relatively low in oil contents, but high in nitrogen contents	Relatively high in oil contents, but usually low in nitrogen contents
Oil contents	Sale price low	Sale price much higher
Sulphate	Sale price very high	Pre-war sale price very low
Sulphuric acid	Very low in price delivered	Generally high in price delivered
Bagging	Very low in price delivered	Generally high in price delivered
Machinery and repairs	Low in price delivered	High in price delivered
Wages	Low	Before the war double the scale; now probably four times the old rate
Coal	Low in price delivered	Generally dearer, but in this cost great variations will be found
Market for sulphate	World-wide and therefore in constant demand	Local and therefore seasonal, entailing carrying large stocks
Money	Easily obtainable at low interest	Much dearer

The probable future demand for sulphate of ammonia and its market price are quite obscure. It is known that the manufacture of the products of nitrogen has been immensely increased during the war, while the present consumption is probably not larger than it was before the war, if as large. It is known that much of this increase is from by-product coke ovens, and therefore this source of supply will be persistent in the future, whatever level prices reach. It is known that the remainder of the increase is from processes that obtain the nitrogen from the air, and although it is not certain, it is supposed that these plants will continue to operate.

If sulphate of ammonia and other products of nitrogen are necessary for the welfare of those interested in agriculture, it is not likely that these works, indirectly, in part, paid for by those so interested, will be allowed to lie idle, so that the coke barons and others may charge a high price for a by-product. It is therefore probable that prices will fall to their pre-war level and perhaps lower. Notwithstanding, and in spite of these facts, writers and speakers still persist in claiming that the successful establishment of the oil shale industry depends upon the continued extreme recovery of the nitrogen contained in the shale.

This article is written with the hope of showing that this contention is wrong. Only under special conditions, not often present on this continent, will the utmost possible recovery of the nitrogen in the oil shale become of financial and economic importance and in such rare cases it is possible to add to the approved "single purpose" retort special machinery, especially designed, operated independently from the retort, which will recover the nitrogen as well as if not better than can today be done in the nitrogen recovery section of the "dual purpose" retort.

The axiom still holds good, that by-products should not be manufactured unless the profits accruing upon the money invested in the works and machinery and the working capital necessary for the recovery are equal to or exceed those which would have accrued had the same amount of money been expended in enlarging the output of the original business.

Before a judgment can be arrived at it is necessary that the cost of producing sulphate of ammonia from

nitrogen recovered in the "dual purpose" retort be correctly ascertained.

The late Dr. R. W. Ells, in his report published in 1909 by the Canadian Government on the "Oil Shales of New Brunswick and Nova Scotia," has unintentionally been the cause of much misunderstanding on this point.

On page 35 of his report the cost of the "manufacture of sulphate" is given as 46c. per ton shale. It is not stated to what yield of sulphate per ton shale this figure applies, and as the cost in certain items varies with the yield of sulphate per ton shale, the yield becomes a matter of considerable importance. As, however, Dr. Ells on the previous page had mentioned a shale yielding 77 lb. sulphate per ton, it is presumable that the 46c. was given as the cost of manufacturing 77 lb. of sulphate per ton shale. This cost totals $11.95 per ton of 2000 lb. of sulphate.

Authorities in England have given the cost of manufacturing sulphate from ammonia liquor as being before the war as stated in Table II.

TABLE II—COST TO MANUFACTURE SULPHATE FROM AMMONIA LIQUOR

18 cwt. sulphuric acid at 60 deg. B. at $13.33 per ton	$12.00
3 cwt. lime at $ 2.40 per ton	0.36
Coke	1.10
Bags (containers)	0.86
Repairs, etc	1.10
Labor	3.00
Cost in England before the war	$18.42

This cost is considerably higher than that given by Dr. Ells. Dr. Ells gives no details, so it is not possible to explain this wide (50 per cent) difference, which, however, probably consists in the increased cost of acid (the Scotch purchase their acid at a very low cost, delivered), bags and fuel. Perhaps also Dr. Ells forgot to make any allowance for repairs. In neither estimate are included costs of interest, depreciation or management.

Both Dr. Ells' cost and the English cost were costs before the war, and the cost in both countries would have to be considerably increased to represent today's costs, which may safely be taken to exceed $25 per ton sulphate.

But the $25 cost represents only the cost of manufacture from ammonia liquor to the sulphate. Besides this cost, the cost of recovering the nitrogen (in the form of ammonia) from the shale must be ascertained.

At this point it may be wise to point out that the objective of the investor of money in the oil shale industry is the winning of dollars upon the dollars invested. It is from this viewpoint that the rival retort processes have to be judged. Therefore, to the costs already discussed must be added the extra overhead charges of interest, depreciation and repairs chargeable, owing to the extra cost of the "dual purpose" retort and of its larger exhausters, condensers, pipes and steam boilers, also the extra cost of fuel and water and the extra interest upon working capital required to carry a stock of bags and of sulphate, waiting for shipment to fill the season's orders.

As the making of money is the objective, it is quite legitimate to charge up against the cost of manufacture the interest upon the capital expended, at the rate the money so expended would have earned had it been expended in the recovery of oil from an increased quantity of shale instead of in the recovery of nitrogen and of the manufacture of this nitrogen, so recovered, into sulphate. When this is done, if the total so arrived at is less than the selling price of the sulphate, the manufacture of this sulphate may be considered, but if the total be more, then, and in that case, the manufacture of the sulphate should be avoided.

To show at a glance how local conditions affect the result, Table III has been compiled. The basis upon which this table has been calculated is as follows:

An installation to treat 1000 tons of shale per day of 24 hours, 365 days per year. (1) "Dual purpose" retort, plant with sulphate manufacturing costing $1,200,000. (2) "Single purpose" retort plant without sulphate manufacturing costing $300,000. Depreciation allowed at 15 per cent per annum, interest calculated at different rates from 50 per cent down to 15 per cent (it is believed that some deposits will make it possible for those operating to earn the larger figures and it is not thought that many will expect to earn less than 15 per cent). The returns of sulphate per ton shale are taken from 70 lb. down to 30 lb. By referring to this table and by adding the figure found, where the interest and the per cent of sulphate meet, to the $25 before mentioned, a total will be reached that will indicate nearly the actual cost of the sulphate, when made by the use of the "dual purpose" retort.

TABLE III—COST OF SULPHATE (Overhead and Profit only)

	70 lb. per ton shale	60 lb. per ton shale	50 lb. per ton shale	40 lb. per ton shale	30 lb. per ton shale
50%	$45.79	$53.42	$64.10	$80.13	$106.84
40%	38.73	45.20	54.24	67.80	90.40
30%	31.70	36.98	44.37	55.47	73.96
25%	28.17	32.87	39.44	49.30	65.74
20%	24.65	28.76	34.51	43.14	57.52
15%	21.13	24.66	29.59	36.99	49.32

It is believed that the $25 cost per ton for manufacture, which has to be added to the above, is far too low a present estimate; but using that cost as a basis, the following results are obtained:

Where oil discovery alone would yield only 15 per cent profit on the capital employed and with shale yielding 30 lb. sulphate per ton the cost would be $74.32 per ton; where the oil yields 50 per cent profit, the cost of sulphate would be $131.84 per ton. With 50 lb. shale the low cost would be $54.59 and the high cost $89.10. Seventy lb. sulphate per ton shale is an exceptional return. But to the above total a further charge may have to be added in cases where the capital at command is not sufficient to warrant the erection of a 1000-ton plant using the "dual purpose" retort. In many cases where only 250 tons per day are mined and assembled instead of 1000 tons, it may be assumed that the cost of mining, assembling, and of management will be increased by 25c. per ton of shale. This 25c. per ton shale when retorting shale that yields 30 lb. sulphate of ammonia increases the cost per ton sulphate by no less than $15.

Mention has been made of a possible arrangement by which the nitrogen left in the spent shale can be conveniently recovered. There is no doubt that were the spent shale from a 1000-ton shale unit treated in a revolving horizontal kiln (especially in such cases where the shale contains considerable fixed carbon), it would be possible to recover not only a very high percentage of the nitrogen, but also, if found desirable, the potash contents.

Conclusions

1. The "dual purpose" retort is only of interest when exceptional conditions are present, conditions that are not often met with on the North American continent.

2. The future of the oil shale industry is largely dependent upon the construction of a "single purpose" retort that can be erected at a low cost and which will recover the maximum quantity of oil.

3. It is possible to arrange for a machine which operates independently from the "single purpose" retort, which will recover the contents of nitrogen even more completely than can be done in the nitrogen recovery end of a "dual purpose" retort.

4. Some nitrogen, if desired, can be recovered from the "single purpose" retort, but such recovery is not advisable unless sulphuric acid is obtainable at a low price delivered or unless there be a good local market for the sulphate.

C. P. Zinc for Fixation of the Temperature Scale

By A. O. Ashman

ZINC is probably the most important substance (aside from water) used in the fixation of the temperature scale, its value in this connection being due chiefly to its melting or freezing point, the boiling point being seldom used. The characteristics of this melting point may be stated briefly as follows:

(1) The melting point (419.4 deg. ± 0.1 deg.) as determined by the cooling curve method is extremely sharp and easy to obtain.

(2) It has practically no undercooling effect.

(3) Zinc does not oxidize perceptibly at this temperature, and moreover the oxide is not soluble in the metal, so that the melting point is not affected by oxidation.

(4) Zinc is not easily contaminated by containers commonly used in making melting point determinations, and with due care will last indefinitely.

(5) The position of the melting point is about at the upper limit of usefulness of the copper-constantan couple, and at about the lower limit of the platinum-rhodium couple, the two most commonly used laboratory couples.

Source of Supply

Prior to the war, zinc sufficiently reliable for this work could be obtained from only one source, which in keeping with existing custom was a German concern. Kahlbaum zinc, as well as other metals, was recognized as the standard for this use. Since the opening of the war C.P. zinc has been prepared in this country in a much higher state of purity. This metal is now on the market, and can be obtained in stick form in any desired quantity. It has a constant purity and melting point.

Preparation

The method of preparing C.P. zinc has been published in detail by the Bureau of Standards,[1] and is briefly as follows: The pure zinc is prepared by redistillation of Horsehead spelter. This is carried out in a coal-fired muffle furnace.

Each muffle is filled with approximately 250 lb. of spelter and heated until volatilization begins. The temperature is very carefully regulated by means of a recording pyrometer, as the lead content is dependent almost entirely on the proper temperature, the process being a fractional distillation.

As the zinc is distilled off the lead content of the residue is increased proportionally, and at a certain concentration is carried over with the zinc. When this is the case the charge is drawn and a new one introduced. The burden in the muffles is kept constant by adding spelter equivalent to the weight removed by each draw.

The zinc so prepared is then cast into sticks ¼-in. diameter by 8-in. long, this shape being desirable on account of the ease of breaking without the use of contaminating tools.

The distinguishing characteristics of pure zinc are its extreme softness and beautiful crystallization.

Purity and Effect on Melting Point

Table I, copied from Bureau of Standards Circular No. 66, shows the chemical analysis for Kahlbaum zinc, and zinc produced by the New Jersey Zinc Co.

TABLE I—ANALYSIS OF ZINC SAMPLES

Element Sought	New Jersey Zinc Co.'s Redistilled Horsehead Spelter	C. A. F. Kahlbaum Zinc
Iron	0.005	0.001
Lead	0.0004	0.021
Cadmium	0.0018	0.021
Arsenic	Trace	Trace
Antimony	Not detected	Not detected
Tin	Not detected	Not detected
Sulphur	Trace	Trace
Zinc by difference	99.993	99.957
Total impurities	0.007	0.043
Melting point	419.44°C.	419.30°C.

Wardner and Burgess[2] have found differences of 2.5 deg. C. in the melting points of zinc obtained from different sources. Unfortunately, however, corresponding chemical analyses are not given.

Kreisinger and Barkley[3] point out that metals obtained for this work from chemical supply houses melt at from 2 to 5 deg. lower than corresponding Kahlbaum pure metals.

It is seen from the table that the difference in melting point is 0.14 deg. C. Assuming this is a function only of the impurities present, a difference of less than 0.03 per cent impurities in the zinc will change the melting point by 0.1 deg. C.

In view of the extreme purity of the New Jersey Zinc Co.'s zinc and constancy of the product, we believe that it would be well worth while for the Bureau of Standards to re-determine the freezing point, thereby fixing the temperature scale with an accuracy of at least ± 0.05 deg. and probably 0.01 deg. at that point instead of ± 0.1, as at present.

The methods used in making primary calibrations are well known[4] and will not be given here. It is sufficient to say that the determination of the freezing point is free from experimental difficulties, such as oxidization, contamination, etc. The freezing point of zinc is more sharply defined than that of any other substance used for this purpose, and is probably the easiest of all fixed points to reproduce.

The New Jersey Zinc Co.
Research Division.

[1] Bureau of Standards Circular No. 66, p. 5.

[2] Bulletin Bureau of Standards, vol. 6, No. 2, pp. 164, 173.

[3] Bulletin 145, Bureau of Mines, p. 62.

[4] "Standardization of Rare-Metal Thermocouples," Met & Chem. Eng., vol. 18, No. 7, p. 343, April 1, 1918.

Melting Point Methods at High Temperatures—I*

A Description of the Determination of Melting Points of Metals, Alloys, Salts and Refractory Materials by the Use of Thermo-Electric, Resistance and Optical Pyrometers

By LEO I. DANA and PAUL D. FOOTE

Introduction

THE determination of a melting or freezing point, whether for a physical or physicochemical purpose, resolves itself into the measurement of a temperature under particular conditions and with appropriate technique. The accuracy and ease with which melting points at high temperatures may be determined are due to the comparatively recent developments in pyrometry, electric furnace construction and refractory materials.

The general classes of substances considered are metals, alloys, salts and refractory materials. For the temperature measurements, thermo-electric, resistance and optical pyrometers are employed, depending upon the temperature range and other controlling conditions.

The melting or freezing point of a pure crystalline substance is defined as the temperature at which the solid phase can remain in equilibrium with the liquid phase at normal atmospheric pressure. The effect of pressure is ordinarily insignificant; it is only when the pressure reaches many atmospheres that any change in the melting or freezing point can be readily detected. At the melting point there is a discontinuous change of a number of the physical properties of a material, e. g., thermal conductivity, electrical resistivity, specific volume, etc. In general, alloys, excepting eutectoids, mixtures of refractory oxides and materials with impurities, do not have a definite melting point, but become liquid gradually; that is, they melt over a temperature interval and consequently are considered as having a "melting range."

I. Use of Thermo-Electric Pyrometers

Pure Materials

General Discussion. The experimental arrangement of this method consists of a crucible containing the substance in which a thermocouple, either protected or unprotected, is centrally inserted. The crucible is placed in a uniformly heated portion of an electric furnace. On account of cleanliness, clarity of the atmosphere and preciseness of control, electric resistance furnaces are preferable to gas- or fuel-fired furnaces for accurate melting point determination. When a melting or freezing point is to be observed, the temperature of the furnace is gradually raised or lowered and the temperature as indicated by the thermocouple is noted at frequent and preferably uniform intervals of time. If all conditions were ideal the temperature of the charge would remain constant during melting or freezing. Thus the temperature-time curve would be characterized by a straight line exactly parallel to the axis of time and by a discontinuous change of slope at either end of the line marking the beginning and ending of the period of melting or freezing. Actually, however, the change of state shown by the curve, even for pure materials, is not sudden, but more or less gradual. Only a part of the freezing curve will be flat, and the melting curve usually possesses greater obliquity than the freezing curve. For this reason freezing point determinations are usually more reliable and are employed whenever possible, although the temperature thus obtained is frequently called the melting point, to which it is numerically equivalent.

The reasons for obliquity, and for its existence to a greater degree in the melting curves, have been discussed in detail by White.[1] On heating, the furnace walls are hotter than the crucible and hence heat flows from the furnace to the crucible. When a layer of the charge near the wall of the crucible reaches the melting point, the heat absorbed by the charge goes to supply that necessary for the latent heat of fusion, and the temperature of the outside layer tends to remain fairly constant. The thermocouple measures the temperature of the solid metal in the center of the charge and when thus surrounded by an isothermal layer the rate at which the inside temperature increases is greatly diminished, resulting in a rounding off of the temperature-time curve. As the isothermal layer progresses inward the temperature of the couple slowly rises until the material immediately surrounding it begins to melt, when a condition of stationary temperature is maintained for a short time during which the thermocouple reading gives the true melting point. While the center of the charge is melting, however, the temperature of the outer layer of material in the crucible rises very rapidly and a large temperature gradient is established between the outside and center. The resulting rapid flow of heat to the center of the crucible accelerates the melting and, if the layer of remaining solid metal is unequally distributed about the couple, tends to increase the temperature readings and cause another rounding off of the temperature-time curve. The apparent degree of obliquity found near the beginning and end of the melting period depends considerably on the sensitivity of the temperature measurements and scale of plotting. Thus highly accurate data obtained with a precision potentiometer may be plotted on so large a temperature scale that the curve may appear quite oblique, while the same data replotted on a less-extended scale appear fairly flat. Aside from this, however, the degree of obliquity varies according to the factors controlling the differences in temperature within the charge, such as dimensions and thermal properties, rate of heat supply, etc. If the solid metal could be stirred during a melting point determination the temperature gradients could be diminished, but even with powdered materials where

*Part II will be published in the Jan. 14 issue.

[1] White, "Melting Point Determinations," *Am. J. Sci.*, vol. 28, p. 453; 1909.

stirring is possible it is not convenient and does not appear to be very satisfactory. The larger the diameter of the charge, the faster the rate of heating, the smaller the diffusivity and the less the latent heat of fusion the greater will be the tendency to obliquity. The obliquity may be decreased by slow heating and by using a charge of fairly small diameter. The protection tubes of the thermocouple should be small, of thin wall and should be deeply immersed in the charge. With metals the obliquity is not so great as with salts on account of their higher heat diffusivity and latent heat of fusion; in fact, for most cases the obliquity is of negligible importance with pure metals. But with salts and certain refractory materials, unless special care is taken, the obliquity may be so great as to obscure almost completely the true melting phenomenon.

On cooling, the crucible is hotter than the furnace walls, and heat flows from the crucible to the furnace. The outer layer of the charge solidifies first and during freezing acts as an isothermal layer, thus decreasing the temperature differences between the center and outside of the charge. The rate at which the temperature of the couple falls decreases, causing a rounding off of the first part of the temperature-time curve. While the center of the charge is freezing the outside is completely frozen and rapidly falls in temperature, increasing the temperature gradient and the outward flow of heat, and hence the latter part of the freezing is accelerated.

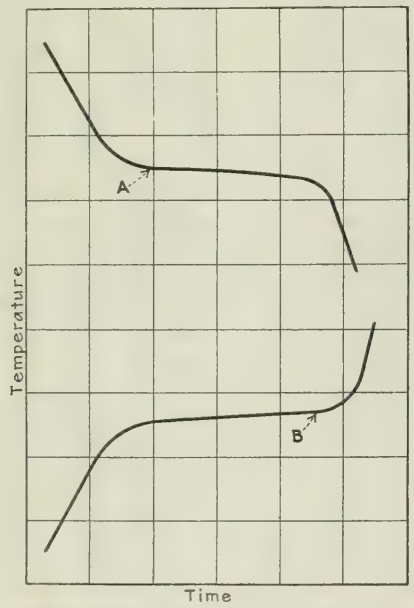


FIG. 1. OBLIQUE FREEZING AND MELTING CURVES

The first part of the approximately flat portion of the curve for freezing corresponds to the true freezing point, and the latter part of the approximately flat portion of the curve for melting corresponds to the true melting point. The same precautions of high narrow charges, narrow protecting tubes, sufficient depth of immersion and small thermocouple wires apply to both cases.

In general the freezing curves are more sharply defined than the melting curves. A liquid cooling and subject to convection currents is likely to possess a more uniform temperature distribution than a solid on heating. Furthermore, the freezing point is chosen at a time immediately following a period of small temperature gradients, while the melting point must be chosen

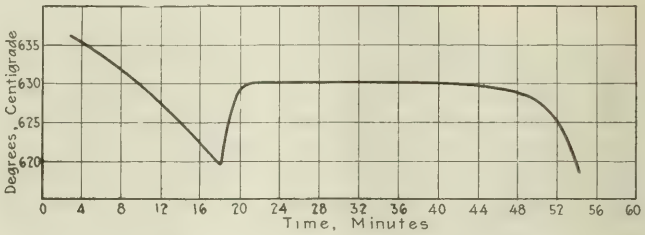


FIG. 2. FREEZING CURVE OF ANTIMONY SHOWING UNDERCOOLING

near the end of the period of melting, when there is possibility of temperature non-uniformity. A further factor of importance is the constancy of heat supply. On cooling with a furnace well insulated, the freeze may extend over a considerable time with all power supply shut off. The furnace thus acquires a uniform rate of cooling. In heating, however, the effect of slight variations in the power supply may alter the true character of the melting curve. Fig. 1 shows a freezing and a melting curve in which considerable obliquity is present. The true temperature for freezing is obtained by extrapolating the straight portion of the freezing curve and noting at what temperature *A* the continued straight line deviates from the observed curve. The melting point *B* is similarly obtained from the melting curve. The first part of the freezing curve and the last part of the melting curve determine these two temperatures, as stated above.

It is impossible to obtain satisfactory freezing curves with certain materials such as silicates on account of extremely slow crystallization, and the melting curves, even though frequently poorly defined, must be employed. The phenomenon of surfusion or supercooling is well illustrated by water, which may be cooled to —30 deg. C. without freezing. Surfusion is due to conditions which do not favor the attainment of equilibrium between the solid and liquid phases at the true freezing point. The conditions tending to produce equilibrium and the elimination of surfusion are slow cooling, stirring of the liquid and the presence of nuclei which serve as centers of crystallization. When a supercooled liquid freezes, it crystallizes very rapidly and the temperature rises to the true freezing point provided the supercooling has not proceeded too far. The

TABLE I.

Laboratory	Crucible Dimensions, All in Cm.				Charge Dimensions		Protection Tube		Distance from Bottoms of Charge to Protection Tubes
	Inside		Outside		Diameter	Height	Diameter		
	Diameter	Height	Diameter	Height			Outside	Inside	
Bureau of Standards	7	15	8.5	16	7.0	11	1.0	0.8	1.0
Geophysical	2.7	8	3.7	10	2.7	5	0.8	0.5	0.5
Bureau of Standards	1.2	3	2.0	3.5	1.2	2	0.15	0.1	0.3

subsequent freezing takes place in a normal manner. Surfusion in most metals seldom exceeds 0.1 or 0.2 deg. C., but in the case of antimony it is very marked and may amount to 30 deg., depending upon the rate of cooling, as shown by Fig. 2. Supercooling also occurs in alloys, especially in eutectics. While the contrary phenomenon of superheating is negligible with pure metals, it may become of importance with alloys, particularly in allotropic transformation and with salts and silicates.

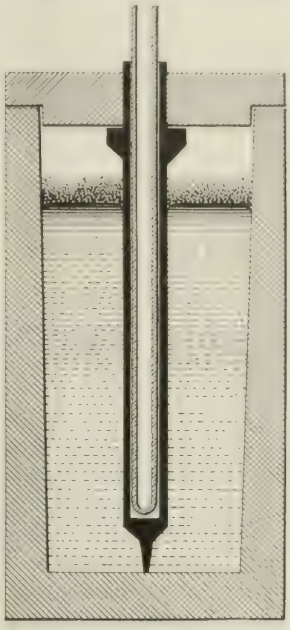


FIG. 3. GRAPHITE SHEATH FOR PROTECTION OF PORCELAIN TUBE IN ALUMINUM

Precision Work With Pure Metals. The primary method for the standardization of thermocouples consists in determining the e.m.f. developed by the couple at the freezing points of several very pure metals. The metals so employed are those the freezing points of which have been accepted as fixed points on the high temperature scale, e. g., tin, cadmium, zinc, antimony, aluminum, silver, gold, copper, etc. For this work and for the reverse problem of accurately determining the freezing points of metals and alloys the greatest precautions against contamination of the couple and the metal are required. Precision work at high temperatures requires the use of homogeneous platinum-90 per cent platinum, 10 per cent rhodium couples. The diameter of the wire usually employed is 0.5 or 0.6 mm., but for certain special purposes wires of 0.1 mm. are useful.

Crucibles and Protecting Tubes. Of all crucible materials Acheson graphite has the greatest utility. It is very pure, can be machined into any desired shape, and is not attacked by most of the common metals. At high temperatures the gases formed from its oxidation provide the reducing atmosphere necessary for the protection of the metal. Table I illustrates sizes of graphite crucibles which have been used in various investigations. For resistance thermometry the largest size shown is necessary, but for general work the intermediate size shown is recommended. In this case a smaller protecting tube is desirable, for example, one with an outside diameter of 5 mm.

Some metals, such as nickel and iron, combined with graphite, and certain other metals also should not be heated under the reducing conditions present with graphite. Crucibles of magnesia, alumina or mixtures of the two are suitable for iron and nickel. Porcelain crucibles may be used for many of the metals, but there is always danger of these cracking when the metal melts or freezes.

Up to 500 deg. C. protection tubes and insulating tubes for the couple made of pyrex glass are useful. From 500 to 1100 deg. C., lower grade porcelain glazed on the outside only or fused quartz are satisfactory. Above 1100 deg. C. tubes having a composition approximating that of sillimanite, Al_2O_3, SiO_2, are recommended.[2]

Porcelain tubes, or crucibles, or any material containing silica cannot be used in contact with aluminum, as the silica is readily attacked. Aluminum may be melted in a graphite crucible and the porcelain protecting tube itself may be protected by a very thin sheath of graphite. Fig. 3 illustrates one convenient manner on which the sheath may be mounted in the crucible. The sheath is held down in the metal by the weight of the cover and is allowed to remain in the crucible after the aluminum is frozen. The thermocouple protecting tube fits tightly inside the sheath. At present there is no satisfactory protecting tube for nickel. This material and its alloys can be best studied by optical methods.

Table of Melting Points. Table II lists the more common metals the melting points of which can be used for the standardization of thermocouples by the crucible method.

[2]Such porcelain is made by Stupakoff Laboratories, Pittsburgh, under the trade name "Usalite," and by Charles Engelhard Co., New York, under the trade name "Impervite."

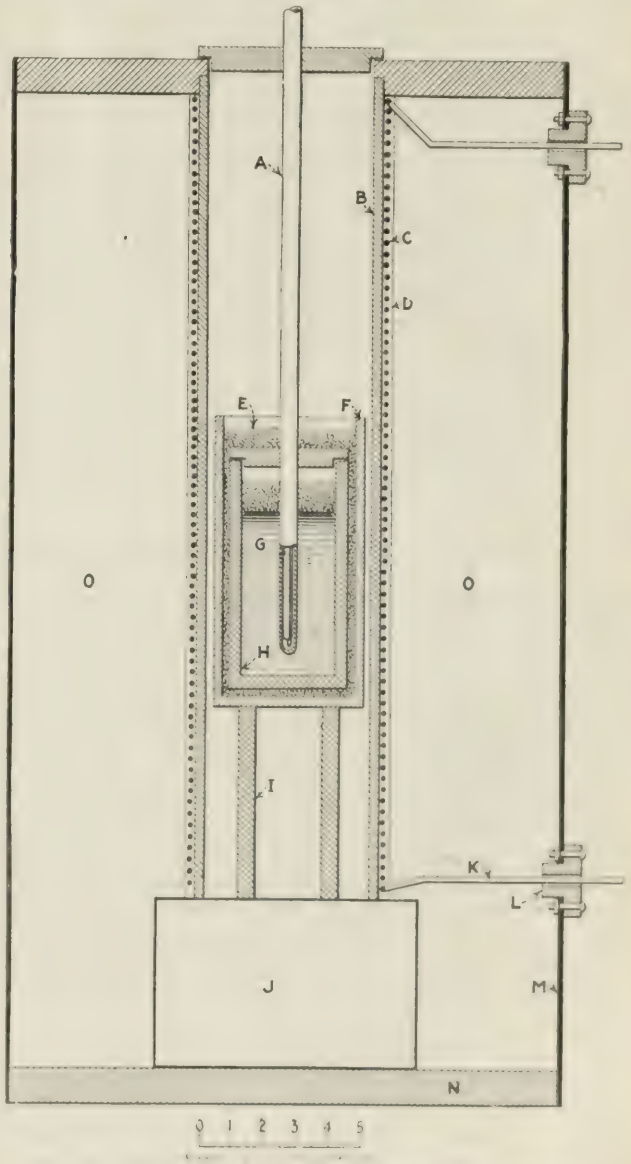


FIG. 4. MELTING POINT FURNACE FOR METALS AND ALLOYS

TABLE II.

Metal	Melting Point, Deg. C.	Crucible Material	Atmosphere
Tin	231.9	Graphite, porcelain or pyrex glass.	Reducing, neutral or air
Bismuth	271	Graphite, porcelain or pyrex glass.	Reducing or neutral
Cadmium	320.9	Graphite, porcelain or pyrex glass.	Reducing or neutral
Lead	327.4	Graphite	Reducing or neutral
Zinc	419.4	Graphite	Reducing or neutral
Antimony	630.0	Graphite	Reducing, CO
Aluminum	658.7	Graphite	Reducing, CO
Silver	960.5	Graphite	Reducing, CO
Gold	1063.0	Graphite	Reducing, neutral or air
Copper	1083.0	Graphite	Reducing, CO
Nickel	1452	MgO, Al_2O_3 or mixtures of the two	H_2, N_2, or vacuum

The surface of the metal should be covered with a layer of powdered or flaked graphite, and the crucible should be provided with a cover having a hole through which the thermocouple tube is inserted. Under no circumstances should graphite be exposed to an air current above 500 deg. C., as it readily oxidizes and crumbles away. The furnace should be tightly closed at the bottom and no larger openings exposed at the top than

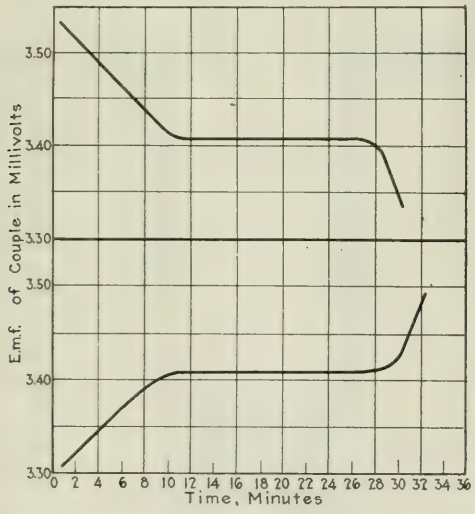


FIG. 5. FREEZING AND MELTING CURVES OF PURE ZINC

absolutely necessary. When fairly small graphite crucibles are employed it is frequently desirable to use a larger outside crucible of porcelain and fill the space between the two crucibles with graphite powder.

Construction of Furnace. Fig. 4 shows the construction of a furnace using crucibles of the intermediate size given in Table I for operation up to 1100 deg. C. The graphite crucible *H* containing the metal *G* and the pyrometer tube *A* rest in a porcelain crucible *F* and are completely covered by powdered graphite *E*. The porcelain crucible is supported in the alundum tube *D*. The heater tube is of alundum, R. A. 98, length 25 cm., inside diameter 5 cm. and wall thickness 3 mm. This is preferably corrugated on the outside and is wound with 60 to 80 turns of No. 14 "Chromel A" wire, *C*, to the ends of which are welded the lead in terminals *K* of No. 10 Chromel. The alundum tubes *B* and *D* rest on a good-conducting fire brick about 5 x 8 x 8 cm. The shell *M*, 32 cm. high, is of sheet iron or monel metal painted with aluminum paint. The ends of the shell are closed by impregnated asbestos boards *N*, 1 cm. thick and 17 cm. in diameter. The annular space *O* is packed with sil-o-cel powder. The lead-in wires are insulated from the metal shell by asbestos board or steatite bushings. The furnace in series with a rheostat for control may be operated on 110 volts and consumes about 1 kw. at 1100 deg. C.

Larger furnaces are required for the large crucibles described in Table I. Such a furnace may be constructed from the following stock material: Alundum tube, R. A.

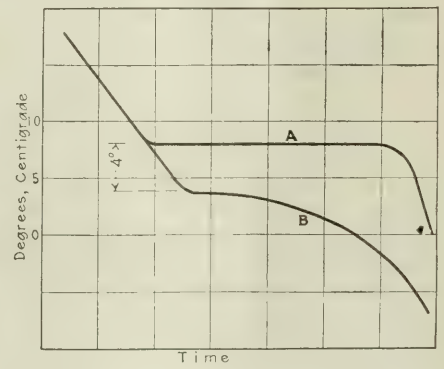


FIG. 6. FREEZING CURVES WITHOUT AND WITH IMPURITY

98, length 45 cm., inside diameter 8 cm., wall thickness 6 mm. Chromel A winding No. 5 wire; 60 turns separated by asbestos cord and covered over with a layer of alundum cement. Diameter of shell 36 cm.; height of shell, 60 cm.; sil-o-cel powder insulation, general construction similar to Fig. 4. Power required for 1100 deg. C. about 55 amp. at 60 volts. Using the large crucibles a freeze of copper with all power off extends over a period of about 20 minutes.

General Precautions. In order to melt for the first time a metal which is in small pieces, the graphite crucible, filled with the material, fitted with a cover having a hole in which the thermocouple fits tightly, and surrounded by powdered graphite, is slowly heated. If convenient CO or N_2 may be passed into the furnace, but CO_2 should not be used. The surface of the metal should not be covered with graphite at first, as it may filter into the interior and become imprisoned there. When the metal has been melted, however, the graphite

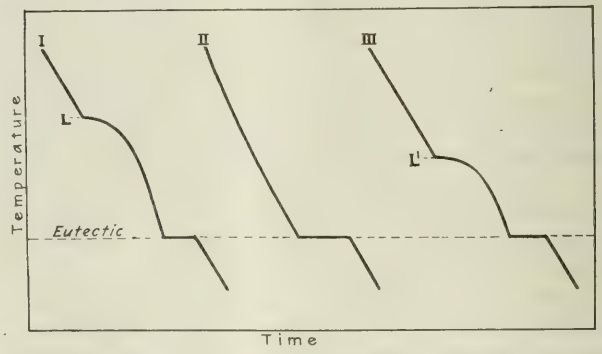


FIG. 7. FREEZING CURVES OF SIMPLE EUTECTIC ALLOYS

layer on the surface is quite desirable. With the exception of antimony, which should be stirred just as the freezing point is reached to reduce supercooling, it is not advisable to stir the molten metals, as pockets of graphite are thereby formed.

If there is doubt concerning the proper depth of immersion, several determinations should be made at different depths until a position is found where a slight variation does not affect the temperature measurement.

The pyrometer tube may be allowed to remain in the metal for a few degrees below the freezing point without breaking, and if it cannot be removed then, the metal should be immediately remelted.

A uniform rate of cooling of about 2 deg. C. per minute from 10 deg. C. above the melting point is satisfactory for a freezing point determination. The values obtained from melting and freezing curves should agree to from 0.1 to 0.01 deg. for pure metals, and the curves should have a flat portion extending over at least 10 minutes. If the curve is not fairly flat, the metal is likely impure and hence possesses a melting range instead of a true melting point. Fig. 5 illustrates an observed freezing and melting curve for zinc. The freezing curve is constant to 0.05 deg. C. for a period of 15 minutes and the melting curve for 10 minutes. The obliquity in the latter part of the melting curve amounts to 0.1 deg. in 6 minutes.

Metals With Impurities, and Alloys

An impurity in a metal usually lowers the melting point and produces obliquity in the melting and freezing curves, the magnitude of both of these effects increasing, within limits, as the amount of impurity is increased. Assuming the amount of impurity is small and that an ideal solution with the metal in the liquid state is formed, the lowering of the freezing point Δt may be expressed approximately by the Raoult-Van't Hoff equation:

$$\triangle t = \frac{R\Theta^2}{L} \cdot \frac{N_1}{N}$$

in which R = 1.99, Θ = absolute temperature of the freezing point of the pure metal, L = molar latent heat of fusion of the pure metal, N_1 = number of mols of impurity, and N = number of mols of pure metal. In Fig. 6, *A* represents the freezing curve of a pure substance and *B* the curve obtained when an impurity is present. The lowering of the freezing point is 4 deg. C., an amount readily caused by a few tenths of 1 per cent of an impurity at about 800 deg. C. In general, the above equation for freezing point lowering holds only for an impurity which forms the simplest type of eutectic alloy with the pure metal. Evidently it cannot be applicable to those impurities which are wholly or partly soluble in the metal in the solid state, that is, which form solid solutions, for in some of these cases the melting point is raised by the addition of the impurity, as for example nickel added to copper.

For most of the common metals the oxide is insoluble in the pure metal, but with copper this is not the case, and special care must be taken, preferably by the maintenance of a strongly reducing atmosphere, to avoid the formations of cuprous oxide, Cu_2O. This oxide forms a eutectic with copper saturating it at 3.45 per cent of Cu_2O or 0.395 per cent of oxygen by weight, and freezing at 1063 deg. C. As an example of the application of the above equation, the freezing point lowering of copper at the eutectic, considering the Cu_2O as the dissolved impurity, will be calculated.

$$\triangle t = \frac{R\Theta^2}{L} \cdot \frac{N_1}{N} = \frac{2\ (1083 + 273)^2\ (2.19)}{(63.6)\ (43.3)\ (143)}$$

$$\triangle t = 20.4 \text{ deg. } C.$$

The lowering found experimentally is 20.0 deg. C.

If the copper contains only a small amount of the oxide, the first solidification begins slightly below the melting point of pure copper and crystals of copper separate from the solution. The concentration of the dissolved impurity Cu_2O accordingly increases, so that the freezing point of the remaining part of the solution is still lower. The pure copper will continue to separate from the liquid at a gradually decreasing temperature until the solution becomes saturated with Cu_2O. This results in rounding or obliquity of the cooling curve. When the remaining solution is saturated, both the Cu and the Cu_2O solidify together, at a constant temperature, as a eutectic mixture. At this point a halt occurs in the cooling curve, the magnitude of which depends upon the amount of the eutectic present. The effect of a small amount of Cu_2O will escape notice in an ordinary melting point determination, but if considerable oxide is present the freezing curve shows the two retardations, one below 1083 deg. and the other at 1063 deg. C. Observation continued through the latter point may serve as a rough criterion of the purity of copper suspected of contamination by its oxide. The obliquity of the curve also may be an indication of impurity. If a copper wire is slowly heated in air, the melting usually

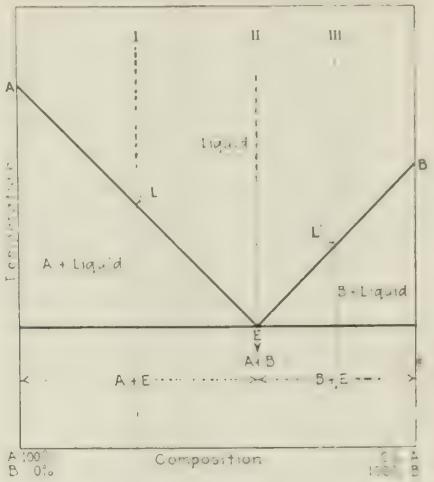


FIG. 8. TEMPERATURE-COMPOSITION DIAGRAM OF SIMPLE EUTECTIC ALLOY

begins at the eutectic point 1063 deg. instead of at 1083 deg. C.

Oxygen dissolves in silver and may lower the melting point as much as 5 deg. C. if the silver is heated in air.

An alloy may be considered as a metal containing large proportions of one or more impurities. Let us consider the simplest case of an alloy of two metals *A* and *B* which are mutually soluble when liquid and insoluble when solid. If *A* first begins to separate from the solution, the remaining liquid becomes richer in *B*, and as shown above, this part of the freezing curve gradually changes in slope as illustrated by Fig. 7, Curve I, L. As the temperature is lowered the solution finally becomes saturated with *B*, and *A* and *B* crystallize together as a eutectic, shown in Fig. 7 by the lower flat portion of the cooling curve. The alloy accordingly has a melting or freezing range extending from the temperature at which separation of *A* first begins to the temperature at which the eutectic mixture solidifies. If the original composition of the alloy is the eutectic mixture, there exists a true melting point as shown in Fig. 7, II, and not a melting range.

The general form of the temperature-composition diagram of the simple binary alloy described above is illustrated by Fig. 8. The curves I, II and III, of Fig. 7 show

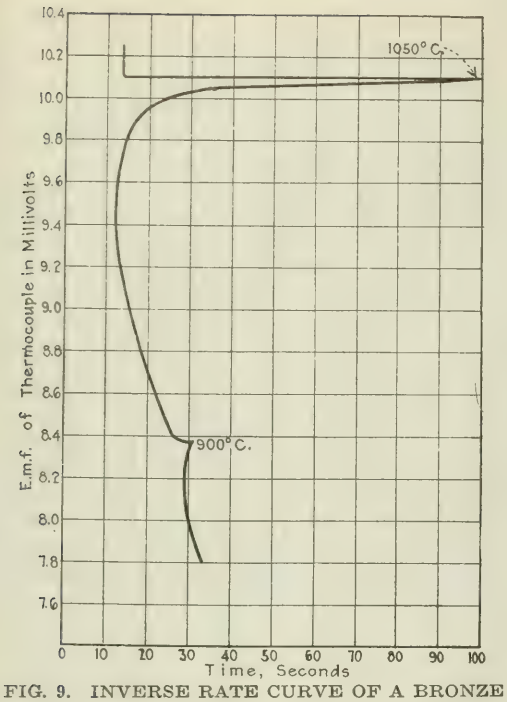


FIG. 9. INVERSE RATE CURVE OF A BRONZE

the form of the cooling curves obtained with the alloys of compositions I, II and III of Fig. 8.

Often a binary alloy exhibits two halts in the melting and freezing curves, one oblique and one flat, or both oblique. Furthermore, other complications may arise, such as the formation of solid solutions, compounds and allotropic transformations accompanied by heat changes which require more sensitive methods of detection than by a simple cooling curve. In general the larger the melting range in a binary alloy the more difficult it becomes to locate the lower transformation point because of the small amount of crystallization per degree drop in temperature and the resulting small heat effect. The same general details for melting point of pure metals apply to alloys. The eutectic alloy Ag-Cu, 71.9 per cent Ag, 28.1 per cent Cu, melts at 779 deg. C. and is useful as a standardization temperature for thermocouples.

For alloys having a large melting range, accurate control of the rate of heating and cooling is essential. Automatic control of the rate may be obtained by a salt water rheostat as applied by Burgess and Crowe,[3] or an automatic magnetic control system may be installed. Scott and Freeman[4] describe a modified Rosenhain furnace for critical point work. This consists of a vertical tube furnace, with a uniform temperature gradient, through which the material is automatically moved at a definite rate.

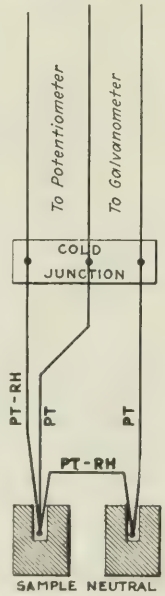


FIG. 10 DIAGRAMMATIC REPRESENTATION OF DIFFERENTIAL METHOD

If the ordinary temperature-time curve does not give evidence of a change of state at the beginning or end of a melting range or at a transformation point, the more sensitive means of detection, such as the inverse-rate method and differential method, may be employed. The former consists in determining the time required for the specimen to fall a definite temperature interval, and in plotting this time against the temperature. The experimental arrangements are the same as for the ordinary time method, except that the time must be measured more accurately. Merica[5] has described a device consisting of two stop watches, one of which is stopped and started at the end of each time interval. Fig. 9 shows an inverse rate curve through the melting range of a bronze. The lower transformation at 900 deg. C. could not be detected by the ordinary temperature-time method.

The differential method is still more sensitive to small thermal changes. This consists in measuring the temperature differences between the material in which the transformation takes place and a neutral body having no transformation points in the same temperature interval, such as platinum or nickel, and plotting this difference against the temperature of the material. Two thermocouples are employed as illustrated by Fig. 10, one a differential couple and the other an ordinary couple which measures the temperature of the sample under investigation. By use of a sensitive galvanometer with the differential couple, extremely minute thermal transformations may be easily detected. Slight variations in the rate of heating produce no noticeable effect.

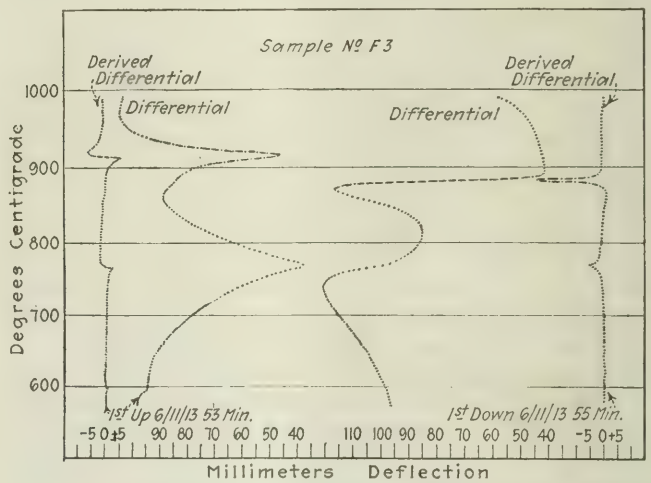


FIG. 11. COMPARISON OF DIFFERENTIAL AND DERIVED DIFFERENTIAL METHODS

Another method of interpreting the data is by means of the derived differential curve, first suggested by Rosenhain.[6] This amounts to differentiating the differential curve in respect to the tmperature and plotting the value so obtained against the temperature. The derived differential is accordingly related to the differential curve in the same manner that the inverse rate is related to the temperature-time curve. Thus if Θ is the temperature of the neutral body, the derived differential is the graph $\frac{d\,(\Theta - \Theta^1)}{d\Theta}$ vs. Θ. The method consists in observing successive values of $(\Theta - \Theta^1)$ for equal increments of Θ, say 2 deg. C., and plotting successive differences $(\Theta - \Theta^1)$ against Θ. The experimental arrangement is the same as that required for the differential method. Fig. 11 shows both differential and derived differential curves for the same sample of pure iron at the transformation points A_2 and A_3.

[3]Bu. of Standards, Scientific Paper No. 213.
[4]*Bull.*, A. I. M. E., August, 1919.
[5]*Bull.*, A. I. M. E., July, 1919.
[6]Burgess, Bu. of Standards, Scientific Paper No. 99.

Present Status of American Glassware*

The American Pre-War Contribution to the Progress of the Glassware Industry Was Limited Mostly to Art Glass, Selenium-Red and Other Color Glass and Low-Expansion Glass; Now America Excels in the Manufacture of Glass and Glassware for All Practical, Industrial and Scientific Uses

By E. C. SULLIVAN

AMERICA had achieved certain results in glass chemistry before the war, but stimulus of necessity arising from the shutting off of foreign supplies both in glassmaking materials and of finished glasses has brought about more than ordinary progress during the past few years. As a result this country seems fully abreast of its competitors and in some respects has forged ahead, producing ware of better quality at no increase in price to the consumer and pushing development beyond that reached abroad.

America has long been the acknowledged leader in ornamental cut-glass, no other country having equaled the brilliance and richness of the American product.

An art glass which had its origin in America is the well-known Aurene or Favreuil glass, a glass of golden iridescence produced by spraying upon the surface of the finished article a liquid which reacts with the constituents of the glass and produces very remarkable soft color effects. It is made into vases, bowls for indirect lighting, etc.

Colored Glasses

A development of very great importance in the field of colored glass which owes its origin to America is the selenium ruby. Selenium, as is well known, is a rare element which is obtained chiefly as an impurity which separates from copper when that metal is refined electrolytically. It was discovered by a Pittsburgh glass maker that under certain conditions selenium could be made to produce a clear red of almost any depth desired. The selenium red has the great advantage for railway signal work that it transmits practically all the red rays and except for some yellow nothing else. In other words, it is a color filter. Other red glasses transmit other parts of the spectrum in addition to red. Gold ruby, for instance, transmits the red rays incompletely and at the same time lets some blue light pass. The selenium red is used universally by railways in this country for the danger signal, and tons of the comparatively rare element are consumed annually in preparing the glass.

In other railway signal glasses also this country is well in the lead, both in design of the semaphore lens and in production of the most efficient colors. Time was when each railroad had its own set of signal colors, the greens, for instance, ranging from blue-green to a yellow chrome-green, while the yellows varied from a reddish yellow to a green-yellow not far removed in hue from some of the yellow-greens. To straighten this confusion the glassmaking chemist called to his assistance the physicist and the physiological psychologist, and after years of collaboration the result today is for each color a universally adopted standard hue which affords maximum light transmission and maximum distinctiveness. The standard green gives more light than any other green and is less likely than any other green to be mistaken for another color, as yellow or blue. Similar standards now exist for each signal color. By the redesigning of the semaphore lens and the employment of the so-called high-transmission colors the intensity of the color-signal has been very greatly increased.

Low-Expansion Glasses

Another advance in glassmaking due to America was the introduction of low-expansion so-called heat-resisting glass for railway lantern globes. A trainman's lighted lantern set down on the car-platform or in the caboose is not unlikely to rest on a projecting brake-ratchet or on a broom handle, the result being that the flame plays directly against the glass. Then when the lantern is taken out into the rain or snow the overheated glass cracks and the signal fails—which in an emergency may be a matter of life or death. Chimneys of a thin glass of low expansion had been successfully used abroad. This glass, however, did not meet satisfactorily the severe conditions to which the thick-walled lantern-globe was subjected in service, and a glass was developed in this country for lantern-globes lower in expansion than any glass which had been made in commercial quantities up to that time. The low-expansion globes, both colorless and colored, are practically the only ones in use at present.

Glass for Electric Light Bulbs

Potash glass had always been considered essential for incandescent electric light bulbs, of which hundreds of millions are used annually. Glass chemists had developed non-potash glasses which appeared to have the same properties as the potash glasses, but the uncertainties involved in so radical a change were thought to outweigh the advantages, until the war, by excluding foreign potash, made action imperative. The non-potash glass has now been in use for some years and in many respects gives better results than the potash glass which it replaced. Except for certain special purposes a return to potash glass for bulbs in the future seems very doubtful.

This non-potash bulb-glass, however, like the potash glass and like all bulb-glasses from the beginning, contained 20 per cent or more of lead. One objection to the use of lead in glass is its cost. Even at its pre-war price of about 4c. per lb., it was an expensive glassmaking material, and during the war this price was doubled and trebled. Another drawback is the fact that among glassmakers there is a tradition that lead glass must be melted in pots and cannot be melted in a tank. Pot-melting is the old inefficient method of making glass, while tank-melting is the modern continuous op-

*Read at the Chemical Exposition, Chicago, Sept. 23, 1919.

eration adapted to the use of automatic conveying machinery for materials and to machine methods of working the glass. Two or three years ago a tank-melted bulb-glass was successfully introduced which contained neither potash nor lead, and its use has extended until a very large proportion of all lamp bulbs are now made of comparatively inexpensive materials by efficient labor-saving methods adapted to large-scale production.

Selective Spectrum-Absorbing Glass

In the field of glasses for transmitting or absorbing certain definite portions of the spectrum America appears to be at least abreast of her competitors.

There has been a demand for a glass which while absorbing as little of the visible spectrum as possible would afford the eye complete protection from the short wave-length ultraviolet. This has been accomplished in this country by development of a very pale but brilliant yellow glass which absorbs ultraviolet almost completely.

The glass just mentioned absorbs ultraviolet and transmits the visible light. Another recent American glass is unique in that it transmits ultraviolet and absorbs the visible. This ultraviolet has been called the invisible purple and is for the most part invisible. If all other light is excluded from the room, the radiation from an electric arc transmitted by this glass causes in the eye a puzzling and rather weird sensation of haze, owing to the fact that the eye cannot bring the rays to a focus as it can those of the visible spectrum. The weirdness is heightened by the ghastly appearance of teeth, eye-balls, finger-nails, etc., which like other fluorescent substances such as uranium glass, anthracene, rhodamite, willemite, change the invisible ultraviolet to visible light, which they radiate.

Welders' Glasses

For protection of operators of the electric-arc welding process from the radiation which if not guarded against causes serious burns of the skin and injury to the eyes, "welders' glasses" have been worked out which absorb not only ultraviolet but also infra-red and such excess of the visible light as causes glare. The light transmitted by these glasses is in the yellow green of the spectrum, in which visual acuity is highest.

Another unique glass absorbs only the infra-red. It is of pale-green color and transmits most of the visible, but in thickness of only 2 mm. absorbs 95 per cent or more of the invisible heat-rays. A piece of carbon paper so held in the rays from a projection lantern as to take fire almost at once is protected indefinitely if this glass is interposed. Ordinary glass is entirely ineffective. Eyeglasses of the heat-absorbing glass have a wonderfully comfortable and cooling effect in high-temperature work.

X-Ray Shield Glass

Various new glasses were developed to meet exigencies which arose during the war. One was a glass for X-ray shields which had about one-third the protective power of metallic lead of the same thickness and was the most effective glass used for the purpose up to that time. It formed part of a portable X-ray outfit used effectively close to the front lines in France. Colored glasses for marksmen, for naval gunners and for aviators, sextant glasses, special Fresnel ship lights, were other developments for direct use in connection with the war, and there were others which for military reasons are still held confidential.

Chemical and Cooking Utensils Glassware

The first high-grade chemical glassware made in this country was produced as long ago as 1902. It was fully equal to the best imported ware in resistance to chemical attack and was a low-expansion glass which could be heated directly over the flame without breaking. For 17 years, therefore, chemical glassware has been made in this country which for all practical purposes was on a par with the best foreign ware.

During the war other chemical glasses were put on the market, and today according to the findings of the Bureau of Standards at Washington better chemical glassware is made in this country than was ever imported.

With regard to resistance to chemical attack, the Bureau investigated flasks and beakers of five American brands with nine reagents each. Allowing one point for each of the 90 comparisons thus possible, the American brands score 60 points against 25 for the best foreign, 5 points being tied. Expressing the result in other words, this is equivalent to the American glasses having made a better showing in six of the nine reagents, an equal showing in one-half of one reagent, and a poorer showing in 2½ of the nine.

In power to withstand sudden cooling and in mechanical strength three American brands were found superior to the foreign, one of the American being far superior to all others in mechanical strength.

Apparatus built of the same glass used for flasks and beakers gave good service to chemical manufacturers during the war.

An expression from the Army medical authorities may be quoted as fairly typical of the enthusiasm of users of the American ware. They wrote that American flasks for preparing typhoid vaccine were far ahead of any such flasks ever obtained abroad; that the American glass had met the requirements so thoroughly that "aside from any sentimental reasons we would not take the foreign flasks if they were given to us."

In the same connection may be cited the fact that representatives of the American Chemical Society, the principal users of chemical glassware, appeared before the Ways and Means Committee of the lower house of Congress to urge that the domestic industry be fully protected by abolition of all duty-free importation of chemical glassware.

The glass baking-dish is a purely American development which seems to have established a permanent place for itself. The glass must possess the same qualities which are necessary for high-grade chemical glassware—resistance to the attack of water and dilute acids and alkalis, and low expansion-coefficient. A broad patent has been issued by the United States Patent Office on this invention. The unexpected feature of these dishes is the fact that baking takes place more rapidly in the glass than in metal, which has been shown to be due to the fact that glass reflects but a small per cent of the oven heat which is radiated upon it, while a metal utensil reflects 90 per cent or more of such heat.

Pots for Glass Melting

Before the war German clay had been considered essential to the manufacture of glass pots, but American clay pots are giving in every respect fully as satisfactory service as was had from the imported material.

A Rapid Method for the Analysis of Monel Metal

By Philip Covitz

BY COMBINING various well known rapid volumetric and gravimetric methods, an important saving of time without sacrificing accuracy is assured in analyzing monel metal, an approximate average percentage composition of which is:

Cu, 20 to 30; Ni, 60 to 70; Fe, 0 to 3.5; Al, 0 to 0.5; Mn, 0 to 3.5; C + Si, 0 to 0.8.

The usual procedure has been to dissolve a weighed quantity of the alloy (usually 1 gram) in nitric acid, filter off the silica and carbon, electrolyze the filtrate for copper, remove iron, aluminum and manganese by brominizing the ammoniacal electrolyzed solution, redissolve the precipitate and separate the elements; and finally determine nickel by the glyoxime method in the filtrate from the various precipitations. Carbon was obtained in a separate sample.

Separate Determinations

Inasmuch as all elements except carbon were determined on the same sample, precipitations and reprecipitations and washings resulted in the accumulation of large volumes of filtrates, which required considerable evaporation. The loss of time in concentrating filtrates should be avoided. In the method described below, this time factor is considerably reduced.

Carbon is determined by direct combustion in the Fleming apparatus.

Silicon is determined by filtering solution of metal before electrolysis, and ignition of the precipitate in a muffle.

Manganese is obtained by the bismuthate method on a separate sample.

Copper is found by usual electrolysis.

Nickel is determined directly on a separate sample, none of the elements interfering.

Iron and *aluminum* are separated from other elements in the solution of a separate sample, by precipitation with NH_4OH in presence of NH_4Cl. The precipitate is dissolved and the iron separated from the aluminum by boiling with KOH. The iron is then determined by the Zimmerman-Reinhardt process, while the aluminum is determined as $Al(OH)_3$ in the filtrate from the $Fe(OH)_3$.

Determination of Silicon

Weigh 1 g. of monel shavings into 200 cc. beaker, add 10 cc. HNO_3 (1.42), heat until dissolved and evaporate to approximately 7 cc. Dilute to 50 cc. with hot H_2O, filter through No. 42 Whatman 12.5 cm. paper into 300 cc. beaker. Wash thoroughly with hot H_2O, keeping volume of filtrate below 150 cc. Ignite and weigh SiO_2. If precipitate is heavy and discolored treat with HF and determine loss.

$$\text{Per cent Si} = 46.9 \times \text{SiO}_2 \text{ ppte.}$$

This method is open to criticism in that the silica is not dehydrated. In the opinion of the writer dehydration in most cases for silicon in monel metals is unnecessary. If the analyst should prefer it, however, the following procedure should be adopted:

Weigh 1 or 2 g. of borings in porcelain dish, add 10 cc. HNO_3 (conc.) and 5 cc. H_2SO_4 (conc.), evaporate cautiously to dryness, and heat until H_2SO_4 fumes freely. Cool, dissolve in 10 cc. conc. HCl, dilute to 50 cc. with hot H_2O, filter, wash with hot 1 to 1 HCl and hot H_2O, dry, ignite in muffle and weigh SiO_2. Do not use this filtrate for electrolysis.

Copper

Cool filtrate from SiO_2, make up to 150 cc., and add 5 cc. 1 to 1 H_2SO_4. Electrolyze, using a current of 1.5 amp. for 2 hours. Rinse electrodes, wash with C_2H_5OH, dry one minute in oven at 110 deg. C. and weigh deposited copper.

Iron and Aluminum

Weigh 1 g. of borings into 500 cc. beaker, add 10 cc. HNO_3, heat until dissolved, and dilute to 250 cc. with hot H_2O. Add 5 g. NH_4Cl, make ammoniacal, and boil 5 to 10 minutes. Allow precipitate to settle and filter through No. 40 Whatman paper (12.5 cm.). Wash thoroughly with hot H_2O. Reject filtrate. Transfer bulk of precipitate back to original beaker, pour hot 1 : 1 HCl through filter, and catch solution in this beaker. Wash paper free from iron. Warm beaker gently (do not boil). When precipitate has dissolved dilute to 250 cc. with hot H_2O, add 3 g. NH_4Cl and NH_4OH in excess. Boil 5 to 10 minutes, allow precipitate to settle and filter through No. 40 paper. Wash thoroughly with hot H_2O. Discard filtrate. Again dissolve precipitate as before, using as little HCl as possible, and wash filter thoroughly. Heat gently until iron is dissolved and add slight excess of 50 per cent KOH. Dilute to 150 cc. and boil 5 to 10 minutes. Let settle, filter through No. 40 and wash thoroughly with boiling H_2O. Save filtrate.

Iron

Place paper containing precipitate of $Fe(OH)_3$ into original beaker, add 10 to 15 cc. HCl and warm gently until precipitate dissolves. Add from dropper $SnCl_2$ solution drop by drop until decolorized, and then add 10 cc. $HgCl_2$ solution. Wash into 800 cc. beaker containing 400 cc. cold H_2O and 20 cc. preventive solution. Dilute to 600 cc. and titrate immediately with 0.03N $KMnO_4$ to end point which remains one minute. Conduct blank titration using same quantities of reagents.

To prepare 0.03N $KMnO_4$ dissolve 2 g. permanganate in H_2O and dilute to 2 liters; standardize vs. sodium oxalate. Preventive solution: dissolve 160 g. $MnSO_4$ in H_2O, dilute to 1750 cc.; add 330 cc. syrup H_3PO_4 (1.7) and then 320 cc. H_2SO_4 (1.84). Stannous chloride: dissolve 150 g. $SnCl_2$ in 250 cc. H_2O and 250 cc. strong HCl. Mercuric chloride: make up saturated solution with hot H_2O, allow to cool and filter.

Aluminum

To the filtrate from the $Fe(OH)_3$ add strong HCl in excess and boil thoroughly 10 to 15 minutes. Add excess NH_4OH and again boil 15 minutes. For small amounts of $Al(OH)_3$ it may be necessary to prolong the boiling and, in cases of traces of aluminum, standing over night in warm place is advisable. Filter off, wash precipitate thoroughly with hot H_2O, dry, ignite, and weigh as Al_2O_3.

$$\text{Per cent Al} = \text{wt. ppte.} \times 53.03$$

In some instances a trace of iron may dissolve on boiling the iron aluminum solution with KOH. This will of course show up with the Al_2O_3. In the event of any significant amount of Fe_2O_3 in the Al_2O_3 precip-

itate, purification may be obtained by fusing the combined oxides with KOH in a silver dish, dissolving the fusion in hot water and filtering off the Fe_2O_3. Aluminum may then be determined as indicated above.

Manganese

Weigh 1 g. borings into 300 cc. Erlenmeyer flask, add 20 cc. HNO_3, heat until dissolved and dilute to 60 cc. with hot H_2O. Add 1 g. sodium bismuthate and boil 5 minutes, or until permanganate color which forms is changed to brown. Now add 1 g. $FeSO_4$ and boil until brown fumes are expelled and the solution resumes its green color. Cool under tap to room temperature, add 1 g. bismuthate, agitate, and allow to stand 5 minutes. Filter by suction through asbestos and wash with 50 cc. 3 per cent HNO_3. Dilute filtrate to 300 cc. and titrate with ferrous ammonium sulphate solution to the disappearance of the permanganate color. A few trials will produce a satisfactory end point.

To prepare ferrous ammonium sulphate dissolve 30 g. $Fe(NH_4)_2(SO_4)_2.6H_2O$ in cold H_2O, make up to 2 liters and add 75 cc. concentrated H_2SO_4. Standardize against monel metal of known manganese content. In the absence of such, excellent results may be obtained by standardizing against a Bureau of Standards high-manganese steel (1 g. sample) to which has been added 0.25 g. pure copper, and, if available, 0.75 g. pure nickel. Three per cent nitric acid is made by diluting 60 cc. HNO_3 (1.42) to 2 liters.

Nickel

Weigh 0.1 g. borings into 200 cc. beaker, dissolve in 10 cc. HNO_3, dilute to 50 cc. with hot H_2O and filter into 500 cc. beaker. Wash thoroughly with hot H_2O and dilute to 300 cc. Add 10 cc. tartaric acid solution and make faintly alkaline with NH_4OH. Heat to 80 to 85 deg. C., add 50 cc. glyoxime solution, and allow to stand in warm place 15 minutes. Filter by suction through Gooch (which has been previously dried in oven at 110 deg. C. for 45 minutes, cooled and weighed) and wash thoroughly with hot H_2O. Dry at 110 deg. C. for 45 minutes, cool and weigh.

$$\text{Per cent Ni} = \frac{\text{wt. ppte.} \times 20.31}{\text{wt. sample}}$$

The following precautions should be observed: An excess of NH_4OH is harmful in that the red precipitate of nickel dimethyl glyoxime is slightly soluble in NH_4OH. The proper degree of alkalinity may be easily recognized by the appearance of the first permanent shade of the familiar copper ammonium blue. The solution should just barely smell of NH_4OH. The best temperature for precipitation is 85 deg. C.

In preparing the tartaric acid solution dissolve 150 g. crystalline tartaric acid in 300 cc. hot H_2O, filter and dilute to 500 cc.; in preparing the glyoxime, add to 4 g. dimethyl glyoxime in small flask 100 cc. ethyl alcohol. Connect flask to return condensor or to long piece of glass tubing, and warm on steam bath until the salt dissolves. Dilute to 500 cc. with C_2H_5OH, and filter.

Carbon

Run direct combustion on 1.3636 g. borings by any of the common combustion methods.

Gain in weight of absorption apparatus $\times$ 20 = per cent carbon.

The method advocated is one devised by William R. Fleming, metallurgist and chief chemist, Andrews Steel Co., Newport, Ky., with a few changes. (See *Iron Age*, Jan. 1, 1914.) The essential principle of this combustion is the rapid passage of oxygen through the combustion train (325 cc. per minute) and the short time of combustion (5 minutes). The absorption bulb is a double chambered apparatus (Sargent bulb), a large chamber containing 20, 40 and 60 mesh soda lime of 2 per cent moisture packed in alternate layers, and a small chamber containing P_2O_5.

The writer has found that it is safe to increase the time of combustion, and actually uses 15 minutes for combustion, especially on high carbon steels and cast irons. The furnace should be at 1000 deg. C. preferably, but should not fall below 950 deg.

Reports on Five Analyses

By running several determinations simultaneously, a monel metal may be analyzed with considerable accuracy in a few hours.

The following percentages were obtained by the above method.

Cu	25.88	28.92	28.70	28.34	27.59
Ni	68.41	67.05	66.65	66.12	67.25
Fe	3.09	1.75	2.26	2.58	2.48
Al	0.32	0.27	0.20	0.42	0.03
Mn	2.09	1.74	2.04	2.28	2.27
C	0.25	0.27	0.26	0.24	0.38
Si	0.02	0.02	0.02	0.04	0.02
	100.06	100.02	100.13	100.02	100.02

Cleaning and Pickling Iron and Steel for Enameling Purposes

A paper on this subject by Mr. R. R. Danielson of the Bureau of Mines was drawn up for presentation at the meeting of the American Ceramic Society, Sept. 24, 1919, but arrived too late for the meeting. It deals with the several phases of cleaning discussed under the following heads:

(*a*) Removal of grease.
(*b*) Removal of oxides.
(*c*) Neutralizing baths.
(*d*) Drying of wares.

Under the subject of grease removal, a list of the various types of chemical grease removers is given and the procedure for using them on a commercial basis is taken up. The advantages and disadvantages of scaling and cleaning are discussed. Considerable part of the paper is devoted to the problem of pickling with the various acids. Special attention is given to the use of niter cake as a substitute for acids and data are presented on the use of this material in commercial work.

Under the head of neutralizing baths, the development of mottling of gray ware enamels is discussed. The composition of a prepared neutralizing agent is given and the results are compared with those obtained with the use of soda ash on metal prepared for ground coating. The object of the paper is to present general data from cleaning and pickling practice as a guide for investigative work on the various problems of these processes. The paper in full will be printed in the *Proceedings* of the American Ceramic Society.

The Civil Service Commission announces that open competitive examinations for laboratory assistant (men only) will be held Feb. 4-5 and March 3-4, 1920.

Dangers in the Dyestuff Industry*

A Review of Incidental Accidents Due to Inexperience in New Industries, With Special Reference to the Dyestuff Industry—Explosion Risks of Dyes and Intermediates, of High Pressure Apparatus and of Inflammable Vapor Mixtures

By Dr. L. C. CONE,
National Aniline & Chemical Co., Buffalo, N. Y.

THE amount of danger in any industry is in inverse ratio to the knowledge and experience of the organization operating that industry. If a green crew, under the control of an inexperienced foreman, is employed in even so simple an operation as ice-cutting, there are bound to be accidents. The dyestuff industry of this country has been, in comparison with our older established industries, in the class of the above ice-cutting experiment. As a further complication added to inexperience has come the insistent demand for a large tonnage production of new products. These conditions have accentuated the dangers to such an extent that many serious accidents have resulted. Statistics gathered from our dyestuff and intermediates factories during the past five years would give a rather alarming picture of the risks of the business. There has been, however, on the part of the more stable companies engaged in the industry, no lack of appreciation of the nature of the risks involved. As a result of this appreciation of the dangers, constant progress is now being made in reducing the number and severity of accidents.

Inexperience a Source of Danger

Before we forget the hectic experience of the past five years some chemical genius, with a power of description and a keen sense of humor, should write the story of the war-time chemical development of this country. Many events in this development have the elements of sublimely ridiculous humor in them. One instance I have in mind where two college boys, without industrial experience, rented an old, abandoned, windowless brewery, with broken wooden floors, and a couple of rusty boilers. In this building they installed a makeshift aniline plant, and, in spite of every handicap, made aniline and sold it at a profit. It took American ingenuity and grit to make this plant go, and perhaps it also required American inexperience. An experienced aniline operator would have foreseen too many dangers to have ever started the project. Statistics of accidents from that and similar plants could hardly be considered the normal risk of our business. The proprietors themselves were always blue about the lips, and many a night they were just able to struggle home, get into a tub of warm water, drink a glass of milk, take a dose of salts, and go to bed. Is it not a wonder that, with the large number of such plants scattered all over the country, built by inexperience, and operated in spite of all hygienic laws, that the list of fatal accidents has not been greater? Gradually, however, we have been learning, partly by experience and partly by study, more about the risks of our business until today the hazards of the well-regulated dyestuff factory are little greater than the hazards of any mechanical plant containing a large and varied assortment of moving machinery. The chemical risks of the industry are largely centered about the manufacture of intermediates. The dangers of aniline, nitrobenzol, dinitrobenzol, dinitrotoluol, etc., have been so frequently discussed, and the methods used by companies like our own for minimizing the risks of these manufactures so thoroughly described, that there is no need to go into this matter at this time.[1]

Our company has never suffered a fatality from any of these poisons, although we have had some very sick men. Under the conscientious watchfulness of Dr. Kessler, of our Marcus Hook plant, the number of such cases has become relatively small. I am certain that if any safety man desires further detailed information in regard to our methods of handling these cases, Dr. Kessler in response to an inquiry would be more than willing to acquaint him with our experience.

Practical Results of Safety Work

The experience of our Buffalo works is the most illuminating experience of any of our plants, because in that factory is concentrated practically every risk of the dyestuff industry. While we do not make aniline there, we handle enormous quantities of the product under a very wide variety of conditions. We make and use large quantities of dinitrobenzol, dinitrochlorbenzol, and other poisonous products. In the first six months of 1918, as shown in the table, our serious chemical accidents were 21 in number against 59 of a mechanical nature, or 26.2 per cent. The first six months of 1919 there were 13 severe chemical accidents against 36 severe mechanical accidents, or 26.5 per cent. These figures, taken from a report by Mr. Doepke, our safety engineer, show that even under the rather strenuous conditions of high production prevailing during these periods, and during the very unsatisfactory labor conditions of 1918, the mechanical accidents far surpassed the chemical accidents. A closer analysis of the accident chart herewith will show that the majority of these accidents are of the preventable type. Acid burns, alkali burns, fume poisoning and eye accidents can, by education and constant watchfulness, be avoided, or at least reduced to a very low point.

Explosion Risks

Omitting further discussion in regard to these ordinary causes of chemical accidents, I wish to call attention to what I consider to be the greatest hazard of the dyestuff industry today, at least from the standpoint of severity of results. This is the explosion risk. From this cause alone we suffered three fatalities in 1918. These fatalities occurred in one instance where a considerable quantity of explosive dye ignited and killed three men. Records of the dyestuff industry,

*Read at the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, October, 1919.

[1] *J. Ind. Eng. Chem.*, vol. 8, pp. 573, 1161; (1916).

during the last two or three years especially, have been full of reports of similar accidents at other plants. The disastrous fire at the plant of the Atlantic Dyestuff Co. in Nyack, N. Y., was caused by an explosion. According to the Sept. 1 issue of the *Journal of Industrial and Engineering Chemistry* (p. 893), there was recently another serious dyestuff explosion in Boston, Mass. Practically every dyestuff company in the country has had more or less experience along the same lines. This is a hazard which chemists and safety men must inform themselves about and which they must guard against more carefully. The greatest risks of explosions about dyestuff plants are three in number: Explosions of dyes and intermediates, explosions of pressure kettles, and explosions of vapors mixed with air.

Explosion of Dyes

The type of explosion which has caused our greatest loss is the explosion of dyes themselves. We have been prone to forget that dyes are organic compounds, some of them closely related to explosives. We have not accustomed ourselves to consider each new dye as a possible explosive, but have gone ahead, powdering and grinding our products in blissful ignorance until an accident has called our attention to the danger. A dye widely used for khaki shades on wool during the war was known as chrome yellow. This was made in very large quantities, dried, ground, packed, and shipped. It is doubtful if a single producer of this dye tested this material for its explosive properties before he began to produce it on a commercial scale, yet, as I can quickly demonstrate to you, by igniting a small portion of the dye, its quick burning properties render it more dangerous than many of our violent explosives. It is further doubtful if a single producer of this dye escaped the penalties of his failure to test the product. One large producer informed me that the total profits from his company's manufacture of this dye had been lost through disastrous fires and accidents. The same thing is true of another widely used chrome dye, which is frequently known as metachrome brown. This product has been the cause of at least three disastrous explosions in different companies to my own knowledge. With these experiences in mind we shall be very remiss in our duties if we do not examine every new dye for its explosive properties. A general rule, well known to chemists who have dealt with explosives, indicates what classes of dyes are apt to develop explosive characteristics. This rule may be summed up very roughly as follows: "Be extremely critical toward dyes which are to be handled in the form of dry powders unless they are well supplied with sulphonic acid groups."

Even after the dye is given a clean bill of health by the chemist because of its composition, it would not be remiss to have the dye tested before drying and powdering. This is a service which the dye producers owe to their consumers as well as to their employees, for many dyes are mixed in mills and exposed to conditions which might produce explosions.

Explosion of High Pressure Apparatus

With this danger of dye explosion eliminated, the next explosion risk which the chemical industry faces is that of pressure kettles. Chemistry at high pressure has only begun its development in this country. Processes which have normally been considered impossible are gradually being carried out under conditions of high pressure. The best illustration of this is the Haber synthesis of ammonia from nitrogen and hydrogen. This reaction will not take place between the two gases under atmospheric pressure, but when the two gases are brought together at very high pressure in the presence of a catalyst at elevated temperature, the two unite to a certain extent to form

COMPARATIVE ACCIDENT REPORT, 1918-1919—FREQUENCY AND SEVERITY

1918					January-July	1919					
No. Accidents Time Lost	No. Days Lost	No. Minor Accidents	Per Cent Frequency	Per Cent Severity	Nature of Accident	No. Accidents Time Lost	No. Days Lost	No. Minor Accidents	Per Cent Frequency	Per Cent Severity	
52	321	268	71.11	15.05	A. Non-Chemical Injuries 1. Traumatic Lesions—Head, Trunk, Extremities 2. Burns	35	361	165	73.26	38.16	
1	29	16	3.78	1.36	Steam and Water	..	...	13	4.76	.....	
2	8	8	2.44	0.38	Hot Liquids	..	...	11	4.03	.....	
1	13	3	0.89	0.60	Flames	..	...	...	.....	.....	
					3. Electrocutions	1*	360	...	0.37	38.06	
2	33	9	2.44	1.55	4. Eye Accidents — Grinding, Chips, etc.	..	...	1	0.37	.....	
59	404	304	80.66	18.94		36	721	190	82.79	76.27	
					B. Chemical Injuries						
1	3	20	4.67	0.14	1. Acid Burns	1	48	7	2.93	5.08	
..	...	16	3.56	.....	2. Alkali Burns	1	2	10	4.03	0.21	
3*	1605	....	0.67	75.25	3. Explosion Burns	..	...	...	.....	.....	
					4. Fumes	..	...	...	.....	.....	
3	11	2	1.11	0.51	Nitrous—Sundries	..	...	1	0.37	.....	
5	17	1	1.33	0.80	Nitrochlorbenzol	6	64	1	2.56	6.77	
1	8	....	0.22	2.38	Nitrobenzol	..	...	...	.....	.....	
1	4	....	0.22	0.19	Meta-Phenylenediamine	1	2	...	0.37	0.21	
					Dinitrobenzol	2	12	...	0.73	1.26	
1	55	....	0.22	2.58	Aqua Ammonia	..	...	...	.....	.....	
					Hydrogen Sulphide (H_2S)	2	97	...	0.73	10.25	
2	15	2	0.89	0.70	5. Aniline Poisoning—Fumes and Absorption	..	...	...	.....	.....	
					6. Eye Accidents						
2	6	15	3.78	0.28	Acids—Colors	..	...	8	2.93	.....	
2	5	10	2.67	0.23	Alkalis	..	...	7	2.56	.....	
21	1729	66	19.34	81.06		13	225	34	17.21	23.78	
	Total Non-Chemical		80.66	18.94			Total Non-Chemical		82.79	76.22	
	Total Chemical		19.34	81.06	(3 deaths)		Total Chemical		17.21	23.78	(1 death)
	Grand Total		100.00	100.00			Grand Total		100.00	100.00	

* Fatal Accidents—Customary charge for each case of death—360 days.

ammonia. With the growth of our American chemical industry, reactions of this type will be more and more largely introduced into our manufacturing plants. As they are introduced, the explosion hazard will become greater and greater, and the safety men must co-operate closely with the technical engineers to see that every possible precaution is taken against disastrous results to our workmen and to our plants. It has been rumored that the very important intermediate, paranitraniline, has been made commercially by only one process in this country because another process, which offers many advantages, has a great explosion risk connected with it owing to very high pressure. If the American dyestuff industry is to be permanently successful, it must not permit itself to be restrained because of high pressure explosion risks. The control of this risk is primarily of course a technical engineering problem, but after the engineering lay-out is complete the safety man will find his opportunity to provide such appliances and such conditions as will give minimum destruction to life and property in case the engineering equipment ever fails.

Explosion of Inflammable Vapor Mixtures

The risks of explosion due to the ignition of mixtures and combustible vapors with air are already thoroughly appreciated by the technical and safety men. I only wish to call attention to the fundamental principles which must be followed in safety precautions to avoid explosions of this kind. While every effort to keep flames away from inflammable mixtures is commendable, these precautions alone will never entirely prevent ignition of explosive mixtures. Every effort must be concentrated on preventing the formation of such mixtures. Many disastrous explosions have occurred where every precaution has been taken to avoid the presence of all sources of fire. It is never possible to entirely do away with the chance formation of either frictional or electrical sparks. These are apt to be formed at most unexpected times, and at these times, if an explosive mixture of air and vapor is present, an unexplained disaster results. One of the most disastrous explosions I have ever witnessed, in which a large and well equipped plant was completely destroyed, was due to a chance frictional spark.

Static Discharges Must Be Guarded Against

As an illustration of the extreme difficulty of preventing ignition by chance sparks I will cite a case of my own observation where a large amount of toluene was stored in a glass enameled steel tank. It never occurred to the operators that a glass enameled steel tank is an ideal electrical condenser. The contents of the tank were not grounded in any way. A leak of toluene from the bottom valve soaked the floor under the tank; the workman, in attempting to repair this leak, made connection between the contents of the tank and the floor through a wire in his hand; the toluene on the floor immediately became ignited. Quick-witted workmen threw a few shovels of snow, which happened to be convenient, over the burning toluene and succeeded in smothering the flame before it ignited the tank.

For handling problems of this kind the safety engineer must have a very clear appreciation of the fundamental principles of both physics and chemistry, and must further work in close touch with the technical men of his own organization. By such close co-operation and careful study of each accident that occurs it will be gradually possible to eliminate the explosion risks of our industry.

Legal Notes

Exclusive License of a Patented Chemical Process Not a Sale of Business in a Foreign Country

By Wellington Gustin

THE distinction between the "sale" of a chemical company's foreign business and its contract to license the manufacture and sale of its products under the patents held by it in a foreign country was recently decided by the Supreme Court of Massachusetts (Arnold vs. North American Chemical Co., 122 N. E., 283). The inventor of a patented shoe "filler" brought suit against the defendant chemical company to recover his part of the proceeds of what he claimed was a sale of its foreign business.

Referring to the facts, it appears that the defendant chemical company, in a written contract with the plaintiff, agreed "that if it ever sells the filler business for Canada or for any foreign country," it would pay him a proportionate part thereof. The question for determination was whether the defendant had become liable under this clause of the contract.

The "filler business" was the right to manufacture and sell a certain trade-named shoe filler, a patented article used in the manufacture of shoes.

Terms of the Contract

After entering into the contract as stated above, the defendant chemical company made a contract whereby it granted to a British corporation, which theretofore had been its sole agent to sell this patented product in England, "an exclusive license under the patents in the territories of Great Britain and Germany to manufacture, use, exercise and sell this shoe filler from 1908 to August, 1919, subject to the further terms and conditions of the agreement, with right to assign the license or to grant sub-licenses therefor." Other terms and conditions followed as to the furnishing to the defendant by the British corporation of patterns of "outfits" and of the chemical compound required for the manufacture.

At the end of five years either party might terminate this part of the contract by one month's notice, whereupon the defendant was to furnish the British licensee with the formula by which to make the compound and further instructions as to its preparation, if necessary under some restrictions as to time. The payment to the defendant for these rights was a gross sum in several installments. In this connection it was stipulated that in the event the defendant should default for 21 days in furnishing the chemical compound required by the British licensee, the latter would have the option either to demand the formula with which the compound was made, with instructions as to its preparation, or to require a refund of all payments made to the defendant under the contract.

It was further provided that in case the British licensee should bring suit against any infringer of the patents before 1910 the defendant would bear half the court costs, lawyers' fees, etc. The defendant agreed to make no sales of the filler except for its American trade, and agreed also to pay one-half the British income tax in five annual payments.

In 1914 a supplemental agreement was entered into extending the term of the license for a further term of five years on six months' notice to the defendant.

This they called a "license extension." It was recited that the British corporation desired to discontinue its obligations as to Germany, and the defendant thereafter was to relieve it from paying German taxes and was to have the privilege of selling the product in Germany, Australia and South America. Defendant was to continue to supply the British corporation the compound for the manufacture of the filler on stipulated terms.

Was the Contract a Sale?

Since the plaintiff sued to recover under his contract with defendant, claiming a sale of the filler business for Canada and other foreign countries by the latter, the point decided by the court was whether these two contracts between the British licensee and defendant constituted a sale of its business in a foreign country.

There was no evidence introduced showing the patent laws of either England or Germany touching the sale or assignment of patent rights that might limit these contracts, therefore the court held that the words of the contracts and the acts of the parties were to be construed according to the common law principles prevailing in the State where the contract was made.

Definition of a Sale

The court defined a sale to be "the transfer of property from one person to another for a consideration of value." The word "sale," it said, had a well-defined meaning. It implies the passing from the seller to the buyer of the general and absolute title to property as distinguished from a special interest, a bailment, a license, a lease, a pawn, or other limited right falling short of complete ownership. Therefore it is plain that the contract between the defendant and the British corporation in form was not a sale. They called it an "exclusive license." Those terms imply a privilege or authority granted to another by one who possesses and retains a superior right or power. Applied to a patent it signifies the assignment by the patentee to another of rights less in degree than an interest in the patent itself. The law, however, will not be bound by the form of the transaction, but will look to the interest of the parties, considering all the words used, in order to determine whether there has been a sale.

Court Holds This Was a License, Not an Absolute Transfer

From this test the contract confers a license and is not the equivalent of a sale or absolute transfer. It was limited in point of time, for the period during which the British corporation had rights under the patents was definitely restricted, and well may have been less than for the term for which the patents were issued in England and Germany, as the unexpired term of these patent rights did not appear in the record.

Referring back to the terms and stipulations of the two contracts with the British corporation, they will be seen to impose restrictions and limitations and conditions such that the combined effect of these clauses demonstrates that the entire title to the patents in Great Britain was not transferred to the British corporation, and hence they did not amount to a sale. The obligation on the defendant to pay part of the expenses of litigation for infringement and to bear a part of the income tax, and the retention by the defendant of the formula of the compound show a retention of an interest, however small, in the British and other patents.

The other conditions which have been enumerated are confirmatory of an intention, as expressed in the contract, by the defendant not to sell and by the British company not to buy the "filler business." Without the aid of the defendant the plaintiff could not use the patent monopoly business in Great Britain.

Therefore, the court ruled, the effect of the written instruments was to grant a license and not to make a complete transfer, and judgment for defendant was affirmed.

Measure of Damages for Failure to Deliver Acid Under Contract

In an action founded upon a breach of contract a writ of attachment was quashed by the court for the reason that the damages for the breach were unliquidated. (T. J. Parker, Inc., vs. Anthony Hammond Chemical Works, 107 A., 44.) The plaintiff appealed from this order of the trial court to the Supreme Court of New Jersey.

From the plaintiff's case it appears that it entered into a contract with the defendant for the sale and delivery of 2,000 lb. of benzoic acid at $2 a lb., the delivery to be made in parcels of 500 lb. each and to begin in the first week of December, 1917, and to continue thereafter each week until the delivery was complete. The defendant failed to perform the contract, and plaintiff sought to recover the damages sustained by it by reason of this failure of performance and obtain its writ of attachment against the defendant.

Distinction Between Liquidated and Unliquidated Damages

The court said that on its face this was an action for unliquidated damages for which an attachment should not be granted. But plaintiff's claim to sustain its writ was that the damages are liquidated, in that after the breach of contract it went into the market and purchased 2,000 lb. of benzoic acid at $4.75 per lb., the daamges being definite and ascertainable by mere computation, the sum due being the difference between the contract price of $2 and the purchase price of $4.75.

However, the purchase by plaintiff was not made until more than a month after the time for the completion of the delivery under the contract had elapsed. Hence, the court said, this claim of plaintiff rested on an unsound basis. Ordinarily the difference between the contract price and the value of the goods at the date fixed for delivery is the measure of damages. In this case, whether the price paid was the fair market value of the acid at the time fixed for its delivery and whether the acid which was actually purchased was of the same character and value as that contracted for are questions to be determined by the jury and upon its determination the amount of the recovery would depend.

What the jury might determine is uncertain, and where the amount of the recovery depends on the finding of the jury upon these points the damages are, of course, unliquidated. Therefore the court held that a claim for damages for failure to deliver goods in pursuance of an executory contract of sale is a claim for unliquidated damages, and plaintiff's writ of attachment was quashed.

Copper-Aluminum-Iron Bronze as an Acid-Resisting Alloy

By O. L. Kowalke

ALTHOUGH much has been written concerning copper-aluminum-iron bronze for bearings, gears, etc., in machinery, there does not appear to be much data available on its acid-resisting properties. In tensile strength and ductility it ranks with mild steel; it can be easily machined to a nice finish; it can be forged while hot and also rolled into sheets. Sound castings of a wide range in size can be made of it free from shrinkage-holes or blow-holes.

A number of other alloys have been studied in the University of Wisconsin laboratories for their acid-resisting properties, but most of them were rather weak mechanically. The satisfactory mechanical properties of copper-aluminum-iron bronze prompted a study of the resistance to corrosion in acids and alkalis. Commercial bronzes were preferred over those made in the laboratory. Through the courtesy of the American Metal Products Co., Milwaukee, Wisconsin, several commercial bronzes were obtained for these tests, but the results on two only, Bronzes A and B, whose average compositions and properties are given below, will be reported here.

Composition:	Bronze A	Bronze B
Copper	87.0 per cent	85.6 per cent
Aluminum	9.8 per cent	10.81 per cent
Iron alloy	3.14 per cent	3.57 per cent
Ultimate unit stress	74,800 lb. sq.in.	66,600 lb. sq.in.
Per cent reduction in area	19.0 per cent	13.0 per cent
Per cent elongation in 2 inches	21.0 per cent	11.5 per cent
Specific gravity	7.71	7.58

The specimens for the corrosion tests were practically uniform in size, having dimensions approximately 1 in. long by 0.07 in. wide by 0.07 in. thick, were finished smooth, and had square edges. Each specimen was stamped to identify it for composition and serial number, and its total surface was measured so as to determine the corrosion per square inch.

Most of the corrosion tests were made at room temperatures, 72 deg. F. and 85 deg. F.; a few tests were made at 194 deg. F. The regular "C.P." acids of the laboratory were used and made up to strengths desired by titration methods. For the tests at room temperatures the various acids were put into covered beakers in amounts of 200 cc. Two specimens of bronze were set on edge in each beaker in such manner that all the surface was exposed to acid and that they did not touch each other. The specimens were removed periodically, washed in water, dried thoroughly, and then weighed on an analytical balance. The combined loss in weight of both specimens was then computed as loss per square inch. For the corrosion tests at higher temperatures wide-mouthed flasks were provided with rubber stoppers through which were inserted glass tubes 3 ft. long, open at both ends, to serve as condensers. An electrically heated oven kept the flasks and contents at an average temperature of 194 deg. F. In other respects the procedure was identical with that at room temperature. The results of the tests are given in Tables I and II for Bronzes A and B respectively.

It will be noted in Table I that Bronze A is resistant to several acids and particularly to sulphuric, lactic, phosphoric, tartaric, and acetic. Nitric acid attacks the metal readily, the concentrated acid acting violently. Hydrochloric acid and aqua ammonia both attack the metal too readily for commercial purposes. Caustic soda makes but little inroad on this metal either hot or cold; the slight gain during corrosion at 194 deg. F. is due to the formation of a film that was difficult to remove by rubbing with a cloth.

Table II gives the results for Bronze B, and the striking fact is the resistance to corrosion in sulphuric acid. By increasing the aluminum in this metal 1 per cent, the iron alloy about ½ per cent over the proportions in Bronze A, the resistance to corrosion is materially increased, even though the average temperature was 13 deg. F. higher. Nitric acid also attacks Bronze B too rapidly; hydrochloric acid attacks it more readily than Bronze A. Ammonia does not corrode this metal so readily as Bronze A.

TABLE I—BRONZE A
Cumulative Loss in Grams per Square Inch

	Sulphuric Acid			
	Temperature, 72 Deg. F.			Temperature, 194 Deg. F.
Days	50 per Cent	35 per Cent	10 per Cent	35 per Cent
7	0.0125	0.0033	0.0090	0.0094
14	0.0167	0.0075	0.0178	0.0624
21	0.0212	0.0131	0.0278	0.2016
28	0.0246	0.0177	0.0365	0.2520
		Hydrochloric Acid		
7	.....	0.0484	0.117	.....
14	.....	0.2010	0.924	.....
21	.....	0.781	1.73	
28	.....	.....	1.90	...
		Ammonia		
7	0.130	0.185	0.112	..
14	0.350	0.435	0.194	.....
21	0.531	0.640	0.413	.....
28	0.700	0.850	.....	.....
		Caustic Soda		
7	0.0005	0.0006	0.0010	*0.0014
14	0.0006	0.0006	0.0024	*0.0014
21	0.0008	0.0013	0.0036	*0.0021
28	0.0007	0.0016	0.0055	*0.0020
		Lactic Acid		
7	0.0025	0.0031	0.0031	0.0130
14	0.0051	0.0062	0.0077	0.0538
21	0.0082	0.0097	0.0126	0.0980
28	0.0111	0.0132	0.0168	0.1550
		Phosphoric Acid		
7	0.0025	0.0040	0.0056	0.0002
14	0.0046	0.0078	0.0113	0.0004
21	0.0081	0.0132	0.0197	0.0083
28	0.0114	0.0181	0.0281	0.0395
		Tartaric Acid		
7	0.0009	0.0015	0.0026	0.0013
14	0.0014	0.0025	0.0044	0.0029
21	0.0022	0.0037	0.0061	0.0099
28	0.0028	0.0046	0.0077	0.0155
		Acetic Acid		
7	0.0081	0.0076	0.0046	0.0026
14	0.0170	0.0139	0.0092	0.0083
21	0.0299	0.0243	0.0173	0.0398
28	0.0386	0.0312	0.0221	0 0713

* Gain.

TABLE II—BRONZE B
Cumulative Loss in Grams per Square Inch

	Sulphuric Acid		
	Temperature 85 Deg. F.		
Days	50 per Cent	35 per Cent	10 per Cent
7	0.0016	0 0020	0.0056
14	0.0016	0 0029	0.0072
21	0.0018	0 0035	0.0095
28	0.0024	0 0044	0.0120
35	0.0025	0 0049	0.0145
		Acetic Acid	
7	0.0156	0.0087	0 0076
14	0.0300	0.0183	0 0154
21	0.0492	0 0302	0 0256
28	0.0689	0.0442	0.0334
35	0.1001	0 0559	0 0447
		Ammonia	
7	0 0144	0 0302	0 0868
14	0.1376	0 1993	0 [illegible]
21	0 2733	0.2806	0 2237
28	0.3810	0.3406	
35	.....	0.3791	
		Caustic Soda	
7	...	0 0015	0.0026
14	...	0 0016	0.0045
21		0.0019	0 0059
28	...	0.0022	0 0072
35		0.0025	0 0078

It is interesting to note from the results below that the corrosion in 35 per cent sulphuric acid of a forged specimen of Bronze A is only about one-half that of the rolled sheet and cast varieties.

CORROSION OF FORGED, ROLLED SHEET, AND CAST BRONZE A IN SULPHURIC ACID 35 PER CENT.

Cumulative Loss in Grams per Square Inch at 72 Deg. F.

Days	Forged	Rolled Sheet	Cast
7	0.0014	0.0034	0.0033
14	0.0028	0.0066	0.0068
21	0.0041	0.0113	0.0111
28	0.0055	0.0136	0.0144

Chemical Engineering Laboratory,
University of Wisconsin,
Madison, Wis.

Cost of Copper in 1918

IN submitting a report on the cost of producing copper for 1918, covering 85 companies, 95.5 per cent of the United States production, the Federal Trade Commission remarks that the reduction of prices by the Government did not hinder the maximum production nor prevent the very high earnings of copper companies. Table I shows the relation between production and prices, and despite the forced reduction in price by quarters in 1917 from 33.7c. to 32.4c., to 27.2c. and to 23.5c. per lb., production was practically stationary.

TABLE I. RELATION BETWEEN PRODUCTION AND PRICES

Year	Production,* Lb.	± %	Price in New York † Electrolytic, Cents
1913	1,224,484,098	.....	15.5
1914	1,150,137,192	—6.07	13.3
1915	1,388,009,527	+20.68	17.5
1916	1,927,850,548	+38.89	28.5
1917	1,886,120,721	—2.16	29.2
1918	1,908,533,595	+1.19	24.7

* U. S. Geological Survey.
† War Industries Board.

Again, on an aggregate investment of $672,000,000 it seems that about 30 cents investment is required to produce a pound of copper yearly. The profit per pound is shown by Table II to be 8.34c., or at an actual average rate of 28 per cent.

As a matter of fact 6 porphyries producing 570 million pounds netted 41.84 per cent; 6 lake companies producing 100 million pounds netted 46.97 per cent, and 6 other companies producing 424 million pounds netted 52.29 per cent. Another view of the matter is to be had from Table III, which shows that nearly half of the copper was produced for less than 16c, (and sold at 24.6c), while 85 per cent of the production cost less than 20c.

TABLE II. COST AND PROFITS PER POUND OF COPPER AND RATE OF RETURN ON INVESTMENT FOR "PORPHYRY," "LAKE" AND OTHER COMPANIES, BY COST GROUPS, FOR THE YEAR 1918

Group	No. of Companies	Production	Per Cent of Production	Weighted Average Cost, Cents	Weighted Average Selling Price, Cents	Profit or Loss per Pound, Cents	Investment per Pound, Cents	Per Cent of Return on Investment
Porphyry	11	778,360,356	34.47	14.886	24.672	9.786	28.803	33.98
Other....	53	1,253,767,585	55.52	16.700	24.388	7.688	29.779	25.82
Lake.....	21	226,106,184	10.01	17.622	24.637	7.015	33.000	21.26
Total and average	85	2,258,234,125	100.0	16.167	24.511	8.344	29.765	28.03

TABLE III. QUANTITIES OF COPPER PRODUCED IN 1918 AT DIFFERENT RATES OF COST PER POUND

Item	No. of Companies	Production, 1918	Per Cent of Total	Accumulated, per Cent
Cost less than 12 cents.....	2	122,245,051	5.41	5.41
Cost between 12 and 13 cents..	4	208,571,191	9.24	14.65
Cost between 13 and 14 cents..	4	314,653,177	13.93	28.58
Cost between 14 and 15 cents..	4	359,617,743	15.92	44.50
Cost between 15 and 16 cents..	2	98,307,293	4.35	48.85
Cost between 16 and 17 cents..	8	460,528,645	20.39	69.24
Cost between 17 and 18 cents..	9	255,399,696	11.32	80.56
Cost between 18 and 19 cents..	3	72,373,388	3.20	83.76
Cost between 19 and 20 cents..	5	28,491,436	1.26	85.02
Cost between 20 and 21 cents..	5	36,871,193	1.63	86.65
Cost between 21 and 22 cents..	9	135,538,602	6.00	92.65
Cost between 22 and 23 cents..	3	60,861,465	2.70	95.34
Cost between 23 and 24 cents..	5	44,919,772	1.99	97.32
Cost between 24 and 25 cents..	1	6,230,694	0.28	97.66
Cost between 25 and 26 cents..	3	7,605,224	0.34	97.90
Cost over 26 cents.....	18	46,119,555	2.04	100.05
Total all companies reporting	85	2,258,234,125	100.0	.....
Approximate pounds duplicated ..		63,700,000	.....	.....

For the purposes of the Commission the term "cost per pound" is the cost of a pound of marketable copper at the Atlantic seaboard, including all items of labor, material, supplies, overhead, depletion and depreciation, but does not include interest, or income or excess profits taxes. Precious metals and by-products are credited. Production was reckoned by the quantity of copper in ore or concentrate, less smelted deductions, or by the smelter output.

TABLE IV. AVERAGE COST OF PRODUCTION OF COPPER BY OPERATIONS AND BY GEOGRAPHICAL DIVISIONS, AND PERCENTAGE OF EACH ITEM OF COST TO TOTAL, FOR THE YEAR 1918

Operation	Arizona and New Mexico Cost per Pound	Utah, Nevada and California Cost per Pound	Montana, Idaho and Washington Cost per Pound	Michigan Cost per Pound	Other United States Cost per Pound	Mexico, Cuba and South America Cost per Pound	Canada and Alaska Cost per Pound	All Companies Reporting Cost per Pound
	Weighted Average Costs							
Pounds produced	863,493,944*	350,323,659†	331,624,111‡	226,106,184	15,838,808	350,764,079	120,093,340	2,258,234,125
Mining	$0.05615	$0.04277	$0.10858	$0.10693	$0.06403	$0.05532	$0.06198	$0.06946
Depletion of ore at cost	.00627	.00528	.01225	.00508	.00385	.00718	.00999	.00720
Purchases of ore	.01056	.00649	.01613	.....	.00403	.00053	.....	.00515
Transportation to reduction plant	.00648	.01731	.00436	.00748	.00656	.00491	.01903	.00837
Reduction	.05278	.07800	.05165	.04551	.10988	.06939	.05523	.05891
Transportation to refinery or seaboard	.00728	.00743	.00722	.00416	.00500	.01782	.00620	.00854
Refining	.01183	.01272	.01211	.00114	.01106	.00692	.01398	.01029
General and administrative	.00899	.00892	.00432	.00742	.01730	.01373	.01007	.00899
Selling expense	.00189	.00169	.00025	.00061	.00194	.00421	.00241	.00188
Credit for precious metals	.01048	.01260	.04262	.00211	.02455	.02353	.01626	.01712
Total cost	$0.15175	$0.16801	$0.17425	$0.17622	$0.19910	$0.15648	$0.16263	$0.16167
Labor	$0.04424	$0.04464	$0.09473	$0.07832	$0.06995	$0.02915	$0.04611	$0.05307
Materials and supplies	.03242	.04119	.04296	.05050	.06536	.03031	.04386	.03764
Overhead	.01851	.01428	.01784	.01096	.04907	.04826	.01117	.02145
Depreciation	.00686	.00692	.01170	.01261	.01299	.01207	.01520	.00945
Depletion	.00627	.00528	.01225	.00508	.00385	.00718	.00999	.00720
Tolls	.05393	.06830	.03739	.02086	.02243	.05305	.05256	.04998
Credits	.01048	.01260	.04262	.00211	.02455	.02354	.01626	.01712
Total	$0.15175	$0.16801	$0.17425	$0.17622	$0.19910	$0.15648	$0.16263	$0.16167

* Approximate duplication 23,500,000 lb.
† Approximate duplication 4,400,000 lb.
‡ Approximate duplication 35,800,000 lb.

TABLE V. COMPARATIVE COSTS OF PRODUCING COPPER BY OPERATIONS OF FIVE GROUPS OF REPRESENTATIVE COMPANIES FOR THE YEAR 1918

Operations	(a) Group 1	(b) Group 2	(c) Group 3	(d) Group 4	(e) Group 5	(f) Group 6
Production, 1918 (pounds)	54,302,538	504,728,617	156,341,715	183,521,467	320,913,109	217,055,154
Mining, including depletion	$0.14644	$0.04174	$0.06747	$0.08009	$0.07485	$0.05465
Purchased ore	.....	.....	.00030	.01142	.01349	
Transportation to reduction plant	.00845	.01183	.01828	.00810	.00483	.00296
Reduction	.04939	.06135	.03861	.07430	.05043	.07426
Transportation to refinery	.00694	.00662	.00659	.00716	.00944	.01063
Refining	.01800	.01200	.00992	.01079	.01126	.00330
General and administrative	.00657	.00823	.00927	.01181	.00914	.00765
Selling	.00149	.00159	.00208	.00214	.00199	.00358
Credits	.03436	.00366	.00974	.01428	.03590	.00110
Net total	$0.20292	$0.13970	$0.14278	$0.19153	$0.13953	$0.15593
Labor	$0.09188	$0.03501	$0.03795	$0.06992	$0.04046	$0.03850
Materials and supplies	.03413	.03060	.02448	.05337	.03114	.04082
Overhead	.01678	.01538	.02256	.01669	.02338	.03935
Depreciation	.00167	.00636	.00726	.01030	.00537	.01703
Depletion	.00984	.00285	.00893	.00593	.00879	.00253
Tolls	.08298	.05316	.05134	.04919	.06629	.01880
Credits	.03436	.00366	.00974	.01427	.03590	.00110
Net total	$0.20292	$0.13970	$0.14278	$0.19153	$0.13953	$0.15593

(a) Operate mine only, balance of operations are toll.
(b) "Porphyries" companies operate mine and mill, balance of operations are toll.
(c) Operate underground mine and mill, balance of operations are toll.
(d) Operate mine, mill, and smelter, balance of operations are toll.
(e) Operate mine and smelter, balance of operations are toll.
(f) These companies operate mine, mill, smelter, and refinery, toll paid for transporation only.

TABLE VI. COMPARISON OF THE COST OF PRODUCTION OF COPPER AND QUANTITY OF OUTPUT, BY GROUPS, FOR THE YEAR 1918

	Number of Companies	Production	Per Cent of Production	Accumulative per Cent of Production	Cost per Pound
Companies other than porphyries and lake:					
Producing up to 1,000,000 pounds	5	3,663,715	0.29	0.29	$0.28300
Producing 1,000,000 to 5,000,000 pounds	15	35,762,536	2.85	3.14	.26652
Producing 5,000,000 to 10,000,000 pounds	13	98,305,383	7.84	10.98	.21109
Producing 10,000,000 to 25,000,000 pounds	7	119,151,794	9.50	20.48	.21256
Producing 25,000,000 to 50,000,000 pounds	4	162,862,598	12.99	33.47	.18581
Producing 50,000,000 to 75,000,000 pounds	5	297,468,241	23.73	57.20	* .13180
Producing over 75,000,000 pounds	4	536,553,318	42.80	100.00	.15519
Total	53	1,253,767,585	100.00	.....	$0.16700
Lake					
Producing up to 2,000,000 pounds	5	6,976,960	3.09	3.09	$0.34614
Producing 2,000,000 to 5,000,000 pounds	6	19,648,056	11.78	11.78	.22691
Producing 5,000,000 to 11,000,000 pounds	4	33,601,942	14.86	26.64	.16187
Producing over 11,000,000 pounds	6	165,879,226	73.36	100.00	.16579
Total	21	226,106,184	100.00	.....	$0.17622
Porphyry					
Producing 15,000,000 to 50,000,000 pounds	4	94,888,019	12.19	12.19	$0.17924
Producing 50,000,000 to 98,000,000 pounds	4	294,703,233	37.86	50.05	.15575
Producing over 98,000,000 pounds	3	388,769,104	49.95	100.00	.13623
Total	11	778,360,356	100.00	.....	$0.14886

* Due to one company having a very low cost on account of the ore assaying close to three times as great as that of any other.

Costs were calculated on as near a uniform basis as possible, according to forms shown in blank in the report. The principal item of difference is in the calculation of the charge for depletion of the ore body. Two viewpoints stand out clearly in respect to the method of calculation and purposes of such a charge. For convenience they may be designated: (1) The cost viewpoint and (2) the tax viewpoint. The Commission has used the cost viewpoint in all reports, which makes an average difference of over 2c. per lb. and in individual cases as much as 5c. per lb. from that claimed by the companies.

The method of calculation used by the Commission is as follows: The actual cost of the mineral lands divided by the tons of ore in reserve plus the tons of ore mined gives the depletion cost per ton. To reduce it to depletion per pound, this result is divided by the recoverable pounds of copper in a ton of ore. The difficulties, of course, are to determine (1) the actual cost of the mineral land; and (2) the quantity of ore in the ground.

"Up to the year 1917," quoting the Commission, "few companies reported depletion as a cost; whereas practically all companies now include such a charge based on the revaluation of their mineral land. This is one of the largest single factors accounting for the apparently large increase in the cost of producing copper in the last year or two."

Table IV shows for the year 1918 the average costs of production by operations and by geographical divisions, giving the costs per lb. and the percentages of each item of cost, together with the same costs itemized by the elements of expense.

Items of note in Table IV are the relative low costs from Arizona and New Mexico, where most of the porphyries, as well as some high-grade mines, are located. Excessive values for depletion due to inflated land values may be noted in Montana, while the figure for mining reflects the fact that deep mines and high labor rates are the rule. Michigan mines from very deep levels, but the industry exists by reason of low smelting and refining costs as well as smaller transportation and other tolls. Abnormally low labor costs in Latin America are counterbalanced by the overhead.

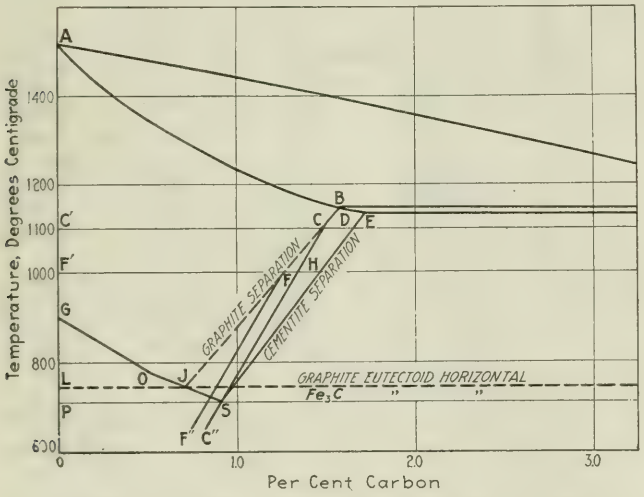
Reclassification according to nature of operations, as in Table V, also gives interesting materials for comparison.

Another interesting factor affecting the cost of production is the quantity of output. Table VI is a statement showing that large producers generally produced copper at a lower cost than the small ones.

Synopsis of Recent Chemical and Metallurgical Literature

Graphitization of White Cast Iron.—A study of certain phases of chilled-iron car wheel manufacture was made by Dr. MERICA and L. J. GUREVICH, of the Bureau of Standards, and the results, with certain theoretical conclusions, were presented in a brief paper read at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, Chicago, Sept. 24, 1919. The composition of the materials used ranged from C 3.67 to 3.90, Si 0.55 to 0.64, S 0.10 to 0.20, P 0.31 to 0.34 and Mn 0.53 to 0.63. Such variation in analysis did not affect the results, except that with higher carbons the temperature range at which graphitization is complete is somewhat more narrow. Speed of graphitization varies directly with the annealing temperature, but no considerable precipitation of carbon from these white irons occurred at 730 deg. C., even after 48 hours. This may therefore be taken as a safe annealing temperature for car wheels.

A curious fact was noted, that iron annealed at 1100 deg. C. and furnace cooled showed less graphite than another annealed for the same period at 1000 deg. C.



PORTION OF IRON-CARBON EQUILIBRIUM DIAGRAM

and cooled in the furnace, when practically all pre-eutectoid cementite had been decomposed. Quenching after annealing corroborated this observed difference. Upon slow cooling there is considerable crystallization of graphite upon the nuclei present, but a sample annealed at 1100 deg. C., cooled slowly to 1000 deg. C. and quickly cooled will have less graphite than one annealed at 1000 deg. C. and then quickly cooled. The authors present a diagram (shown herewith), to explain these facts. At 1100 deg. there is an amount of carbon in solid solution equal to C'C; at 1000 there is, if in equilibrium, a lesser amount equal to *F'F*. On cooling from 1100 deg. there is apparently a lag in its separation, not following line *BS*, but some line *CS*. Consequently upon arriving at the eutectoid horizontal, the combined carbon left in solid solution precipitates out as pearlite, and in amount will be greater in the sample cooled from 1100 than that from 1000. The graphite crystallizing about pre-existing nuclei along lines *CS* and *FF'''* is thus thought to come directly from solid solution. The fact that only 0.20 per cent of combined carbon was found in some specimens after annealing and slow cooling would either indicate that the graphite eutectoid lies at much lower carbon content than previously supposed, that a graphite eutectoid is precipitated on slow cooling, or that pearlite breaks up into graphite and iron directly upon its formation.

Recent Chemical and Metallurgical Patents

American Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Acetone From Acetic Acid.—Vapors of acetic acid are passed over a catalyst consisting of a manganese salt, metallic manganese or alloys of manganese, such as ferromanganese of high Mn content. The use of a metallic or alloy catalyst containing manganese presents the advantages, among others, that no extraneous support, such as pumice or the like, is required in order to present a large surface of catalyst to the vapors; and the relatively high heat conductivity of such catalyst renders it possible to maintain the temperature conditions practically constant, as well as uniform, throughout the reaction zone. At a temperature of 490 to 500 deg. C. yields of 95 to 98 per cent theoretical are obtained. (1,315,525; HARRY A. MORTON, assignor, to Union Carbide Co.; Sept. 9, 1919.)

Electrothermic Production of Acetylene From Hydrocarbons.—By introducing a high-frequency alternating current arc discharge beneath the surface of a hydrocarbon liquid, GEORGE O. CURME, JR., obtains a gaseous mixture containing hydrogen and acetylene. Using solar oil approximately 8.5 cu.ft. of gas was obtained per hour with a power input of 6.1 kw. for eight arcs in series. A frequency of 300,000 cycles or over is desirable. The gas analyzed: Hydrogen, 50 per cent; acetylene, 25 per cent; ethylene, 12.5 per cent; methane, 7 per cent; other hydrocarbons, 5 per cent. Approximately 4.5 lb. of carbon in the form of carbon-black distributed through the oil, and about 3.3 lb. of carbon in the form of electrode deposits, was produced per 1000 cu.ft. of crude gas. The oil consumption was about 50 lb. per 1000 cu.ft. of gas. (1,315,540; assigned, by mesne assignments, to Union Carbide Co.; Sept. 9, 1919.)

Acetaldehyde and Acetic Acid From Ethylene.—Ethylene combines with mercuric sulphate in aqueous solution to form a compound of the type $HgSO_4.C_2H_4$, which yields acetaldehyde and acetic acid by electrolytic oxidation. The cell consists of a steam-jacketed tank, mercury cathode, porous diaphragm and an anode of platinum, lead peroxide, magnetite or other suitable material. The anolyte is dilute sulphuric acid containing mercuric sulphate, the catholyte dilute sulphuric acid. The presence of cerium salts in the anode chamber acts catalytically in favoring the oxidation. Ethylene is passed into the anolyte through a perforated ring. If it is desired to produce acetaldehyde, the solution is heated above 21 deg. C., so that the acetaldehyde is volatilized as formed. If, however, acetic acid is the product required, the gas outlet is closed and the acetaldehyde is thus held in solution and further oxidized to acetic acid. (1,315,543 and

1,315,546; GEORGE O. CURME, JR., assignor, by mesne assignments, to Union Carbide Co.; Sept. 9, 1919.)

Production of Dimethyl Sulphate.—Anhydrous alcohol is saturated with SO_2 and treated with a mixture of SO_2 and Cl_2 in the proportions indicated by the equations:

$$Cl_2 + SO_2 + 2CH_3OH = CH_3Cl + CH_3HSO_4 + HCl.$$
$$Cl_2 + SO_2 + 2CH_3OH = (CH_3)_2SO_4 + 2HCl.$$

During the reaction, part of the methyl chloride is carried off by the excess SO_2 and the HCl formed. By heating the product on a water bath, the CH_3Cl, SO_2 and HCl remaining in solution are vaporized. The methyl chloride can be isolated from the gaseous products by passing through an alkaline absorption medium which will combine with the SO_2 and HCl. The product still contains methyl hydrogen sulphate, but by distilling under diminished pressure, this is converted into dimethyl sulphate and sulphuric acid, which may be easily fractionated.

$$2CH_3HSO_4 = (CH_3)_2SO_4 + H_2SO_4$$

Yields of well over 50 per cent by weight of dimethyl sulphate are obtained, which, in conjunction with methyl chloride also produced, represents a yield approaching the theoretical. (1,317,648; THOMAS H. DURRANS, assignor to A. Boake, Roberts & Co., Ltd., Stratford, London; Sept. 30, 1919.)

Apparatus for Treating Fuller's Earth.—The impurities contained in fuller's earth which has been used for filtering or bleaching hydrocarbon oils are soluble in sulphuric acid, so that the earth can be re-used after an acid treatment. The process consists in placing the earth in a vat and allowing sulphuric acid to percolate through the mass. The excessive time required in the method has led CLIFFORD M. HUSTED of Jersey City to devise an apparatus in which the complete purification (including washing and drying) may be accomplished in approximately one-half hour. The earth to be treated and the purifying chemical, sulphuric acid, are fed continuously into a rotating drum equipped with baffles to insure thorough mixing, and flanges to retard the passage of the mixture through the drum so that the earth is retained long enough to insure adequate treatment. The earth is now discharged into a washer and separating tank, where it is washed by a continuous stream of water. The bottom of the tank is inclined and provided with a screw conveyor which carries the settled earth to a second washer. From this the earth passes to a rotary drier. (1,317,372; assigned to Standard Oil Co.; Sept. 30, 1919.)

Graphitized Electrodes. — The manufacture of graphitized electrodes up to and including the 12-in. sizes which are the present commercial size limit involves the following essential steps: Petroleum coke, a low-ash, low-sulphur residue from petroleum distillation, is crushed and then calcined or "shrunk" by heating to approximately 1000 to 1100 deg. C., usually in a gas- or oil-fired kiln. Thereby the hydrocarbons which are volatile at or below the calcining temperature are largely expelled. The calcined material is again crushed, graded, bonded with pitch or similar heavy hydrocarbon, and molded or extruded through dies into the appropriate electrode sections. The resulting so-called green electrodes are then baked in gas-fired kilns, usually at a maximum temperature of about 1000 deg. C. They are then ready for graphitization, which is carried out in electric resistance furnaces at a much higher temperature range (above 2000 deg. C.). The principal advantages secured through graphitization are a large increase in electrical conductivity, and a marked decrease in the tendency to oxidation at the working temperature of the furnace. The present limit of industrial graphitization is reached at a diameter of approximately 12 in., either for round or square sections. As this limit is approached the proportion of losses through breakage or by the development of cracks or other defects undergoes a relatively very rapid increase, with the result that there exists a rather definite size limitation, above mentioned, beyond which graphitization has not up to the present time been commercially practiced. The breakage and the development of defects referred to occur partly during the baking of the electrodes prior to graphitization, and partly in the graphitizing operation itself.

In case graphitization is not desired, it is for many purposes advantageous to use in the electrode mix, instead of the low-ash petroleum coke, certain forms of carbon particles which are higher in ash but more compact, and of greater mechanical strength, notably hard coal of anthracite type. This coal is preliminarily calcined or shrunk to expel volatile matter, this operation being most advantageously carried out in electric calcining furnaces at relatively very high temperatures, up to 1600 to 1800 deg. C. This material is then crushed, graded, bonded and shaped, substantially as above described, and the green electrodes are then baked at about 1000 deg. C. to form the finished commercial article. Graphitization of these hard coal electrodes has not been commercially practiced. ARTHUR H. HINCKLEY of Niagara Falls has succeeded in making electrodes up to 24 in. in diameter from anthracite coal particles which can be graphitized. The process outlined above is modified as follows: The finely powdered anthracite coal (45 per cent to pass through a 200-mesh screen) is mixed with 12 to 15 per cent pitch in kneaders at 160 deg. C. The mass is briquetted in a steam-heated hydraulic press and baked at 1000 deg. C. The baked material is crushed and graded and is then ready for use. It is superior to the electrically calcined coal generally employed, since it has sufficient tensile strength to endure without fracture the strains set up in the electrode during the heating and cooling operations incident to baking and graphitizing, thus permitting the successful manufacture of larger electrodes. (1,317,497 and 1,317,498; assigned to National Carbon Co.; Sept. 30, 1919.)

Detinning Process.—Scrap tin is treated with a strong aqueous solution of caustic soda at 120 to 150 deg. F. in an iron tank which is lined with some material electro-negative to tin, such as graphite. The galvanic action set up between the graphite and the tin accelerates the solution of the tin. This operation is repeated until the bath is rich in tin. The tin solution is then transferred to a second iron tank. Bales of scrap tin are suspended in the bath and a current is passed, the tank being the cathode and the tin the anode. In this manner the tin from the bale is dissolved and deposited, while the tin is also deposited from the bath, so that the latter can be returned to the first tank. (1,316,926; CHARLES P. TATRO and GEORGE DELIUS of Seattle, assignors of one-third to BENJAMIN R. BRIERLY; Sept. 23, 1919.)

Cymene Sulphonic Acids.—Sulphuric acid of specific gravity 1.84 is caused to descend over baffle-plates, pebbles or coarse pumice stones, in a tower, which is heated and maintained at a temperature of 180 to 190 deg. C. Paracymene is heated to boiling and its vapors are passed up through the tower. The vapors come into contact with the descending hot sulphuric acid and are completely absorbed by it, with the formation of water and cymene disulphonic acids. The water escapes from the tower as steam and may be condensed in any suitable condenser attached at or near the top of the tower. The sulphonic acids, together with a slight excess of unused sulphuric acid, are carried downward by means of gravity, and discharged from the bottom of the tower. The product contains a considerable amount of cymene-2-sulphonic acid, which is separated from the disulphonic acid by well-known means, such as, for example, the formation of the barium salts by neutralizing with barium carbonate, filtering the solution of the salts of the sulphonic acids from the barium sulphate and concentrating the vapor to crystallization, when the barium salt of the monosulphonic acid of cymene separates first, leaving the barium salt of the disulphonic acid in solution, from which it may be obtained by the addition of alcohol. (1,316,823; JOSEPH A. AMBLER, HERBERT A. LUBS and HARRY D. GIBBS; filed under the act of March 3, 1883, 22 Stat. L., 625; Sept. 23, 1919.)

Book Reviews

INDUSTRIAL ELECTROMETALLURGY, INCLUDING ELECTROLYTIC AND ELECTROTHERMAL PROCESSES. By *Eric K. Rideal.* 259 pages. 25 illustrations. New York: D. Van Nostrand Co.

The history of the English chemical industry within the past fifty years is unique in many respects. Much of the pioneer work of the chemical key industries, such as the dye industry, was carried out in England. The industries were fostered and developed and soon became foremost in the world. Thereupon a period of relaxation set in, the industries became of secondary importance or they left the Empire entirely. Such was the case of the dye industry, which virtually passed out of existence in England and grew to enormous proportions in Germany; of the aluminum industry, which went to America; and of the tungsten industry, which became a German monopoly. These facts were pointed out by the British Association about fifteen years ago, when an earnest endeavor was made to revive the chemical and metallurgical industries at home; but it remained for the World War to make the English people fully realize the actual status of their industries. Soon after the outbreak of the war the chemist was called upon to produce chemicals and chemical products which had previously been imported from Germany and Austria. An urgent demand immediately arose for concise accounts of the best and most modern methods of making the chemical products in question. In response to this demand a number of the foremost British chemists and engineers arranged to publish series of practical handbooks. The book before us is the third in a series edited by Samuel Rideal. The remarkable rebirth and rapid development of the British chemical industries within the past three years is without doubt largely due to the untiring efforts of these chemists and engineers.

Dr. Rideal's book will be welcomed by American chemists and instructors, but in particular by the young electrochemist. The subject is admirably well treated and attractively printed and illustrated. The book is divided into the following eight chapters: Electrolysis in aqueous solutions; electrolysis in fused electrolytes; electrolytic preparation of the rarer metals; electrothermal processes; carborundum and oxysilicides of carbon; carbides; electrothermal nitrogen fixation by metals and metallic compounds; iron and the ferro-alloys. Not only are the various processes described from the technical point of view but considerable space is devoted to the underlying theories of the several chemical or thermal reactions. Those who wish to make a more thorough study of the subject will find the numerous literature references very convenient. There are very few misprints and but few misstatements. On page 92 the author states that there "has been no electrolytic process devised for the refining of tin," although America has been turning out electrolytic tin since 1916. The process was described in the *Engineering and Mining Journal* of that year. These minor defects will undoubtedly be removed in the second edition, which will surely appear, judging by the great popularity of this first edition.

COLIN G. FINK.

Personal

H. G. BAIN, until recently attached to the San Francisco office of the Midvale Steel & Ordnance Co. sales organization, has joined the Tacony Steel Co., Philadelphia, Pa., as sales representative for the upper part of New York State.

R. E. BAKER has resigned as works manager of the Keokuk Electro Metals Co. to accept a position as research engineer for the Victor Chemical Works at Chicago Heights, Ill.

ROY BRAKEMAN, formerly chief engineer of the Fairfield Works of the American Steel & Wire Co., Fairfield, Ala., is now associated with the Otis Steel Co., Cleveland, Ohio, as chief engineer.

S. E. BRETHERTON, JR., who recently returned from the Burma Mines Co., is now at Atascadero, Cal.

E. F. BRUNDAGE has severed his connection with the Maryland Chemical Co. and is now with the General Chemical Co., Baltimore, Md.

Dr. CHARLES F. CHANDLER of Columbia University is to be the recipient of the Perkin medal to be awarded at the meeting of the Society of Chemical Industry this month.

GEORGE C. DEWEY, recently in the U. S. Army, is now chemist and assayer with the Selby Smelting & Lead Co., at Selby, Cal.

Dr. F. GIOLITTI is in the United States on a mission from Stein & Co. of Paris, France, who have organized an American branch to exploit their ideas in gas furnace construction.

M. R. HULL has resigned his position as designing engineer and superintendent of power for the Nevada Consolidated Co. to accept a position as designing engineer for the affiliated companies the Chile Exploration Co. and the Braden Copper Co., with headquarters in New York City.

HENRY S. KENYON, formerly with the Thomas A. Edison Co., is head of the oil and wax division of the Southern Oil & Chemical Co., 21 Park Row, New York.

EDWARD D. KILBURN, who has been New York district manager of the Westinghouse Electric & Manufacturing Co., was recently elected vice-president and general manager of the Westinghouse Electric International Co.

F. G. MOSES, formerly at the Salt Lake City station of the Bureau of Mines, is now connected with The Barrett Co., in charge of the flotation oil department.

WILLIAM C. REDFIELD, Secretary of Commerce for seven years, has associated with H. P. Wilson in the investment security business under the name of Redfield & Wilson, 50 Broad St., New York City.

HUGH ROLLIN, formerly president of the Rollin Chemical Corp., is no longer president and general manager of the company, owing to a change in the stock control, and has severed all connection with the company.

DOUGLAS E. SCOTT, who for several years has been in charge of the experimental paper mill of Arthur D. Little,

Inc., Cambridge, Mass., has resigned and is now connected with the United Fruit Co., Boston, Mass.

HERVEY J. SKINNER, for many years vice-president of Arthur D. Little, Inc., Cambridge, Mass., has severed his connection with that organization and has opened an office as a consulting chemical engineer at 248 Boylston St., Boston, Mass. Mr. Skinner was with the Arthur D. Little, Inc., organization seventeen years, during which time it grew to its present large size, occupying a large modern laboratory building on the Charles River in Cambridge. Mr. Skinner has had a varied experience especially in pulp and paper problems and will specialize in development work on propositions requiring technical advice and assistance in putting them into commercial operation.

Current Market Reports

The Non-Ferrous Metal Market

New York, Jan. 5:—Copper holds steady at 19c. for near-by delivery, 19½c. for future delivery. There has been very little trading in tin, the February-March quotation being 58¾c. Lead and zinc are both firm.

	Cents per Lb.
Copper, electrolytic	19.00
Aluminum, 98 to 99 per cent	33.00
Antimony, wholesale lots	9.75
Nickel, ordinary	42.00
Nickel, electrolytic	45.00
Tin, Straits, spot	58.25
Lead, New York, spot	7.75
Lead, E. St. Louis, spot	7.50
Zinc, spot, New York	9.25
Zinc, spot, E. St. Louis	8.87½
Silver (Dollars per oz.)	1.35

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	28.50
Copper sheets, cold rolled (over 14 oz.)	30.50
Copper bottoms	37.00
Copper rods	29.50
High brass wire and sheets	25.50
High brass rods	24.50
Low brass wire and sheets	28.25
Low brass rods	28.25
Brazed brass tubing	37.25
Brazed bronze tubing	42.00
Seamless copper tubing	32.00
Seamless bronze tubing	36.00
Seamless brass tubing	30.50

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23¼ @ 24¼
Aluminum, sheet scrap	22¼ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp	14½ @ 14¾
Copper, heavy and wire	13⅝ @ 14
Copper, light and bottoms	12½ @ 12¾
Copper, heavy cut and crucible	15¾ @ 16
Brass, heavy	7½ @ 8¼
Brass, casting	10½ @ 10⅝
Brass, light	5⅝ @ 6¾
No. 1 clean brass turnings	8¼ @ 8⅝
No. 1 comp. turnings	11¼ @ 12
Tea lead	4.65 @ 4.75
Lead, heavy	6.00 @ 6.25
Zinc, scrap	4¼ @ 4½

RARER METALS

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00

The Iron and Steel Market

Pittsburgh, January 2, 1920.

Marketing problems in the iron and steel trade are relegated altogether to the rear, but there is much shopping on the part of jobbers and manufacturing consumers, who do not merely wish to match a certain piece of goods but rather are in search of material of all sorts for prompt delivery. They are quite bare of stocks, and shopping is likely to be more strenuous in the next few weeks than it was even in December. In contracting, on the other hand, there is little being done and little is to be expected in the next two months. Substantially all the tonnage the mills were willing to place under contract for the first quarter or half of the new year has been disposed of.

With the mills it is a question of production and distribution. The Steel Corporation and several of the independent producers have adhered to the March 21 or Industrial Board schedule of prices, and as higher prices would be paid by many buyers, and have been paid to some of the independent mills on comparatively large tonnages, it is necessary for producers who have sold at the basis prices to distribute their output very carefully so that regular customers may receive their appropriate quotas.

STEEL PRODUCTION PROSPECT BRIGHT

As to production, there is a reasonable prospect that within three or four months the mills will be able to approach measurably close to capacity output. In January, 1919, steel ingot production was about 87 per cent of capacity, output decreasing until approximately a 50-per-cent rate was reached at the middle of May, an increase at once beginning which brought the industry up to about an 83-per-cent rate in the fore part of September. The strike inaugurated Sept. 22 cut output by about one-half, and since then there has been a gradual recovery, production at the present time being at about 80 per cent. The strike is left behind, but labor shortage, labor inefficiency and lowered morale remain, the objective now being to correct the situation in these respects.

The present deficit in steel supply can of course be made up readily, provided production can be increased to the extent that should be expected and that consumptive demands do not very greatly increase. With capacity operation there would soon be room for the railroads to re-enter the market as buyers, and this is expected to occur. In all probability the large mills that have hitherto catered to railroad demand have been endeavoring to save some space for the railroad owners when control of their properties is returned to them March 1.

The acute deficit in steel supplies probably amounts to several hundred thousand tons, while the deficit represented by stocks in the hands of jobbers and manufacturing consumers being below normal may amount to more than a million tons. Capacity, however, in finished rolled steel is about 725,000 gross tons a week, while production is now at 550,000 to 600,000 tons a week, so that the case is far from hopeless. The longest time estimated for the trade to "catch up" and regain a normal basis is six months.

PRICE POLICIES AND PREMIUMS

Last March an agreement was reached between the "Industrial Board" set up by Secretary Redfield of the Department of Commerce and representatives of the iron and steel industry whereby certain price reductions would be made in the interest of stabilization of prices so that investors would be encouraged to proceed. Both parties to the agreement made statements that buyers should expect to buy, during 1919, at lower prices than those announced to become effective March 21. Within a short time the Industrial Board disappeared. In May and June various independent producers were cutting the March 21 prices, but the Steel Corporation and a few independents did not. Later, when the market was in position to advance, the Steel Corporation showed steadfast adherence to the regular schedule.

All that was positively known was that the Steel Corporation intended to adhere to the schedule during 1919, but a definite pronouncement has now been made showing that the Steel Corporation intends to continue the policy for an indefinite time, or until conditions radically change. Judge Gary, chairman of the Steel Corporation, in a statement given out after the directors' meeting of Dec. 30, indicated the corporation's adherence at this time to the policy, so that no change is to be expected even though 1919 has passed into history. With the Steel Corporation are several of the large independent producers and perhaps a few of the smaller producers. Higher prices than the March 21 schedule have been paid freely for early deliveries of the majority of finished steel products, but in the circumstances such prices must be regarded as "premium prices," the excess being due to the delivery time involved. Those who pay the premium prices are buyers who have no regular standing as customers of the mills adhering to the basis prices, or customers who desire tonnage in addition to that allotted them.

The Chemical and Allied Industrial Markets

New York, January 2, 1920.

The general chemical market remains firm, with better prices and smaller sales. The quotation on *oxalic crystals* jumped from 30@31c. per lb. to 31@32c. per lb. on car lots, and from 30@33c. per lb. to 32@35c. on less than car lots. *Calcium chloride*, fused lump, has been active, and as a consequence the low price has come up from $19 to $20 per ton, showing a present quotation of $20@$25 per ton on car lots and $30@$40 on smaller quantities. *Carbon tetrachloride* also jumped ½c., the present quotation reading 12½@14½c. per lb. *Potassium bichromate*, among the leaders in activity, is quoted at 32@33c. per lb. in car lots and 34@35c. per lb. in less than car lots, against 26@27c. and 30@33c. of the previous report. *Potassium permanganate* rose from 55@65c. to 70@75c. per lb., while *potassium prussiate red* went up to $1.10@$1.20 per lb. against $1.05@$1.15 of last week.

Alcohol at present is on a very unstable footing owing to the uncertainty as to the future of this item. *Ethyl* and *denatured alcohol* continue at the same nominal quotations of $5.25@$7 per gal. on the former and 80@82c. per gal. on the 188 proof and 76@78c. on 190 proof, denatured. *Methyl*, or *wood alcohol* is unobtainable, and the price has jumped to $1.57 per gal., against a high mark of $1.38 for last week. In order to restrict the sale of wood alcohol the Internal Revenue Department is bonding all handlers of this item.

Coal-tar products have exhibited nothing of especial interest, prices remaining firm. *Dimethylaniline* is still going up and is now quoted at 90c.@$1, against 60@93c. per lb. of the previous report, and there is very little on the market to be had even at this increased price. *Phenol* jumped from a previous high mark of 16c. to 19c. per lb., while *phthalic anhydride* is quoted at 70c.@$1 per lb.

Waxes have been inactive during the past week and prices remain unchanged. The *paraffine grades* are still behind in production, which partially accounts for the high prices at present. All contracts being written at present are for future delivery.

In *naval stores* the lower and medium grades are displaying an upward tendency in price, *rosin EI* rising to $19 for 280 lb., against $18.25 of last week. *Wood turpentine*, dest. dist., is now quoted at $1.51@$1.58 per gal.

In order to meet the demand of the buyers the prices of some of the vegetable oils have been dropped slightly, *olive oil* commercial coming down from $2.80 to $2.60 per gal., while *palm lagos* dropped a cent to 16c. per lb. *Rapeseed oil blown* came up 10c., with a range at present of $1.60 @$1.70 per gal., while *rapeseed oil refined* also went up 5c. to $1.65 per gal.

Another gap has been caused by the holiday and the absence of cables from the English and India rubber market leaves the domestic market somewhat unstable. Prices have gone up, with *up-river coarse* quoted at 36@37c. per lb., against 35c. last week, while *caucho ball* jumped from 51½c. to 54½c.

The *ferro-alloy* market remains practically unchanged, the only activity being in *spiegeleisen*, which jumped from $33@$45 to $40@$50 per gross ton. The low quotation on *ferromanganese* dropped to $100, making the present quotation $100@$130 per gross ton.

An active market in the ores and semi-finished products is predicted for the near future, the present prices, however, remaining.

Among the miscellaneous materials, *fuller's earth* is still scarce. Owing to uncertain labor conditions in Florida, the domestic grade of this item is practically unobtainable at $25@$30 per ton. *Barytes*, domestic white floated, which has been in heavy demand by the paint industry, is hard to find. The former quotation of $35@$40 per ton remains.

Chicago, December 31, 1919.

Firm prices in most lines mark the closing days of 1919 in the local market, excellent demand holding in all branches of the trade. A sharp decline has been experienced in pine tar products, but renewed demand is now tending to reestablish former high prices.

Heavy Chemicals: The formerly noted upward trend of *caustic soda* has been accentuated by heavy export shipments of granulated to Europe, $4.50 cwt. now being the ruling price, f.o.b. works. Domestic purchases of solid are also heavy and $4 f.o.b. works is quoted. *Bleach* also has taken a further advance to 2½c. and *soda ash*, light, ranges from $2 to $2.10 per cwt. Indications are that the market on the above-mentioned items is practically fixed for some time at the prices named.

Sodium bichromate has recovered from its violent spurt of three weeks ago when prices were named ranging from 30 to 40c. per lb. The price now is established, for the time, at least, at about 22c. Other items which have had interesting fluctuations recently are all holding firm, *potassium carbonate* being quoted at 27c., *acetone* at 15c. and *potassium prussiate, red*, $1.10, *yellow*, 70c.

Acids show no changes of interest except in *sulphuric*, the market having strengthened some, current quotation on 66 deg. being $22. *Muriatic*, 20 deg., at 2½c. and 40 deg. *nitric* at 8c. for spots show no change. Manufacturers report future production pretty well covered by contracts at prices only slightly less than those ruling for immediate delivery.

Coal-Tar Products: The effect of the coal strike was felt more keenly in this than in any other chemical line, as it curtailed production at a time when supply was already short on account of previous troubles in the steel industry. *Benzol* and *toluol* are hard to get in any great quantity, 32c. being the ruling price for available stocks. *Aniline oil* at 33c. and *aniline salts* at 36c. show no recent change. Supply on these two items is very short, and the prices quoted are for future delivery, spots demanding and receiving one or two cents more.

No great activity is noted in *benzoic acid*, 95c. being quoted on U. S. P. for today's delivery. *Salicylic acid* is under slightly better demand, 45c. still being asked. *Picric acid* is the weakest item of the line, plenty being offered at 20c. with no buyers visible at that figure.

Vegetable Oils: This line, owing to curtailment of users' activities during the coal strike, has been very quiet, but in the last few days a slight strengthening has been noted and indications are that some of the large consumers are preparing to enter the market for quantity contracts for future delivery. *Cotton oil*, crude, is today quoted ½c. higher at 19½c., and *prime summer yellow* advanced the same amount to 25½c. *Corn oil*, under the weak demand of the past few weeks, has done well to hold firm at 18c., sellers' tanks. *Linseed oil* some time ago advanced to $1.85 in tanks, $2.09 being asked for local deliveries in lots of 4 bbl. or less. With speculation rife as to the distribution of the forthcoming Argentine crop of seed, and with all crushers sold up to capacity for some time to come, it looks as if high prices in *linseed oil* will remain for some weeks at least.

With light demand, market in *cocoanut oil* and *soya bean oil* has been quiet, a slight firmness being felt in the last few days. At existing rates of exchange with the Orient, lower prices seem impossible. On *cocoanut oil* 18½c. in tanks, f.o.b. coast, is asked and 16½c. on *soya bean oil*.

Flotation Oils, Naval Stores: A sharp decline due to a weakening of demand, which in turn was due to the fuel shortage, occurred about ten days ago. From the previous high mark of $1.60@$1.65, .933 *pure distilled pine tar oil* has dropped to $1.35, and *destructively distilled* is quoted at the same figure. *Turpentine*, being shortest in supply, has fluctuated less, $1.85 now ruling against $1.95@$1.98 in the middle of December. *Rosin* shared slightly in the decline, quotation on F grade having dropped 50c. to $18.50.

Fertilizers: While the temporary shutdown of the great fertilizer plants here during the bituminous strike was not of sufficient length to seriously affect production for the year, it had the effect of skyrocketing prices on the local market. Ground blood is hard to get at the prevailing price of $7.75 and unground is quoted at about $7.50, a recent advance on the two lines of 40c. and 75c. respectively. Tankage is also up nearly 50c., quotation of high-grade ground being $7.25. All other grades are priced in proportion.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.60 – $0.65
Acetone	lb.	$0.20 –	.21 –
Acid, acetic, 28 per cent	cwt.	2.50 – $2.75	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	13.00 – 13.50	13.50 – 15.50
Boric, crystals	lb.	.15 – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	–	2.25 – 2.50
Hydrofluoric, 52 deg.	lb.	.12 –	.14 –
Lactic, 44 per cent tech.	lb.	.11 – .14	.12 – .16
Lactic, 22 per cent tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	–	4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.07 – .07½	.08 –
Oxalic, crystals	lb.	.31 – .32	.32 – .35
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	–	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	12.00 – 16.00	–
Sulphuric, 60 deg., drums	ton	17.00 –	22.00 –
Sulphuric, 60 deg., carboys	ton	20.00 –	25.00 –
Sulphuric, 66 deg., tank cars	ton	17.00 – 18.00	22.00 – 23.00
Sulphuric, 66 deg., drums	ton	20.00 – 21.00	25.00 – 26.00
Sulphuric, 66 deg., carboys	ton	25.00 –	30.00 – 40.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	20.00 –	26.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	25.00 –	32.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	30.00 –	35.00 –
Tannic, U. S. P.	lb.	–	1.35 – 1.45
Tannic (tech.)	lb.	–	.42 – .55
Tartaric, crystals	lb.	–	.69 – .74
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
Alcohol, Ethyl	gal.	4.80 – 4.95	5.50 –
Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
Alcohol, denatured, 188 proof	gal.	–	.80 – .82
Alcohol, denatured, 190 proof	gal.	–	.76 – .78
Alum, ammonia lump	lb.	– .04½	.04½ – .04¾
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ –	.09½ – .10
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	–	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .13½	.14 – .14½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½ – .14	.13½ – .15½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.10 –	.11 – .12
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.09 – .09½
Arsenic, sulphide, powdered (red arsenic)	lb.	–	–
Barium chloride	ton	90.00 – 95.00	95.00 – 100.00
Barium dioxide (peroxide)	lb.	.22 –	.24 –
Barium nitrate	lb.	.09½ – .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½ – .04
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	–	.65 – .75
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	–	.04½ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	–	2.75 – 3.75
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.02 – .03
Calcium sulphate, precipitated	lb.	–	.09 – .09½
Carbon bisulphide	lb.	.05½ –	.06 –
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .14
Carbonyl chloride (phosgene)	lb.	–	.75 –
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Cobalt oxide	lb.	–	1.50 – 1.55
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	–	.28 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Formaldehyde, 40 per cent	lb.	–	.20 – .37
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.50 –
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.50
Lead acetate, normal	lb.	–	.15 – .16
Lead arsenate (paste)	lb.	–	.13 – .17
Lead nitrate, crystals	lb.	–	.85 – .86½
Litharge	lb.	–	.09½ – .10½
Lithium carbonate	lb.	–	.50 –
Magnesium carbonate, technical	lb.	–	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.00 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	–	.75 – .90
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	–	.58 – .60
Potassium bromide, granular	lb.	–	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.25 –	.30 –
Potassium chlorate, crystals	lb.	.18 – .20	.21 –
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .40
Potassium iodide	lb.	–	3.55 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	.70 – .75
Potassium prussiate, red	lb.	–	1.10 – 1.20
Potassium prussiate, yellow	lb.	–	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	–
Rochelle salts (see sodium potas. tartrate)		–	–
Sal ammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)		–	–
Salt cake (sodium sulphate)	ton	15.00 – 21.00	–
Silver cyanide	oz.	–	1.25 –
Silver nitrate	oz.	–	.81½ – .82½
Soda ash, light	100 lb.	1.95 –	2.05 –
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.05½ – .06½	.07 – .08
Sodium bicarbonate	100 lb.	2.35 –	2.75 – 3.00
Sodium bichromate	lb.	–	.22 – .25
Sodium bisulphate (nitre cake)	ton	3.00 – 8.00	10.00 –
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	– .09	.09 – .10
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.50	1.50 – 1.75
Sodium chlorate	lb.	.15 –	.16 – .18½
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	–	4.10 – 4.35
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	– 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	– .18
Sodium peroxide, powdered	lb.	–	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04	.04½ – .05
Sodium potassium tartrate (Rochelle salt)	lb.	–	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .24	.24 – .26
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.15 – 1.25	1.50 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	–	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	–	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.10 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	2.95 –	3.15 – 3.40
Tin bichloride (stannous)	lb.	.44 –	.46 – .50
Tin oxide	lb.	–	.60 –
Zinc carbonate, precipitate	lb.	–	.20 –
Zinc chloride, gran.	lb.	.12½ –	.13½ – .14
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	–	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.32 —	.50
Aniline oil, drums extra	lb.	.34 —	.36
Aniline salts	lb.	.43 —	.45
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.00 —	1.15
Benzidine, base	lb.	1.10 —	–
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.31
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.18 —	–
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.80 —	.85
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	.90
Cresylic acid, 50%, first quality, drums	gal.	.60 —	–
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	2.25
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.65
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.06½ —	.07½
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.45
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	.95 —	1.10
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.70 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12½ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.00
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 —	.60
Salicylic acid, U.S.P.	lb.	.45 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

*Nominal quotations.

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.32 —	.30
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.44
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white pure	lb.	.63 —	.66
Carnauba, No. 1	lb.	.80 —	.83
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.44 —	.50
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.06½
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.09
Paraffine waxes, refined, 128-130 m.p.	lb.	.09¾ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.13
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.25
Pine oil, pure, dest. dist.	gal.	1.00
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	47
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.65
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.00
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	....
Pinewood creosote, ref.	gal.	.51

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.00 —	$17.50
Rosin E-I	280 lb.	17.55 —	19.00
Rosin K-N	280 lb.	19.75 —	23.00
Rosin W. G.-W. W.	280 lb.	22.50 —	24.25
Wood rosin, bbl.	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	1.65 —	1.69
Wood turpentine, steam dist.	gal.	1.63 —	1.64
Wood turpentine, dest. dist.	gal.	1.51 —	1.58
Pine tar pitch, bbl.	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.90
Retort tar, bbl.	280 lb.	15.00 —	15.25
Rosin oil, first run	gal.	.86 —	.91
Rosin oil, second run	gal.	.88 —	.93
Rosin oil, third run	gal.	.95 —	1.12
Rosin oil, fourth run	gal.	1.05 —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.50 —	$0.51
Upriver coarse	lb.	.36 —	.37
Upriver caucho ball	lb.	.36½ —	.37
Plantation—First latex crepe	lb.	.54½ —	....
Ribbed smoked sheets	lb.	.54¾ —	....
Brown crepe, thin, clean	lb.	.46½ —	.48¾
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.	lb.	$0.18½ —	$0.20
Castor oil, AA, in bbls.	lb.	.21¼ —	.22
China wood oil, in bbls.	lb.	.22½ —	.24
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½ —	.19
Cocoanut oil, Cochin grade, in bbls.	lb.	.19½ —	.22
Corn oil, crude, in bbls.	lb.	.19 —	.21½
Cottonseed oil, crude (f.o.b. mill)	lb.	.18 —	.19
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.23 —	.28
Linseed oil, raw, car lots	gal.	.... —	1.87
Linseed oil, raw, tank cars	gal.	1.80 —	1.84
Linseed oil, boiled, car lots	gal.	.... —	1.90
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.16 —	.17½
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23¼ —	.23½
Peanut oil, refined, in bbls.	lb.	.26 —	.28
Rapeseed oil, refined in bbls.	gal.	1.45 —	1.65
Rapeseed oil, blown, in bbls.	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.17¾ —	.22
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15¼ —	.15⅞

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	$ .04 —	$ .05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	35.00 —	45.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C.	lb.	.... —	....
Shellac, V. S. O.	lb.	.... —	....
Shellac, Diamond I.	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn.	gross ton	100.00 —	130.00
Spiegeleisen, 16-20% Mn.	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo.	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	12.00 —	12.50
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq. ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14¾
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.15½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13¾
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

BRIDGEPORT—I. Pick, c/o A. E. Fisher, archt. and engr., 373 Fulton St., Brooklyn, N. Y., is having plans prepared for the construction of a 1-story silverware factory. Estimated cost, $30,000.

HARTFORD — The Hartford Rubber Works, Park and Bartholomew Aves., has awarded the contract for the construction of 3 additions to its plant to Stone & Webster, 147 Milk St., Boston. Estimated cost, $2,225,000.

STRATFORD (Bridgeport P. O.)—The Albert-Peck Co., Bruce Ave., will build a 2-story, 67x180-ft. silverware factory. Estimated cost, $50,000. Work will be done by day labor.

District of Columbia

WASHINGTON—The Dist. Comrs., Room 320, District Bldg., will soon award the contract for the furnishing of 1 oxy-acetylene welding equipment and supplies for the McKinley Manual Training School.

Illinois

QUINCY—Lockwood, Green & Co., engrs., 38 South Dearborn St., Chicago, will soon receive bids for the construction of a 3-story, 60x175-ft. drug factory, for the Monroe Drug Co., 601-11 North 4th St. Estimated cost, $200,000.

ROCKFORD—The Rockford Paper Box Board Co., Catherine St., has awarded the contract for the construction of a 3-story, 100x100-ft. paper boxboard factory, to the Holm Page Co., 1604 4th Ave. Estimated cost, $85,000.

Louisiana

NEW ORLEANS—The Marland Oil & Refining Co., Ponca City, Okla., plans to construct a large refinery here with the necessary pipe lines to the north Louisiana oil fields; also build and equip a large line of tank steamers. Estimated cost, $7,000,000. E. W. Marland, Ponca City, president.

Maryland

CURTIS BAY (Baltimore P. O.)—The Armour Fertilizer Co., 1501 Munsey Bldg., Baltimore, has awarded the contract for the construction of a fertilizer plant on the waterfront, to Westinghouse, Church, Kerr & Co., Inc., 37 Wall St., New York City. Estimated cost, $2,000,000.

HAVRE DE GRACE—E. M. Smith plans to build a brick plant and is in the market for machinery for same.

Massachusetts

MEDFORD—The trustees of Tufts College plan to construct a chemical laboratory building on the Campus.

PITTSFIELD—The General Electric Co. will soon receive bids for the construction of a 1-story, 80x400-ft. enameling plant. C. C. Chesney, manager.

Michigan

HIGHLAND PARK (Detroit P. O.)—The Maxwell Motor Co., Oakland Ave., has awarded the contract for the superstructure for the proposed 1-story, 315x557-ft. pressed steel plant, to the U. S. Structural Co., 520 Book Bldg., Detroit. Estimated cost, $450,000.

MUSKEGON HEIGHTS (Muskegon P. O.)—The Shaw Electric Crane Wks., McKinney St., Muskegon, plans to construct a 1- and 2-story foundry and machine shop at McKinney and Park Aves. Estimated cost, $2,000,000. Manning, Maxwell & Moore, McKinney St., Muskegon, engrs.

Minnesota

ST. PAUL—The Western Chemical Co., Hutchinson, is having plans prepared for the construction of a 3-story, 90x120-ft. chemical factory on Malcolm Ave., here. Estimated cost, $125,000. Downs & Eads, 803 Phoenix Bldg., architects.

Missouri

JOPLIN—A stock company is being organized to build a zinc oxide factory. Estimated cost, $300,000. Address J. Leopold, secretary of the Chamber of Commerce.

Montana

MISSOULA—The Missoula Hide & Wool Co., 511 West Main St., is having plans prepared for the construction of a 2-story, 40x200-ft. tannery. Estimated cost, $25,000. Charles H. Stehling Co., 401 4th St., Milwaukee, Wis., architect and engineer.

Ohio

CLEVELAND—The Crucible Steel Forge Co. will soon award the contract for the construction of a 1-story, 60x900-ft. rolling mill, heat-treating plant, machine shops and warehouse, on Grant Ave. Estimated cost, $300,000. D. W. Wells, 6600 Grant Ave., mgr. James H. Herron, West 3rd St., and St. Clair Ave., architect and engineer.

CLEVELAND — The Enamel Products Co., Eddy Rd. and Taft Ave., has awarded the contract for the construction of a 1-story, 60x190-ft. factory, to the Crowell-Lundoff-Little Co., 571 Euclid Ave. Estimated cost, $75,000.

MACEDONIA—The Pyrite Brick Co. has purchased a site and plans to build a 1-story brick plant on same. Estimated cost, $250,000. Peter Schneider, care of Bldrs. Exch., Rose Bldg., Cleveland, manager.

Oklahoma

GRANDFIELD—The Uncle Sam Oil Co., 1409 Minnesota Ave., Kansas City, Kan., plans to construct a 1-story refinery at the George Hancock Farm. Estimated cost, $500,000.

PRYOR CREEK—V. V. LONG & CO., consult. engr., 1300 Colcord Bldg., Oklahoma City, is preparing preliminary plans for the construction of a water purification plant, etc., for the city.

New Jersey

HOBOKEN—The White Metal Mfg. Co., 1006 Clinton Ave., is having plans prepared for the construction of a 6-story, 135x135-ft. factory and a 2-story, 20x80-ft. foundry. J. C. Schaffer & Co., 38 West 32nd St., New York City, architect and engineer.

New York

BINGHAMTON—The W. R. Hollingshead Co., manufacturing chemists, 148 Oak St., has purchased a site and plans to construct a 4-story factory on same. Estimated cost, $150,000.

BROOKLYN—The Federal Composition Paint Co., 17 Battery Pl., New York City, has awarded the contract for altering a 3-story factory at 258 41st St., to the William Kennedy Constr. Co., 215 Montague St. Estimated cost, $60,000.

North Carolina

LEXINGTON—The city will receive bids until Jan. 20 for the construction of a filter house and installation of filter tubs, coagulating basin, etc. Estimated cost, $500,000. G. C. White, Durham, engineer.

North Dakota

WEBSTER—The Bd. of Educ. will receive bids until Jan. 20 for the construction of a 2-story, 94x140-ft. school. Laboratories will be installed in same. Estimated cost, $145,000. Oscar Magnus, clk. Edwins & Edwins, Northwestern Bldg., Minneapolis, Minn., architects.

Texas

FT. WORTH—The Invincible Oil Corp., 208 West 8th St., plans to build a 5000-bbl. refinery addition in the northern part of the city. Estimated cost, $500,000. W. R. Spann, 208 West 8th St., archt. and engr.

Wisconsin

SHEBOYGAN—C. W. Boley, city engr., and the Bd. of Pub. Wks., City Hall, will receive bids until Jan. 19 for purchasing and installing sterilizing equipment for purifying the water in Lake Michigan used for the city water. Estimated cost, $11,000. J. Steimle, clerk.

TOMAH—The Tomah Rubber Works, 176 16th St., Milwaukee, has awarded the contract for the construction of a 2-story, 100x100-ft. factory, to Charles Larson, Tomah. Estimated cost, $45,000.

Wyoming

CHEYENNE—The Bd. of Trustees of the Memorial Hospital of Laramie Co. will receive bids until Jan. 27 for the construction of a 4-story, 200x200-ft. hospital at 23rd and House Sts., for Laramie Co. An X-ray apparatus and laboratory equipment will be installed in same. Estimated cost, $300,000.

Ontario

MERRILTON—The Canadian Steel & Forging Co. is having plans prepared for furnishing equipment for the proposed steel plant addition. Plans include the installation of enameling and pickling equipment. Estimated cost, $200,000. J. J. Wernette, 441 Houseman Bldg., Grand Rapids, engineer.

NEWMARKET — The city is having plans prepared for the construction of sewers in Darcy and Yonge Sts.; also a sewage disposal plant and an activated sludge plant. Estimated cost, $60,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, engineer.

TORONTO—Balwins Limited, Ashbridges Bay, has awarded the contract for the construction of a 1-story, 70x800-ft. steel plate mill at Ashbridges Bay, to Canadian Allis-Chalmers, Ltd., 212 King St., W. Estimated cost, $200,000.

TORONTO—The Oakoal Co., King St., E., has offered the city $15,000 for its garbage, proposing to erect a plant and make same into fuel briquets. City spends $175,000 yearly at present on garbage disposal.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23-26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9, and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, New York Section, will hold a meeting, Jan. 23, on "Cheap Cyanide and Its Disposition."

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16-19.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE MINING AND METALLURGICAL SOCIETY OF AMERICA will hold a meeting in New York Jan. 13.

Industrial Notes

THE ANHEUSER-BUSCH BREWING CO. is converting a part of its plant into a factory for the production of bodies for automobile trucks and stake wagons. It will be known as the Busch Body Plant.

THE FEDERAL RUBBER CO. of Cudahy, Wis., has opened a sales branch at 1016 Market Street.

ROGERS, MAYER & BALL announce the extension of their facilities for the examination and appraisal of oil properties through the addition to their staff of Mr. Carl N. Anderson, formerly engaged with the Illinois Geological Survey and the Gulf Oil Corporation.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., has added to its sales engineering staff Albert A. Casey, of Cincinnati, Ohio.

THE LAKEWOOD ENGINEERING CO., of Cleveland, Ohio, announces that as an inducement to industrial plant managers, engineers and others to study their interdepartment transportation problems and more fully realize how industrial tractors and trucks help to conserve labor and in-

crease production, an offer of three awards, $1,000, $500 and $250, is made for the three best analyses of the application of the Lakewood Tier-Lift Truck. This contest is open to all except employees of the Lakewood Engineering Co. All papers must be in by Jan. 30, 1920, and the awards will be made prior to Feb. 28, 1920. The award committee has been appointed by the Society of Industrial Engineers.

THE RICHARDSON-PHENIX CO., Milwaukee, Wis., announces that its Philadelphia office, which was closed on account of the lubricating engineers in that office going into Government service during the war, is now reopened, and is in a position to give prompt service in all matters pertaining to the scientific lubrication of machinery. George F. Fenno is the manager.

WESTINGHOUSE, CHURCH, KERR & CO., INC., announces the appointment of Russell W. Stovel as consulting engineer, to devote his time to the company's electrical and mechanical works.

THE LINCOLN ELECTRIC CO. announces that Paul M. Lincoln, for many years commercial engineer of the Westinghouse Co., has resigned from that organization, to enter the consulting engineering field, and in that capacity will have active charge of motor application engineering for the Lincoln Electric Co., Cleveland, Ohio.

LOUIS A. DUFFY, recently of the J. Frank Dunbar Co., New York City, and Stephen H. Sears, formerly connected with the Firestone Tire Co., Akron, Ohio, have opened an office at 133 Front St., New York City, as brokers in crude rubber, under the firm name of Duffy & Sears.

THE UNIVERSITY OF ILLINOIS, Urbana, Ill., announces that owing to the meetings of the National Brick Manufacturers' Association and the American Ceramic Society, which have been scheduled for the last two weeks in February, the dates for the short course to be given by the department of ceramic engineering have been fixed for March 1 to March 13, 1920. Programs of the course are now available for distribution.

THE UNITED ELECTRIC CONSTRUCTION CO., INC., announces the opening of its Cleveland (Ohio) office at 558-559 Hippodrome Annex.

THE ELECTRIC FURNACE CONSTRUCTION Co., Philadelphia, Pa., announces that the Vancouver Engineering Works, Ltd., Vancouver, B. C., has given an order for a "Greaves-Etchells" furnace.

DR. FREDERIC DANNERTH, consulting chemist and specialist in the industries of rubber and related gums, announces the removal of his offices to the Board of Trade Bldg., 800 Broad St., Newark, N. J.

THE GENERAL FIRE EXTINGUISHER Co., Providence, R. I., was taken over Jan. 1 by a new company—Grinnell Co., Inc. The related industries which the Grinnell Co. takes over consist of fire protection, power and process piping, steam, hot water and gas heating, drying, sales of pipe, fittings, valves and supplies.

WALTER A. ZELNICKER SUPPLY CO., St. Louis, announces that Hugh L. Siegal has been appointed assistant to the president. He was formerly general sales manager for the Ford Roofing Products Co.

THE ELECTRICAL REFRACTORIES Co. is the successor to the Novelty Clay Forming Co., having offices at East Palestine, Ohio.

IVAN P. TASHOF, specialist in inventions relating to the chemical, electrochemical and metallurgical industries, announces the opening of an office in the Victor Bldg., 724 Ninth St., N. W., Washington, D. C., for the practice of patent and trade-mark law.

THE YOCUM LABORATORIES is the new name of the business conducted for many years by John H. Yocum at 325 Academy St., Newark, N. J., which began business Jan. 1, 1920. On May 1 the corporation will take possession of its new laboratory at 168 Colt St., Irvington, N. J., which is now being erected under the most recent ideas as to laboratory construction.

THE CREDITORS' COMMITTEE of the British-American Chemical Company, Inc., 42 Broadway, New York City, announce, under date of Dec. 12, 1919, to the creditors, parties to the plan of reorganization and composition agreement, as follows: "The undersigned readjustment committee, acting under the plan for the reorganization of the British-American Chemical Co., Inc., dated Jan. 6, 1919, beg leave to advise you that they became the purchasers of the property and assets of the company named under judicial sale and caused the same to be conveyed to the British-American Chemical Corp. of New Jersey as thereby authorized. The said corporation has been more conservatively capitalized than the plan referred to contemplated. No mortgage bonds have been issued. The preferred stock is limited to $250,000, instead of $400,000, is entitled to 8 per cent dividends instead of 7 per cent, and after July 1, 1920, is convertible into common stock, dollar for dollar, at the option of the holder. The distribution of 10 per cent cash and 50 per cent preferred stock will be made to the creditors parties to the reorganization plan on approval by the court of the final report of the receiver, concerning which you will shortly receive due notice.

"I. M. Dittenhoefer, W. M. Wadden,
"Committee."

THE AUTOMOTIVE PRODUCTS CORP. of New York, which specializes in the exportation of automotive products, announces that it has secured exclusive sales right for all foreign territories of the products of the Standard Roller Bearing Co. of Philadelphia, covering its roller and ball-bearings. It also announces having completed arrangements to export the products of the New Jersey Car Spring & Rubber Co. of Jersey City. Special attention will be given to the metric sizes, which are in great demand abroad at this time in practically all automobile markets, to replace equipment which has deteriorated or been destroyed during the last five years of war when none could be secured, and of new parts and equipment on thousands of machines now being exported from this country or produced in other markets and for which such equipment is not locally available.

THE BOOTH ELECTRIC FURNACE CO., whose incorporation was announced in these columns recently, has opened up the following district offices with a complete staff of engineers and metallurgists, in connection with the sale of electric furnaces for melting steel, iron, and non-ferrous metals: For New York and New England, Edward B. Stott & Co., Flatiron Bldg., New York City, with E. F. Tweedy, secretary of the company, directly in charge; for eastern Pennsylvania, New Jersey, Maryland, Delaware and southern Atlantic coast states, Northern Engineering Co., 308 Chestnut St., Philadelphia, with F. W. Doran in charge; for northeastern Ohio, western Pennsylvania and western New York, Charles L. Foster, formerly sales manager of the Electric Furnace Co., of Alliance, Ohio; with offices at 879 Arcade, Cleveland, Ohio.

THE MID-CONTINENT OIL, GAS & REFINING Co., with offices in Chicago, Kansas City and Oklahoma City, announces that the Cherry process for producing gasoline by electrochemical means will be used in a 2000-lb. refinery to be constructed at Vernon, Woodson Co., Kan.

THE UNITED STATES STEEL CORP. has been given a contract from the Government of Holland for between 15,000 and 18,000 tons of steel rail for the Dutch railways in East Indies.

THE YORK HARDWARE & BRASS Co. has closed a contract with the American Metallurgical Corp., Franklin Trust Bldg., Philadelphia, for the installation of a 1000-lb. revolving electric furnace of the Weeks type for the melting of brass and copper alloys.

Belgian industries still require raw materials and tools, which are coming in slowly owing to the unfavorable exchange and the difficulty of obtaining credit. Materials for the lining of pits in coal mines are needed, as well as cables, beams and machinery of all sorts; also high resistant galvanized steel wire for cable manufacture. The coke ovens require sulphuric acid and heavy tar oils. Resins, iron ore, billets and pig iron, and machine tools of every description are needed. The glass industry needs sulphate of soda. About 45,000 tons of wood pulp are required, as well as many kinds of chemicals, particularly aniline colors. China clay is in demand.

THE ELECTRIC FURNACE Co., Alliance, Ohio, has just installed nine new Baily Electric Furnaces for melting a wide range of non-ferrous metals and alloys, as follows: The Drew Electric & Mfg. Co., Cleveland, Ohio, has purchased a 105-kw. furnace for melting yellow brass. The Nolte Brass Co., of Springfield, Ohio, has installed a 105-kw. furnace, of 1500-lb. capacity for melting yellow brass. The Kennedy Valve Co., Elmira, N. Y., has installed a 105-kw. electric furnace for red brass. The American Bronze Corp., New York City, has contracted for two 1500-lb. electric furnaces for melting bronze. The Dominion Steel Products Co., Brantford, Ont., Canada, has installed a 50-kw. furnace of 500-lb. capacity for yellow brass. The Deming Co., Salem, Ohio, will melt yellow and red brass in a furnace of 500-lb. capacity. The Miller Pasteurizing Machine Co., Canton, Ohio, will use its Baily Electric 50-kw. furnace for yellow brass. Landers, Frary & Clark, of New Britain, Conn., will melt aluminum in a 50-kw. furnace that has a capacity of 200-lb. of aluminum per hour.

ARTHUR D. LITTLE, INC., chemist and engineer, Cambridge, Mass., through its information department, is planning a series of bibliographic studies, to be circulated among the public, university and special libraries of the United States, and the firms and individuals interested in the various studies. Those in course of preparation are: Chemical Warfare; Alcohol from Waste Sulphite Liquors; Industrial Research; The Automobile and Tractor at the Front; The Electric Furnace; Industrial Laboratories; Molasses; The Chemical Action of Light; Woods and Fibers Used as Paper-Making Materials. Copies of the first three are ready and may be had upon request.

Manufacturers' Catalogs

THE BLACKMER ROTARY PUMP CO., Petoskey, Mich., has issued the eleventh edition of the "Blackmer Rotary Pump," which is illustrated and described.

THE STAR BRASS WORKS, Chicago, Ill., has recently issued a 12-page bulletin, No. 6, pertaining to its line of small steam and water jet apparatus, comprising steam and water syphons or ejectors, also small steam jet pumps applicable to apparatus requiring vacuum, used as centrifugal pump primers, etc., fully illustrated, also including considerable engineering data involved. Copies will be sent upon request.

THE MONEL METAL PRODUCTS CORP., Bayonne, N. J., announces new booklets, ready for distribution, descriptive of Monel metal and its properties.

THE WHEELER CONDENSER & ENGINEERING Co., Carteret, N. J., calls attention to a new bulletin, No. 112-B, entitled "Condensers, Pumps, Cooling Towers, etc." This bulletin illustrates the latest developments in condenser practice. It shows a surface condenser containing 50,000 sq.ft. of surface. Sixteen condensers of approximately this size are now under construction. These will contain approximately 1,000 miles of Crescent Brand tubing drawn in the large Wheeler tube mill. The bulletin shows photographs of a number of actual installations of surface condensers. It illustrates and describes surface condensers, jet condensers, barometric condensers, the Wheeler-Edwards air pump, the Wheeler rotative dry vacuum pump, the Wheeler turbo-air pump, the patented Wheeler steam jet air pump, Wheeler centrifugal pumps for all services, jet condensers, barometric condensers, natural and forced draft cooling towers, feed water heaters, and Wheeler evaporators and driers.

THE J. G. WHITE ENGINEERING CORP., New York City, has published an attractive booklet entitled "Nitrate Number One," which briefly illustrates and describes the design and construction of the nitrate plant No. 1.

THE LEEDS & NORTHRUP Co., Philadelphia, Pa., is distributing Catalog No. 86B on the Optical Pyrometer. This bulletin illustrates and describes the use of the optical pyrometer with the hardening forging furnaces, instructions for using, the general use and theory of temperature measurement.

THE GLENS FALLS MACHINE WORKS, Glens Falls, N. Y., has issued two leaflets on rotary sulphur burners. One gives in a table the various sizes, sulphur burned per hour, approximate weight and floor space, together with a description of a 36 in. by 8 ft. machine. The other leaflet gives a table of sizes and combinations, with rated capacities.

THE STRONG-KENNARD & NUTT Co., Cleveland, Ohio, has issued a functional chart showing results gained by proper safety supervision.

THE AEROIL BURNER CO., INC., Union Hill, N. J., calls attention to a new bulletin describing and illustrating thawing outfits and torches for thawing out frozen cars, pockets, hoppers, pipes, switches, loading gates, chutes, etc.

WALLACE & TIERNAN CO., INC., New York City, has issued a leaflet entitled "Adjustable Orifice for Chemical Solutions."

THE SCIENTIFIC UTILITIES CO., INC., New York City, has published a catalog in which chemical glassware, thermometers and laboratory supplies are listed, which should be useful for the chemist and purchasing agent.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, January 14, 1920 — *Number* 2

Annual Meeting of The Mining Engineers

THE annual meeting of the American Institute of Mining and Metallurgical Engineers will be held in New York City, February 16 to 19, inclusive. Owing to the congested condition of hotels in New York City it is necessary at this early date to urge all who expect to attend the meeting to secure hotel accommodations well in advance. The local committees in charge of this meeting are making strenuous efforts to provide for the convenience and entertainment of members who come from a distance. In spite of all that these committees can do, however, it will be necessary for visiting members to take all possible precautions to insure finding hotel accommodations when they arrive.

Mr. Hoover and The Presidency

REPEATED mention of HERBERT HOOVER in connection with the Presidency will be received with gratification by his engineering friends and associates, even though the publicity may be distasteful to a man of Mr. HOOVER'S nature. For several years we have joined with others in raising our voice in support of more active participation by engineers in Government affairs. Repeatedly we have said that the Government would be more efficient if we had fewer lawyers and more engineers in legislative and executive positions, and we see no reason for not extending that observation to include the highest executive position in the Government. The decision of the Democratic National Committee to hold the party convention in San Francisco gives an added impetus to Mr. HOOVER'S candidacy, he being a Californian by adoption. Probably Mr. HOOVER'S greatest claims to political recognition are his undoubted business ability, thorough grounding in economics and familiarity with European conditions. Other possible candidates are more prominent politically, but none of them approach Mr. HOOVER in positive qualifications.

What Kind of an Engineer Are You?

FOUR kinds of technical engineers are to be reported by the census enumerators who are now taking the fourteenth decennial national inventory. Limitation to four varieties is due to an undersupply of cogs in the great census-counting machine now operating at Washington. Civil, mechanical, electrical and mining engineers are to be the proud possessors of these four cogs. All other practitioners of engineering will be forced to trace back their relationship and claim the one of these four titles that appears to be most becoming to them.

Looking at the matter from the basis of alphabetical initials of engineering titles, there seems to be one too many cogs supplied. For only three combinations of C, M and E are required to designate those chosen, as well as the left out, chemical, metallurgical, marine, military, efficiency, as well as that large cosmopolitan class called etcetera engineers. However, not wishing to detract from the seriousness of the subject, it may be asserted that engineers as a whole are not inclined to be overly particular about their titles. The reason for this is that, as they become more proficient, they widen their scope to cover an increased amount of engineering activities in other fields.

It is probable that the great majority of the readers of this journal will choose to be counted with the mechanical engineers. Any one of the other three of the four chosen could do the same without stretching their qualifications very far. The civil engineer deals mainly with the static mechanics of bridges, highways, railroads and pipe lines. The electrical engineer has mastered the mechanics of electrical phenomena. The mining engineer has been schooled so that he is able to direct the activities of machines and miners in the bringing forth of mineral and ore. No outsider should register among these specialized groups unless he is very closely associated with one of them and more than slightly familiar with its work.

As the census years go by, it is to be hoped that other cogs will spring forth and that the chemical and metallurgical engineers will be separated from this broad classification, which from its very nature is capable of subdivision without end and must always provide for the etcetera engineers.

The Steel Strike Officially Called Off

THE steel strike is officially ended and Mr. FOSTER of unsavory reputation has resigned as secretary-treasurer of the committee which deliberately plotted the disruption of the steel industry through a strike for power. Friends of the American Federation of Labor have felt that its reputation for sane leadership and constructive action was greatly damaged by the activities of men of the Foster type. There can be no doubt that the country was never sympathetic with the steel strike, because it was plainly a contest for power and had no justification. Its leaders were avowed radicals, if so mild a term can be applied, and Labor is well rid of them if their retirement from leadership should prove permanent. The strike was a failure from the beginning and resulted only in economic loss to the steel companies and their employees. Steel production in 1919 was reduced by 2,500,000 tons, due to the strike, and laborers lost untold sums in wages. In other words, the strike was a net loss to the country which the public eventually will have to pay.

State of the Milling Art in 1919

IN THE milling of copper ores as well as in the smelting end, there have been few changes of importance made in existing plants, nor have new plants of large size been built. With high labor and commodity costs and a stagnant copper market, the operator has perforce devoted his attention to keeping his costs as low as possible with the equipment already installed. This does not mean, of course, that research and progress have halted—in fact, everywhere is evidenced the keenest interest in comparative performances.

Crushing and grinding account for the greater part of the expense of concentration, and consequently this department is attacked oftenest by well-intentioned economists. Gyratory crushers seem to be the favorite for coarse crushing—mammoth machines are in operation which receive 70-ton carloads of rock at a time, the size of the pieces being limited only by that which can be juggled on a steam shovel dipper. Doubtless it is cheaper to crush in gyratories than to blast in the mine, but a logical crusher to balance heavy shovels requires openings up to 8 ft. in width. Air-dumped steel cars of the type developed for short-haul railway excavation are favored in recent developments; however, Utah Copper, with its comparatively long haul, still retains its older drop-bottom gondolas. At best such a car unloads slowly and with great labor expense, so in order to save in unloading cost as well as to handle partly frozen ore, that company started operation at its Arthur mill of a new primary crushing plant. A carload of ore from the mine is pushed up an incline by an electric "mule," is clamped down into a cradle, and cradle, car and contents are lifted bodily, tilting sidewise about a pivot several feet above the rail. Ore drops from the overturned car on a huge grizzly made of I-beams and rails, and thence slides into the bell of the coarse crusher. All subsequent handling and elevating ending at the mill-feed bins are done by an elaborate system of inclined conveyors.

For the second stage in size reduction two machines are the favorites, rolls and disk crushers. The latter type particularly has been favored in leaching practice, where uniform size and a minimum of fines are desired. With Symons disks it is possible to eliminate screens, since the machine delivers pieces with one dimension constant. However, large flat pieces will be passed. In case the ore does not break into slabs, this characteristic of the disk crusher is naturally a considerable advantage over rolls, from which pieces with three variable dimensions will come. However, the extreme simplicity and tremendous capacity of large Garfield rolls in many cases will incline the balance of favor to their side.

Two types of vibrating screens have been developed, the Mitchell, used by Utah Copper, and Tyler's "Hummer," installed for trial at a number of places. Botn are electrically driven, actuated by the rotation of a tightly enclosed and somewhat unbalanced motor. As high as 3600 vibrations per minute can be given a taut screen surface by such means, their capacity on dry or wet material is tremendous, and if they can handle damp, sticky ore at a reasonable cost, they will surely find a welcome in the crushing field.

For finer crushing the ball mill has undoubtedly come to stay, although LENNOX at the Portland mill believes that Chilean mills have fallen into disrepute largely because they have habitually been given the wrong kind of feed. Like the ball mills at Inspiration, very much better performances in all respects can be had by giving Chileans a certain amount of relatively coarse material. New Cornelia, in its 500-ton experimental flotation plant at Ajo, is equipped for comparative tests on a special 8 ft. x 36 in. Hardinge conical mill, equipped with grates and with a large open discharge, and two rod mills designed by DAVID COLE, 42 in. x 9 ft. 8 in. and 60 in. x 10 ft. respectively. Rod mills are receiving their share of attention; thus at Nocazari favorable results as to power consumption and tonnage have been had from one designed by MARCY. In passing, one is reminded of the open-end mill tested a couple of years ago at Anaconda, where an old tube mill shell had a tire placed around the open end, and carried on double rolls from a disused drier. Metallurgically the results were excellent, giving a high tonnage at more uniform discharge, with less fines, two-thirds the steel consumption and 60 per cent of the power used in the current practice. The mill was abandoned, however, due to mechanical troubles incident to rapid rotation of such heavy masses in makeshift bearings. It is probable that the rod mill may not be able to crush coarse material in one step, but for grinding from, say, $\frac{3}{4}$ in. to 20 mesh and with the production of a uniform product, the open-end rod mill has extremely attractive possibilities.

In ball-mill crushing the cost of the grinding medium is one of the two large items of expense, the other being power. Metallographical investigations into the nature of steels used for balls and linings should improve this material to a surprising extent. Screening during stage crushing is also a most important item of cost. In order to economize at this point, dry crushing of ores from $\frac{3}{4}$ in. to 20 mesh has been tried at two localities in Arizona, in both rod and ball mill, but as yet without success.

As little is known about the fundamental laws of flotation now as a year ago. All mill experimentation, therefore, is empirical, and directed toward increasing recoveries at lower costs, by trying different combinations of oils, reagents and equipment. Very good results have been had with a combination of 60 per cent "X-cake" (alphanaphthylamine) and 40 per cent xylidine, both coal-tar products. In one plant the use of $\frac{1}{2}$ lb. per ton—of which a third is recovered—is producing a tailing containing 0.15 per cent sulphide copper, and a deflocculated granular concentrate which builds up $1\frac{1}{2}$ in. thick on an ordinary drum filter. It is impossible to draw general conclusions from isolated results in this dark corner of metallurgical practice, however, since ores vary so much in character from mine to mine, and even from one part of the same ore body to another. Still, many good reports are circulating about coal-tar products, and there is no doubt that the choice of oil has an important bearing on the recovery and grade of concentrates. It is doubtful whether these new combinations will free the users from the shadow of Minerals Separation, since they probably can be legally defined as "oils," and Messrs. SULMAN, BALLOT et al. control patents covering the use of soluble oils.

In pneumatic flotation the power required to compress the air is the largest single item of expense, and plant layout and porous-bottom construction to reduce frictional head to the minimum should merit closest scrutiny. While canvas or twill remains the favorite, concrete bottoms have given most encouraging results

at Ray Consolidated, while bricks of bakelite and sand, and other porous materials are constantly being tried. In many cases, air pressure can be reduced by using a thin bed of pulp in the flotation machine, the area of the flotation cells may be reduced by judicious intermediate classification, and recoveries may be increased by an efficient primary agitator to mix thoroughly the oil into the pulp. Mixing oil, acid and pulp by an elevator is in general an expensive method, requiring gunmetal buckets, lead-covered pulleys, and a belt renewal after six months.

Tables have by no means vanished, in fact the new Plato table has been given much attention and tried with many different shapes and kinds of riffles. Tables of some sort will be seen in flotation mills for many years to come, roughing high-grade feed and catching coarse mineral in tails.

Catalyst for the Oxidation of Ammonia

DEFERENCE to the article appearing elsewhere in this issue will show that, although the urgent need of adequate catalysts for preparation of nitric acid in the war industries no longer exists, we may, nevertheless, expect the work will be carried on to ultimate perfection, for adaptation to peace-time manufacture. The results of long experimentation carried to partial completion within the last few months have brought to us a wider vision of the large work that is yet to be done. We may well hope for still greater achievements from the scientists both here and abroad in the near future.

The generous manner in which these investigators are making public the conclusions arrived at from their exhaustive research, and the frank and open discussions resulting therefrom, will lead only to the attainment of the true ideal—the greatest benefit to the greatest number in everything that's chemical.

Efficiency and Morale Of Steel Mill Labor

IT IS a familiar dictum that shortage of labor encourages the introduction of labor-saving machinery. There is a general shortage of labor in the United States now and there will be for several years to come unless capital emigrates in tremendous volume or withdraws very largely from investment. Shortage of labor and abundance of capital are interchangeable terms to a greater extent than is commonly recognized.

In the circumstance of there being a shortage of labor one might be disposed to jump to the conclusion that the chief duty of steel mill managements at this time is to devote their attention to the introduction of additional labor-saving devices. There is ground for argument that this is not the correct deduction from the circumstances. Before the strike of September 22 the production of steel was not equal to the actual capacity of the steel-making units in operation, rating them according to performance in the past, say in the year 1916. There may have been some shortage of labor at that time, in point of numbers, but the common complaint was that labor was not performing efficiently. In the past few weeks the production of steel has been far below what it should have been in proportion to the number of men in employment. It is the commonly expressed opinion to-day that for some indefinite time to come steel mill labor will be below par in efficiency and morale.

Obviously this is not a condition that can be remedied by the introduction of additional labor-saving machinery. The condition is rather that on account of the human element the machinery is not producing as it is physically capable of producing. The remedy is to be sought not in additional or modified machinery but in a change in the attitude and performance of the workmen in the steel mills.

Since the inception of the strike of last September much has been said of the ignorant foreigner employed in the steel mills, ignorant even of the language. There has been much talk of the necessity of "Americanizing" him. It certainly follows that if steel mill labor in the past has been largely ignorant of the language, and in the future is to be more familiar with it, there is opportunity to arrange that the labor shall in future work more intelligently and efficiently.

The chief problem, then, seems to be not to improve the machinery of the steel mill, but to improve the men's handling of the machinery. It is not a problem of machinery, but a problem of men. In this day of labor shortage steel mill managements should not follow the dictum cited and study machinery and mechanical possibilities, but should study men and the possibilities of enabling them to do better work with the machinery already provided.

It may be that in the past "payment by results" has been carried in steel mills as far as it could be carried with the various descriptions of men that were at work. As many men, perhaps, have been given tonnage jobs as could understand the essence of a tonnage job, the more tons the more pay, and were sufficiently in touch with the management to have confidence that the pay envelope really represented the performance. Even granting that such has been the case, though there is room for doubt whether payment by results has been extended as far as it could be with the conditions of the past, it is clear that if there is to be, as there certainly must be, an increase in the intelligence of the men and a greater ability to understand the foreman or superintendent, a closer touch between the management and the workmen, payment by results can be extended.

Payment by results is not as popular as it should be on theoretical grounds, and one may venture to assert that the principle would be much more popular to-day if in years past so many employers had not abused the thing in practice. Often employers have cheated men directly and have swindled them by offering piece rates which were reduced when the men furnished more of the goods bargained for than had been expected. The main thing wrong with piece work has been the employers. The steel industry has its own principles and morals well established that when it offers piece rates or payment by results it treats its workmen fairly. There have been quarrels on this subject only when the men wanted to treat the management unfairly, when they refused to accept a reduction in tonnage rates when the tonnage increased not by the efforts of the workmen but by the investment of greater capital in improved machinery. The steel industry now has an opportunity to increase labor performance greatly by getting in closer and more intelligent touch with its workmen and by extending the system of payment by results. That is the rational way to improve the efficiency and morale of the men.

Western Chemical and Metallurgical Field

Chloride Volatilization Experiments on Ore From Tintic District, Utah

THE chloride volatilization process for the recovery of metals from ores that cannot be economically treated by usual metallurgical methods has received considerable attention during the last few years; there are at present, however, no commercially successful installations in operation in which the recovery of the metals is dependent upon the volatilization of these metals as chlorides. Laboratory investigations have almost invariably indicated that an economical recovery should be possible. In semi-commercial experiments difficulties have been encountered, more particularly with the roasting operation. The recovery of the fume has been successfully accomplished by means of bag-houses or by electrical precipitation, but, again, the treatment of the fume has presented difficulties. The practical solution of the entire problem will undoubtedly come with the development of apparatus designed to carry out the particular metallurgical and chemical reactions. Apparently standardized equipment cannot be modified so as to produce a practical unit that will perform its function in this metallurgical scheme with entire satisfaction.

A great deal of experimental work has been done on an ore from the Tintic district at Eureka, Utah, that has indicated the difficulties encountered, and the practical solution of some of these has been obtained. This is an oxidized siliceous ore containing lead, silver and zinc. It occurs as a replacement in limestone and is of a type which cannot be successfully treated by any developed metallurgical method. The ore is so highly siliceous that a pyrometallurgical treatment is impossible; the high lime content makes a hydrometallurgical method using an acid leaching solution uneconomical unless acid can be made on the plant. The average analysis of the ore is: Insoluble 62 per cent, lime 5 per cent, lead 8 per cent, zinc 2 per cent, silver 15 oz., and gold 0.1 oz. per ton. This ore is too low in lead and too high in silica for direct smelting except perhaps by mixing in limited amounts with a basic ore. It contains about 15 per cent of acid-consuming constituents. The physical characteristics are such that it cannot be successfully concentrated by wet methods or by flotation. These facts led to experimentation in order to determine whether the chloride volatilization method would be practical. A variation in this method as usually conceived was the idea of depending entirely upon the volatilization of the metals as chloride.

The ore was ground to 20 mesh, mixed with 10 per cent by weight of salt and roasted in scorifiers in an assay muffle. As a result of twenty tests on representative ore samples the following approximate volatilizations were obtained: Au 90 per cent, Ag 91 per cent, Pb 87 per cent, Zn 72 per cent. Average analysis of the ore and the calcine follows:

	Oz. per Ton		Per Cent	
	Au	Ag	Pb	Zn
Ore	0.10	8.9	3.92	2.9
Calcine	Trace	0.8	0.52	0.8

Recoveries obtained from similar tests upon representative ore samples from a different part of the mine were Au 80 per cent, Ag 74 per cent, Pb 98 per cent, Zn 53 per cent, with the following average analysis of the ore and calcine:

	Oz. per Ton		Per Cent	
	Au	Ag	Pb	Zn
Ore	0.080	20.9	17.3	5.8
Calcine	0.016	5.4	0.4	2.7

Experiments were made to determine the effect of calcium chloride and mixtures of calcium and sodium chloride in various ratios upon the rate and completeness of the volatilization and also the effect of the ratio of the chlorides to the ore. The results of these tests show that where salt is used as the chloridizing agent there is a tendency of the ore to sinter which becomes more noticeable with increasing amounts of lead in the ore. With calcium chloride the tendency to sinter is not as noticeable with the high-lead ores. The best results were obtained when using a mixture of two parts of calcium chloride to one part of salt. Early sintering causes a low volatilization of all the metals.

It was found that an oxidizing atmosphere is absolutely essential in order to obtain satisfactory volatilization of the silver. With the lead, volatilization took place as well in a neutral or reducing as in an oxidizing atmosphere. Pure silver chloride alone is practically non-volatile at the temperature maintained in the furnace or at about 850 deg. In the presence of lead chloride and sodium or calcium chloride it is, however, volatile at this temperature. It is claimed that $AuCl_3$ is decomposed at about 850 deg. C.; the recovery of gold from the fume indicates that the gold may be volatilized as a complex compound, since it is present in the fume as chloride and as metal. The amount of salt, calcium chloride or mixture of the two that produced the best results was found to be approximately 10 per cent of the weight of the ore. With ores containing 15 to 20 per cent lead this amount should be increased, but in any case the proportion to be used must be determined by experiment. Magnesium chloride acts similarly to calcium chloride.

Sintering

The tendency to sinter increases with the fineness of the grinding and with the amount of lead in the ore. The combination of a high lead content with salt as a chloridizing agent was particularly favorable to sintering. This is probably due to the reaction

$$PbCO_3 + 2NaCl + SiO_2 = PbCl_2 + Na_2SiO_3 + CO_2$$

Sodium silicate has a melting point below the temperature at which it is necessary to maintain the furnace charge. Other reactions which tend to take place are

$$2NaCL + O + SiO_2 = Na_2SiO_3 + Cl_2$$

$$2NaCl + H_2O + SiO_2 = Na_2SiO_3 + 2HCl$$

This last reaction takes place fairly rapidly, but can be prevented by proper control of the furnace temperature, while the other reactions proceed more slowly. Addition of lime rock tends to prevent sintering at the furnace temperatures, since lime-soda silicates tend to form and with proper control of furnace conditions this reaction does not proceed far enough to produce a viscous slag. If the volatilization roast be preceded by an oxidizing roast, sintering is to a large extent prevented. Obviously, these reactions do not take place where calcium chloride is used. The preceding reactions are given to show the manner in which sodium silicates are formed. Experimental work has shown that silica is not required for volatilization of the metals.

The results obtained from these experiments war-

ranted the testing of the process on a semi-commercial scale. A small reverberatory furnace was constructed, but did not prove to be satisfactory in operation. In order to volatilize even half of the silver very active hand rabbling had to be resorted to. This was attributed to the incomplete chloridizing, to the difficulty of maintaining proper temperature and particularly to the impossibility of maintaining an atmosphere duplicating muffle conditions. Further tests were made using a rotary kiln and more encouraging results were obtained; the capacity was, however, too low for commercial application. There was a tendency to form a nose ring at the feed-end of the kiln due to the moisture in the incoming ore. Nose rings at the fire end were formed by overheating of the charge. As the standard kiln is fired only at one end, the best operating temperature could not be attained in all parts of the furnace.

Fume from the kiln was passed through cooling pipes to a bag-house. The temperature was not reduced sufficiently to condense moisture on the bags since as the result of the reaction with zinc chloride, hydrochloric acid would be produced. New bags allowed the escape of fumes but not in sufficient amount to condemn the method. Electrical precipitation has been used to recover a similar fume at the Salt Lake City station of the Bureau of Mines, with practically complete recovery of the fume.

Treatment of the Fume

The fume contains lead, silver and zinc as chlorides, gold as chloride and metal, and in addition sodium and calcium chlorides. If copper were present in the ore, it will also be present in the fume as a chloride. Several methods for the recovery of the metals are possible. Zinc and copper can be removed by leaching with water, this will also remove a portion of the lead. The gold, silver and the remaining lead can then be reduced to bullion by fusion with lime and coke.

$$PbCl_2 + CaO + C = Pb + CaCl_2 + CO$$

This reaction will take place in the absence of silica, which latter if present will cause a re-volatilization of the lead. Copper and any silver or gold that may be extracted by the leaching solution can be precipitated on iron. By this method the chlorine is recovered in a form that can be again used in the volatilizing roast.

If the fume cannot be treated directly in the above manner, it may be leached with hot water, or better with a saturated solution of salt, and the lead recovered by one of several methods. If the solution be concentrated, quite pure $PbCl_2$ will crystallize on cooling and the residue can be treated by the fusion method; or this solution can be electrolyzed with soluble iron anodes. Complete precipitation of the metals is possible by boiling with sponge iron. The residue can then be smelted.

Continuation of the investigation with this particular ore and the development plans for a plant to treat the ore by the volatilization method in commercial quantities were temporarily suspended because of the development of ore on the property that was amenable to standard methods of concentration.

Work of a similar nature is being carried on at several experimental plants in the West, and by the Bureau of Mines station at Salt Lake City. Determination of the vapor pressure of silver chloride and investigations of the factors controlling its volatilization at furnace temperatures are now being conducted at the Berkeley station of the Bureau of Mines.

Meeting of Chicago Section American Chemical Society

AT THE Dec. 19 meeting of the Chicago Section, A. C. S., Dr. Hoskins called to the attention of the Section a circular letter which has been issued from the national secretary's office relative to H.R. Bill No. 8078, known as the Longworth bill. This letter contains a request that each individual member of the American Chemical Society communicate personally with Lawrence Y. Sherman and Medill McCormick, Senators, with the request that they use their efforts to make the bill a law. He also read a letter from Dr. Stieglitz, who is in New York, urging the members to communicate with these Senators. If this bill is not passed within a short time Germany could ship a quantity of vat dyes and organic chemicals sufficient to permanently discourage manufacture in the United States. This condition would be further aggravated by the present exchange rates, as the quotations are in German marks. Dr. Hoskins exhorted the members of the local Section to comply with the secretary's request.

Will Limit Chemical Importations

Dr. Redman, chairman, emphasized the fact that this bill will practically prohibit the importation of organic chemicals from *any* foreign country to the United States in all instances where the compound may be obtained in this country at a fair price for a good quality. The bill virtually gives a few years for the development of the industry and covers many chemicals. As these chemicals are also of vital importance in time of war it becomes a national and patriotic measure.

The paper of the evening was "The Business Side of Chemistry," presented by Otto Eisenschiml. His remarks, which are given in part herewith, are well worth the consideration of every man in the chemical and engineering profession.

The Business Side of Chemistry; Some Ideas on the Selling of Chemical Knowledge

Our colleges dismiss their graduates with the impression that their earning power will be in direct ratio to knowledge and chemical ability. That is not so. Chemical knowledge must be sold, and in order to bring handsome returns, must be sold cleverly.

I often wonder if our colleges, training men for chemistry without regard of their future prospects, are aware of the heavy moral responsibility that rests on their shoulders.

I do not blame the colleges for not giving courses in salesmanship of chemical knowledge. I doubt if there is anyone in the colleges who is capable of teaching this.

Business courses would not help the matter, as the graduate will learn this soon enough in his contact after graduation. I do blame the colleges, however, for failing to point out to their students that such salesmanship is essential to their progress.

To acquire chemical knowledge and use it for the common good is a worthy idea. There is nothing, however, in the law of the land or in the ethics of the profession to interfere with one's desire to obtain financial independence at fifty. Assuming that most chemists will live their lives in positions, have they not the right to fair recompense? Are we, like the owls in Athens, supposed to live on nothing but our wisdom?

It is reported throughout the country that professional chemists of caliber are taking up business pursuits in order to provide the wherewithal for decent living. If such a movement should take on large proportions it would be alarming and detrimental to the best interests of civilization. This consideration should bring a discussion on compensation for chemical service above the level of general discussions on money matters.

I have been criticized and ridiculed for discussing the possibility of reducing the number of chemists by disseminating facts among students regarding the true earning power of our profession. Is it more desirable to have men of forty quit in disgust and despair than to give a prospective chemist an inside tip on his future business prospect?

A man may decide to sacrifice his life on the altar of science, but he has no right to sacrifice his wife and children likewise.

Problem a National One

The problem is a national one, and I believe it can be corrected through proper publicity. I would not recommend a specific remedy at the first discussion. But the younger chemist should know that he is going to be up against it after leaving college. I believe in holding the number down to a minimum, not by law or regulation, but by previous advice to the undergraduates. The colleges are responsible for flooding the markets.

Most chemists hold good hands and play them like amateurs. Most business men hold nothing but a small pair and take the pot. The graduate starts wrong by accepting too low a salary for his first position. Most employers are willing to allot any salary and leave it to the man to make good. If he starts at $60 per month, he is forever handicapped. Every chemist who rings a time clock rings his own death knell.

The main thing is to get started right. It is not impossible because of present precedents to get a large salary on the start. If a man can sell shoestrings he can sell chemistry. The trouble with the present graduate is that he does not know how to meet men and market his services. He lacks the knack of salesmanship.

Lack of Business Knowledge the Trouble

Next to starting wrong the promotion in existing positions is very hard. Business knowledge is a mystery to the chemist. That's the trouble! It is easy to learn business, because it is just common sense. To sell a chemical formula to a layman is unfair to both buyer and seller. To sell a chemical service together with a formula is good ethics and very good business. A chemist that does not know the market value of every ingredient he handles is a failure. He can never expect to be more than a servant of industry.

Nothing is gained by the everlasting wail that chemistry is an underpaid profession. The law of supply and demand listens to no moral arguments, no matter how plausible. A laboratory chemist is generally paid merely for collecting facts, and he can expect no high pay for this service. The man that correlates these data and draws the business conclusions is the one that reaps the harvest. Chemists often furnish advice to business men on which the business men make one hundred times the amount of the fee. It is peculiar that so few chemists are willing to take the risk of financing their own devices.

I suggest only individual changes and no revolutionary movement. There is no reason why one brain cannot hold both common sense and applied chemistry.

Discussion

The paper was very heartily received by the Section and a number of approving speeches followed. Mr. McCoy stated that Mr. Eisenschiml's remarks were excellent and to the point. It is a question of salesmanship and also service to the employer. He must show the manufacturer that he is bringing returns to the company.

Dr. Wesson, who has recently been elected president of the American Institute of Chemical Engineers, stated that if he could have met Dr. Eisenschiml twenty-five years ago it would have been money in his pocket. The chemist must demonstrate to future employers that he is an asset rather than a liability.

Mr. Williams voiced the sentiments of Mr. Eisenschiml. He stated that an engineering course and chemical course are the same in that they lead to anything if you quit soon enough.

New Jersey Clay Workers Hold Annual Meeting

The annual meeting of the New Jersey Clay Workers' Association and Eastern Section of the American Ceramic Society has grown to be one of the important events of the year in ceramic circles in this section, and the gathering at New Brunswick, N. J., on Dec. 18 emphasized this impression. Close to seventy members and guests were present at the morning and afternoon sessions, held in the Fine Arts Room, Queens Building, Rutgers College.

The morning session was given over to general business and the presentation of two papers, the first an impressive talk by Charles Howell Cook, president of the Cook Pottery Co., Trenton, N. J., and chairman of the association during the past year, on the subject of "Preparing for Future Competition." He set forth the urgent necessity for the American manufacturer to be watchful of the inroads being made in the importation of ceramic and other wares to this country from England, Germany, Japan, China and other countries. He gave an interesting piece of information that a ceramic school was now operative in China, with a Japanese, educated in the United States, as director.

The other paper was an instructive lecture by Homer F. Staley, Bureau of Standards, Washington, D. C., on "Feldspar as a Pottery Material." The paper covered the composition of pure feldspars, their geological occurrence, winning and preparation, grading and chemical analyses. Reference was made also to the mineral composition of well-known feldspars, and methods of testing and blending. In a summary of the subject, substitutes for this material in pottery production were mentioned, including the most popular, Cornwall stone, white mica and talc.

The afternoon meeting, coming to order after an enjoyable luncheon at the Hotel Kline, was devoted to a broad discussion of fuel. Three important papers on this subject were presented, "Fuel Analyses," by A. C. Fieldner, supervising chemist, Bureau of Mines Experiment Station, Pittsburgh, Pa.; "Oil Burning in a Ceramic Plant," by R. L. Clare, Federal Terra Cotta Co., Woodbridge, N. J.; and "A New Type of Producer-Gas Fire Box," by R. H. Minton, General Ceramics Co., Metuchen, N. J.

Mr. Fieldner's paper was a comprehensive résumé of methods in use for analyzing coal, covering sampling, proximate analysis, ultimate analysis, determination of heating value, fusibility of ash and a survey of the fusibility of ash of American coals. Information was also given regarding a calculation of heating value and ultimate analysis from moisture and ash determination.

Other papers given at the afternoon meeting were "Properties of Pottery Bodies and Glazes," by H. G. Schurecht, Bureau of Mines, Mining Experiment station, Columbus, Ohio, and the "Furnace Gas Producer," by Charles W. Parks, ceramic engineer, International Clay Machinery Co., Dayton, Ohio. Mr. Schurecht's paper was a technical treatise on pottery bodies, embracing such data as elutriation tests on kaolins, the effect of electrolytes, grinding, screening and organic additions on bodies, refractories, coefficient of expansion of bodies, crazing of glazes with special reference to coefficient of expansion, luster decorations for pottery and adventurine glazes.

At the annual election of officers, the following were appointed for the coming year: Abel Hansen, head of the Fords Porcelain Works, Perth Amboy, N. J., chairman; C. S. Maddock, Jr., of the Thomas Maddock's Sons Co., Trenton, N. J., vice-chairman; Charles A. Bloomfield, head of the Bloomfield Clay Co., Metuchen, N. J., counselor; Charles Howell Cook, Trenton, chairman of executive committee; and George H. Brown, director, department of ceramics, Rutgers College, New Brunswick, secretary and treasurer.

Officers of the Iowa Section, A. C. S.

The officers of the Iowa Section of the American Chemical Society for the coming year have been elected as follows: President, W. S. Hendrixson, Grinnell, Iowa; vice-president, P. A. Bond, Iowa City; counselor, R. M. McKenzie, Fairfield; secretary-treasurer, F. S. Mortimer, Iowa City.

American Metal Buys Vogelstein

The American Metal Co. has acquired the entire business of L. Vogelstein & Co. The purchase gives the American Metal Co., which has heretofore been mainly interested in zinc, lead and minor metals, a prominent place in the copper market, as the business of L. Vogelstein & Co. was mainly done in this metal.

Among the assets of the Vogelstein company taken over by the American Metal Co. is the copper refinery at Chrome, N. J., in which Vogelstein up to recently had a minority interest. He now has the controlling interest by purchase from the United States Smelting, Refining & Mining Co.

Mr. Vogelstein acquired a substantial interest in the American Metal Co. at the recent sale of metal company shares held by the Alien Property Custodian. Other purchasers of shares at the same time were the Cerro de Pasco Copper Co., J. Horace Harding, Louis T. Haggin, Charles D. Barney & Co. and others affiliated with the Cerro de Pasco Co.

Annual Dinner of the Chemical Warfare Service

The second annual dinner of the Chemical Warfare Service was held at the New Ebbitt Hotel, Washington, D. C., Friday, Jan. 2, 1920. The dining room was appropriately decorated with small colored balloons filled with hydrogen and attached to each plate. About 150 officers and ex-officers of the service were present.

Members of the service took advantage of the occasion to express their appreciation of Major-General Sibert, director of the Chemical Warfare Service, through the presentation of a large reading lamp of unusual design. The base was of carved wood, while the standard was a 75-mm. gas shell, with a cluster of lamps at the top. Lieutenant-Colonel Amos A. Fries presided as toastmaster; responses were made by Major Brown, Colonel Ellicott, Major Woods, Major Sutherland, General Sibert and H. C. Parmelee. Major H. S. Kimberly was chairman of the general committee.

ANNUAL DINNER CHEMICAL WARFARE SERVICE, WASHINGTON, D. C., JAN. 2, 1920

British Chemical Industry

(From our London correspondent)

INDUSTRIAL conditions seem to be becoming more stable as the international labor situations are taking more definite shape, although the change over from war to peace programs created uncertainty, especially among the smaller firms. The export trade continues to be very active and the home trade is also improving. The American coal strike has naturally contributed to this. The need of increased capital to meet new conditions is illustrated by the great increase in new capital issues. The formation of trade associations still continues, while among the manufacturers of chemicals considerable activity is being shown in new types of plant and apparatus, some of which originate in the United States and for which catalogues and advertisements are issued at frequent intervals. Standardization of plant, detail fittings, and even of pipework and stoneware is still conspicuous by its absence. The coal situation continues to be interesting and if, as is probable, the price can be reduced, this will give a considerable stimulus to the chemical industry.

Two Valuable Reports

In the industrial field interest has centered on the report recently issued by the Factories Branch of the Department of Explosives Supply and on the somewhat overdue final report of the Nitrogen Products Committee. The former gives valuable information on factory records and cost systems presented in such a way that the individual manufacturer can adapt them to his own requirements. The latter will be published shortly and comprises several hundred pages of carefully compiled information and data covering the whole nitrogen field and making all necessary recommendations regarding the future requirements of the British Empire. The general nitrogen situation has been ably reviewed in the technical press by Dr. Maxted and a decision must soon be made in regard to the future of the Haber and cyanamide processes.

Government to Sell Nitrate Plant

It is, of course, common knowledge that the British Government had started to build a Haber nitrate plant at Billingham-on-Tees, Yorkshire, and that when work ceased there soon after the armistice, the buildings had not progressed much further than their foundations, though a good deal of plant was on the site or on order. The government now by advertisement invites offers for the purchase of the factory at private sale, and it is known that a leading British firm, probably in conjunction with firms having linked interests, has made an offer. As it has just been officially announced that licenses have been granted to Brunner, Mond & Co. to operate certain Badische and Haber patents, it seems certain that this is the firm in question, particularly as the necessary capital is available owing to the sale for cash to Lever Bros., Ltd., of Brunner, Mond & Co.'s controlling interest in Crosfield's and Gossage's soap works.

As regards dyes, licenses have just been granted to Morton Sundour Fabrics, Ltd., to operate various patents of the Badische, Bayer, Griesheim and other German dyeworks.

The anti-dumping bill is likely to give rise to much controversy and is viewed with considerable misgiving in some quarters.

The new president of the Society of Chemical Industry, John Gray, of Lever Bros., Ltd., seems to be infusing new life and increased vigor into its activities. The new Chemical Engineering Group already comprises nearly 700 members and is to hold conferences and symposiums on appliances for moving liquids, and on labor-saving devices in chemical works, at Newcastle and Birmingham respectively. For the latter, American specialties will no doubt predominate, and owing to the increased cost of labor, there should be an active demand for them among British manufacturers. Turning to the social side, which has been sadly neglected over here in the past, the Chemical Industry Club is playing an important part and the recent first annual dinner of the club, which now has over 700 members, was a notable occasion. Reciprocal membership has been arranged with the Chemists' Club of New York and many Americans have already made use of the facilities offered.

Dr. J. Gordon Parker has been elected president of the International Association of Leather Trades Chemists, the next conference of which will be held in London in 1921. A new chair of applied physics is to be founded at Glasgow University, while courses and lectures in chemical engineering are being arranged at many universities and technical colleges.

The Shawinigan Co. of Canada has founded a branch company, Shawinigan, Ltd., at 1 Tudor St., London, E. C., 4, for the sale of its products.

Bureau of Standards Plans Increase in Chemical Activities

Congress has been asked for nearly $3,000,000 to carry out the program of the Bureau of Standards during the next fiscal year. The plan includes the expansion of many of the chemical activities of the Bureau. The items of interest to chemists are as follows: For testing chemicals, varnishes, soap materials and inks, $50,000 (an increase of $20,000 over the current appropriation); to study methods of measurements and technical processes used in the manufacture of pottery, brick, tile and other clay products, $50,000 (an increase of $30,000); to determine experimentally important physical constants of materials essential to the industries or in laboratory investigation, such as the determination of the value of gravity, thermal conductivities of material, mechanical equivalent of heat, metallurgical constants (such as specific and latent heats of metals and alloys), the electrochemical equivalent of metals, and the velocity of light, $25,000 (an increase of $20,000); for purchase, preparation, analysis and distribution of standard materials to be used in checking chemical analyses and in testing of physical measuring apparatus, $15,000 (an increase of $10,000); for the investigation of the problem involved in the electrodeposition of metals, $20,000; for investigation, aiming at improvement in the quality of reagents used in chemical analysis and their eventual standardization, $15,000; for the equipment, maintenance and operation of a low temperature laboratory, including the production of extremely low temperatures, the establishment of the low temperature scale, the production of liquefied gases, and the separation of the constituents of air and other gaseous mixtures, the development of containers and other equipment for liquefied gases, and the application of liquefied gases and low temperature investigations to aviation, $20,000.

Inaccuracy of Treating Records Due to Moisture in Wood

Description of the Experimental Work to Determine the Reactions Taking Place in the Treatment of Wood With Inorganic Salt Preservatives — Record of Tests, Discussion of the Results and Conclusions

BY ERNEST BATEMAN*

IN STUDYING the effect of leaching on wood treated with inorganic salt preservatives, such as zinc chloride, copper sulphate, zinc sulphate, cresol-calcium, etc., it has frequently been noticed that the treating record did not check at all closely with the amount of salt found to be present in the wood. The treating record consisted in the weight of the piece before and after treatment, the difference between the two being considered as the amount of solution injected. This weight of solution multiplied by the per cent of concentration should give the amount of salt injected into the piece. Analysis of the wood after treatment frequently showed that there was often as much as 50 per cent more salt actually in the piece than the treating record showed should be the case and rarely if ever did the record and the analysis agree. In commercial practice the same phenomenon was noticed to a greater or less degree. The theory which has been advanced by wood preservers that there is a chemical union between zinc chloride and wood substance seems therefore to have some basis for its existence. If this is the case, then we must also attribute the increased absorption of such salts as zinc sulphate, copper sulphate, cresol-calcium, and, as will be shown in this paper, calcium chloride, to the same cause.

Experimental Determination of Wood Absorption of Inorganic Salt Preservatives

In order to throw some light on the subject small pieces of wood 2 x 2 x 8 in. were treated with zinc chloride solution and the solutions analyzed before and after treatment to determine if there was any change in the strength of solution. The amount of wood used was as great in proportion to the solution as it was possible to make it. Three conditions of wood were used, oven dry, air dry, and green. The analysis of the solutions showed that there was a change in the strength of solution during treatment, but the weakening of the solution was not in proportion to the amount of wood present in the three runs, and in one case no weakening at all was obtained. The results were such that no very definite conclusion could be drawn. It was therefore decided to make a much more comprehensive and detailed study of the treatment, but in place of zinc chloride to use calcium chloride, chiefly because calcium is much more readily and accurately determined than zinc and at the same time it resembles zinc chloride in its solubility, deliquescence, etc. A small treating cylinder was used, and here again, as in the previous case, the amount of wood was made as large as possible in comparison with the treating solution. The weighed wood was treated to refusal at a temperature of 180 deg. F. Three conditions of wood were again used, oven dry, air dry, and green; the first containing no moisture, the second 15 to 20 per cent, while the third had 30 per cent or more. Actual moisture determinations were not made. The solution was weighed before and after treatment, separate solution being used for each run. As soon after treatment as possible the wood was removed from the treating cylinder and placed in covered glass jars to drip and cool. These were then weighed after cooling. The difference in weight before treatment and the weight after treatment and cooling was taken as the treating record. The drip and condensate were also weighed.

The wood was allowed to dry to some extent and was then reduced to sawdust and analyzed for calcium. The method of analysis consisted in ashing a weighed portion of sawdust and determining the calcium volumetrically by means of its oxalate. The accompanying tables show the results obtained.

TABLE I. TREATING RECORDS

	Run 1			Run 2			Run 3		
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Wt. solution before treatment		21.90			21.60			20.90	
Wt. solution after treatment			16.53			16.07			15.77
Wt. of wood after treatment	8.68			8.63			7.80		
Wt. of wood before treatment	4.09			4.80			5.29		
Absorption of sol. (by difference)			4.59			3.83			2.51
Drip			0.58			1.12			1.48
Loss by leakage or evaporation			0.20			0.58			1.14
		21.90	21.90		21.60	21.60		20.90	20.90

TABLE II. ANALYTICAL RECORD

	Run No. 1		Run No. 2		Run No. 3	
	Strength Per Cent	Total Salt	Strength Per Cent	Total Salt	Strength Per Cent	Total Salt
Solution before treatment	1.84	0.4030	1.41	0.3046	1.79	0.3741
Solution after treatment	1.84	0.3042	1.35	0.2169	1.78	0.2806
Drip	1.35	0.0078	1.37	0.0152	1.61	0.0239
Found in wood		0.0873		0.0700		0.0695
Loss by difference		0.0037		0.0025		0.0000

Correction of Results

Although an attempt was made in this work to reduce the losses of both solutions and salt to as small a factor as possible, in spite of these precautions small losses did occur. It is almost impossible to pump 20 lb. of solution from a carboy to a treating cylinder, put it under pressure, heat it to 180 deg. F., then after the completion of treatment release the pressure and catch all the solution, and entirely prevent evaporation either from the wood or solution or both. For this reason a complete audit of the solution and salt was made so that these discrepancies could be corrected.

The discrepancies which appear in this work must

*Chemist in Forest Products Laboratory, Madison, Wis.

always be errors on the loss side and can be divided into two kinds:

1. Losses due to leaks and to transferring the solution,
2. Losses due to the evaporation of the solution because of its elevated temperature after treatment.

The former would cause a loss in both water and salt, the latter a loss of water only. Whenever we find that we have lost both water and salt in the same proportions, we are justified in assuming that this loss was due to a leak, and when we find that there was no loss of salt but a loss of water, we are justified in assuming that this loss was due entirely to evaporation either from the wood or from the solution. Where we have losses in both water and salt, but they do not check, then we can say that the loss of salt was due to leaks, while the loss of water in excess of this loss by leakage was due to evaporation.

Records of Run No. 1

The amount of solution before treatment was 21 9 lb. That accounted for after treatment was 21.7 lb., or a loss of 0.2 lb. The total amount of salt used was 0.4030 lb.; accounted for after treatment 0.3993 lb., or a loss of 0.0037 lb. The concentration of the solution before and after treatment was 1.84 per cent. A loss of 0.20 lb. by leakage would account for 0.0037 lb. of

TABLE III. CORRECTED RECORDS OF RUN NO. 1

	Lb.	Lb.	Lb.
Wt. of sol. before treatment		21.70	
Wt. of sol. after treatment			16.53
Wt. of wood after treatment	8.83		
Wt. of wood before treatment	4.09		
Absorption of sol. by wood			4.74
Drip			0.43
		21.70	21.70
	Strength Per Cent	Total Salt	
Solution before treatment	1.84	0.3993	
Solution after treatment	1.84		0.3042
Drip	1.84		0.0078
Found in wood			0.0873
		0.3993	0.3993

Salt in wood calculating from corrected treating record, 0.0872 lb.
Salt in wood found by analysis, 0.0873 lb.

salt, or the actual loss found by experiment. We can therefore conclude that there was a small leak in the apparatus, which passed unnoticed during the run.

There was no change in the strength of the solution during treatment, nevertheless the drip solution is noticeably weaker than either of the solutions. At the same time there is more calcium chloride in the stick than ought to have been there if the treating record is correct. The sticks, after removal from the treating cylinder, were placed while still hot under a bell jar to drip. The steam arising from the wood condensed on the jar and ran down into the drip solution with a consequent weakening of this solution. The amount of this condensate can easily be calculated. The record shows 0.58 lb. of 1.35 per cent solution as drip. The weight of this solution must therefore have been increased by the amount of water necessary to dilute a 1.84 per cent solution to 1.35 per cent or

$$\frac{1.35}{1.84} \times 0.58 = 0.425$$

That is, the actual drip was 0.43 lb., the remaining 0.15 lb. being moisture which evaporated from the wood during cooling. This should be added to the treating record as being absorbed by the wood. The corrected record then reads as in Table III.

Records of Run 3

In this run there was a loss of 0.89 lb. solution but no loss of salt. All the loss must therefore have been due to evaporation. This may have taken place from the wood or from the solution. It does not seem likely in this run that much of this loss could have

TABLE IV—CORRECTED RECORDS OF RUN NO. 3.

	Lb.	Lb.	Lb.
Wt. of solution before treatment		20.90	
Wt. of solution after treatment	7.87		16.91
Wt..of wood after treatment	5.29		
Wt. of wood before treatment			2.58
Wt. of drip solution			1.41
		20.90	20.90
	Strength, Per Cent	Total Salt	
Solution before treatment	1.79	0.3741	
Solution after treatment	1.66		0.2806
Drip solution	1.66		0.0239
Found in wood			0.0695
			0.3740
Salt in wood from treating record			0.0462
Salt in wood from analyses			0.0695
Difference excess over treating record			0.0233

taken place from the wood because of the short time exposed after treatment. It is known, however, that the stopper was left out of the carboy for some time after the hot solution had been put into it, so it seems likely that the loss occurred at this place. If it all took place here, then the treating record of the solution after treating should be 16.91 lb. instead of 15.77, and the concentration should be 1.66 instead of 1.78. Here again the drip solution is weaker than the solution after treatment and if we follow the same line of reasoning we can correct this $\frac{1.61}{1.69} \times 1.48 = 1.41$. Actual drip $1.48 - 1.41 = 0.07$ due to evaporation. The corrected record then reads as in Table IV.

Records of Run No. 2

In this run we have both a loss of salt and a loss of solution. The loss of salt amounted to 0.0025 lb. or 0.18 lb. of 1.41 per cent solution. The remaining loss, 0.40 lb., must have been evaporation. It seems more than likely that most of this evaporation took place

TABLE V. CORRECTED RECORDS OF RUN NO. 2

	Lb.	Lb.	Lb.
Wt. of solution before treatment		21.42	
Wt. of solution after treatment			16.07
Wt. of wood after treatment	9.01		
Wt. of wood before treatment	4.80		
Wt. of solution absorbed			4.21
Drip			1.14
		21.42	21.42
	Strength, Per Cent	Total Salt	
Solution before treatment	1.41	0.3020	
Solution after treatment	1.35		0.2169
Drip	1.35		0.0152
Found in wood			0.0700
		0.3020	0.3021
Salt in wood from treating record			0.0594
Salt in wood by analysis			0.0700
Excess over treating record			0.0106

from the wood itself, because in treating the pieces became wedged in the small cylinder and considerable difficulty was experienced in removing them. Furthermore, the concentration of the drip is greater than that of the solution after treatment. This could only be obtained by evaporation of moisture from the wood and a consequent removal of the more concentrated solution by washing with the drip. This would of course take place chiefly at the ends and would account for only a small part of the actual loss, since the concentrated solution caused by evaporation from the sides would not be removed by the drip. We are therefore justified in assuming that the loss by evaporation took place chiefly from the wood. On this basis the corrected treating records are as shown in Table V.

Discussion of Results

Table VI summarizes all the important corrected data in the three runs.

TABLE VI. SUMMARY OF CORRECTED DATA

	Oven Dry	Air Dry	Green
Wt. of wood, lb.	4.09	4.80	5.29
Amount of solution used, lb.	21.70	21.42	20.90
Strength of solution before treatment, per cent.	1.84	1.41	1.79
Strength of solution after treatment, per cent.	1.84	1.35	1.66
Change in strength of solution due to treatment, per cent.	0.00	0.06	0.13
Amount of salt injected:			
By analyses of wood	0.0873	0.0700	0.0695
By treating record	0.0872	0.0594	0.0462
Excess injected over T. R.	0.0001	0.0106	0.0233

In only one of these conditions does the treating record agree with the amount found by analysis, that is, the oven dry pieces. In this also the strength of the solution remained unchanged as a result of treatment. If there is any change in the concentration due to chemical affinity it ought also to be shown in this as well as in the two other cases. We can therefore discard the theory that the wood substances enter into a firm chemical union with the materials used in treating.

There is, however, a striking relation between the reduction in concentration of the treating solution, the apparent excess absorption of salt and the moisture content of the wood. With an increasing moisture content of the wood, the difference in concentration of the solutions before and after increases, and the excess salt found in the wood increases.

This leads to the conclusion that the moisture present in the wood acts as if it had actually been added to the solution and decreases its strength. In other words, the water present in the wood is replaced by solution. This solution would then escape measurement because an equal amount of water takes its place. The amounts of water necessary to cause the reduction in strength for the two solutions are respectively 0.85 lb. and 1.69 lb. Unfortunately, moisture determinations were not made, but the treatments were made with the same number of pieces of approximately the same dimension and same species, consequently the oven dry weight of all three runs should be approximately the same. We should be able to form some idea as to whether or not there could be present in the wood sufficient moisture to cause the phenomena noted. If we take the oven dry sticks as a basis of oven dry weight, we find that there was at least 0.71 lb. water in the air dry stick and 1.20 lb. water in the green stick, so that it is not unreasonable to suppose that the difference between these weights and that required may be due to shrinkage of wood, differences in density of wood substance, and differences in the size of the pieces. If we then subtract the amount of water required to dilute the solutions from the green weight of the wood before treatment, we should get the dry weight of the wood.

$$4.80 - 0.85 = 3.95 \text{ lb.}$$
$$5.29 - 1.64 = 3.65 \text{ lb.}$$

Subtracting these weights from the weight after treatment should give us the amount of diluted solution injected into the wood.

Run No. 2	Run No. 3
9.01	7.87
3.95	3.65
5.06 of 1.35 per cent	4.22 lb. of 1.66 per cent sol.

on a salt absorption of 0.0684 and 0.0701 respectively, actually found by analysis being 0.0700 and 0.0695 respectively. From this it would seem that the correct explanation of the phenomena noted is that the water in the wood acts as a diluent of the treating solution and gives a greater treatment than is apparent from the treating record.

Conclusions

The following conclusions can be drawn from this work:

a. There is no apparent reason to suppose that a chemical combination results from the treatment of wood with most inorganic salts, such as zinc chloride, zinc sulphate, sodium fluoride, calcium chloride, etc.

b. The moisture present in the wood at the time of treatment acts as diluent of the solution.

c. Any system of measuring the absorption of salt by wood during treatment which is based on a measurement of the weight or volume of the solution before and after treatment is liable to a very considerable error. Only when the wood is free from moisture are such measurements exact. At all other times either weight or volume measurements will be in error because of the exchange of the moisture in the wood for solution so that more solution will actually be injected than is made apparent from the treating records.

Action of Muriatic Acid on Manila Rope

At the instigation of the National Safety Council, an investigation has been undertaken by the Bureau of Standards, Department of Commerce, to determine the action of muriatic acid on manila rope. The effect of this acid or its fumes on rope of this kind is a great menace, as the acid weakens the rope seriously without any superficial trace of the action being noticeable to the eye. When rope is exposed to this acid, as, for instance, when it is used in blocks and falls of swinging staging when washing down brickwork, etc., many serious accidents have resulted, some of which have been fatal, owing to the fact that the rope has been weakened through contact with this acid or its fumes. The only practical remedy suggested is that of treatment of manila rope before using with some acid-resisting compound. An attempt will be made in this investigation to determine by testing the actual effect of the acid, and ascertain if the deterioration can be remedied by impregnating the rope with a certain compound which the National Safety Council advances as having been effective in protecting machinery and equipment from acid corrosion.

Present Status and Outlook of the Magnesium Industry

By J. T. Rooney, D.S.C.
Metallurgist, Norton Laboratories, Inc.

MANUFACTURE of metallic magnesium is one of those industries which owes its development in this country to conditions brought about by the war. The metal was first produced in England by Davy in 1808, but it was not until the early '60s that attempts were made to produce it on a commercial scale. In recent times, before the outbreak of the war, plants in England and particularly Germany supplied the world's demand for the metal. It was turned out chiefly in powdered form for photographic flashlights, pyrotechnical purposes, and to a small extent in ingot form as a deoxidizer of non-ferrous metals and for use in light alloys of aluminum.

Prior to 1914 the demand for magnesium in the United States was not sufficiently great to stimulate the production of the metal in this country, but the outbreak of hostilities in Europe, the cutting off of the supply from Germany, and the urgent requirements of the allied governments for the metal for military purposes, with consequent alluring prices, induced several firms to undertake its domestic production.

Plants were erected by the American Magnesium Corporation at Niagara Falls, N. Y.; by the Rumford Metal Co., at Rumford, Me.; by the General Electric Co., at Schenectady, N. Y.; by the Dow Chemical Co., at Midland, Mich.; and by the Norton Laboratories, Inc., at Lockport, N. Y., resulting in the production in 1915 of 87,500 lb., in 1916 of 75,400 lb., in 1917 of 115,813 lb.; and in 1918 of 284,188 lb.

Some of these plants closed down after a short period of operation, and practically all ceased production with the sudden termination of the demand when the armistice was signed, and unless new and extensive uses are found for the metal in the near future, most of these plants are destined for the scrap heap.

Preparation of the Metal

Magnesium has been prepared by a great variety of processes, i.e., reduction of the oxide with potassium, or with carbon at high temperatures; electrolysis of aqueous solutions of the salts; and electrolysis of the fused salts (usually the chloride) in admixture with salts of the alkalis or alkaline earths.

The method most generally in use and probably the most successful so far has been the electrolysis of fused magnesium chloride with the chlorides of potassium, sodium or calcium, but the scarcity of potash during the war precluded its use and compelled the substitution of other salts.

When the domestic production of the metal was undertaken, the only data obtainable on the subject were a few vague statements in textbooks, each prospective producer being compelled to work out his own method of manufacture independently, and consequently each process differed considerably in detail from the others, while some entirely new ones were developed. Still, the cost of producing the metal appears to have been about the same in all instances.

There can be little doubt that if the knowledge gained at the various plants by experience of the past few years was pooled, a much more efficient process could be evolved from the combined data than any heretofore existing and the prospect for a greater production of magnesium in the future would be considerably brightened, for while the metal continues to be sold at its present price its application to industry must necessarily be limited.

A favorable factor in the chloride electrolysis process is the possible utilization of the chlorine gas generated at the anodes for the manufacture of by-products, the value of which might materially offset the cost of production of the metal. The simultaneous manufacture of magnesium chloride and potassium chlorate by chlorination of magnesium oxide with waste furnace gases has, in the writer's experience, worked very satisfactorily.

In 1881 von Putner patented a process for obtaining magnesium by reduction of the oxide with carbonaceous matter and a little iron oxide in closed iron retorts heated to whiteness, the vaporized metal passing over into condensers, the process closely resembling the smelting of zinc. Reduction of the metal in this manner is possible because of the more unstable nature of magnesium carbide, which, unlike that of calcium, decomposes at such temperatures. The high cost and difficulty of obtaining the necessary heat were at that time the deterrents to the success of von Putner's method, but today with the ease and economy with which very high temperatures can be obtained by means of the electric furnace, adaptations readily come to mind which should give the process promising possibilities under modern conditions.

Occurrence of the Ores

Magnesium is said to form 2.24 per cent of the crust of the earth and the occurrence of its compounds are almost universal. Great deposits of dolomite, the double carbonate of calcium and magnesium, are very common. Magnesite, or magnesium carbonate, is mined extensively in Hungary, Greece, Canada, and in this country in California and Washington. Enormous quantities of carnallite, kieserite, and other magnesium minerals are available in the great salt beds of Strassfurt, Germany, and may possibly be found also in the deposits in Alsace.

Properties of the Metal

Magnesium has a greater affinity for oxygen than any of the common metals and combines very readily with it at high temperatures. Advantage is taken of this by employing it as a deoxidizer of metals in the foundry. When magnesium is finely divided it will, after ignition, burn with great violence, emitting a brilliant light rich in actinic rays, and is therefore much used for photographic flashlights and pyrotechnical purposes. These uses are likely to maintain a steady although limited demand for the metal.

Some of the more important physical properties of magnesium in comparison with those of aluminum and copper are given in the following table:

	Magnesium	Aluminum	Copper
Specific gravity	1.74	2.7	8.9
Melting point, deg. C.	651	658	1054
Boiling point, deg. C.	1120	1800	2310
Electrical resistivity, mic./cc.	4.35	2.8	1.58
Thermal conductivity	0.376	0.48	1.0405
Coeff. of expansion	.0000259	.0000222	.0000159
Tensile strength (cast), lb.	20,000	15,000	24,000
Elongation, per cent.	9	3	6

At temperatures around 450 deg. C., magnesium can be drawn, rolled, hammered or extruded with comparative ease.

Of course, the properties for which magnesium is chiefly valued as a metal are its low specific gravity and comparative strength, which properties appeal strongly to the modern engineering tendency to lightness in construction, particularly in the case of motor vehicles and aircraft. It is also a very superior bearing metal and has been shown to wear less than even cast iron under similar conditions of test. It machines beautifully, it being possible to cut the finest and sharpest of screw threads with ease and precision, and it is probable that the metal is superior to any other in this respect.

Magnesium, however, also possesses properties which are generally considered as disadvantageous to a metal under certain conditions. Dampness affects the metal, at least superficially; it is attacked by hot or saline waters; it is rapidly corroded by weak mineral or organic acids; and its soft nature renders it easily liable to injury by mechanical abrasion.

The high coefficient of expansion of magnesium may present a serious problem when the metal is used in assembly with other metals which are affected to a considerably lesser degree by varying temperature conditions.

Alloys

So-called aluminum-magnesium alloys have recently come into use, the magnesium contents of which are less than 1 per cent. It is altogether likely that the magnesium used in casting the metal is of greater value as a scavenger than by virtue of any properties imparted to the alloy by the amount retained.

Magnesium has been cast in aluminum in amounts up to 8 per cent, and some very excellent alloys of low specific gravity and great strength have been produced.

Magnesium alloys readily with practically all of the non-ferrous metals, but when the magnesium content exceeds 10 per cent, the binary alloys become, as a rule, brittle. Similarly, when another metal is alloyed with magnesium in amounts exceeding 10 per cent, these alloys also tend to become brittle.

In the development of useful alloys having magnesium as the predominating constituent, there is plenty of opportunity for research. The pure metal is rather difficult to cast, owing to the tendency to oxidation with inclusion of oxidized particles and because of excessive shrinkage. Binary alloys, generally, present the same difficulties as the virgin metal. But when two or more metals are alloyed with magnesium in lesser amounts, the shrinkage, as a rule, becomes very appreciably less, the hardness is increased, the elongation greatly reduced, the crystalline structure becomes very fine, and well-defined castings can be easily produced quite free from oxides or impurities.

Castings of motor pistons, connecting rods, and like parts have been made of magnesium alloyed with small amounts of other metals, and have given as satisfactory service as those of aluminum, with the added advantage of a considerable reduction in weight. As already pointed out, these alloys retain some of the defects as well as the virtues of the predominating constituent and in the case of motor pistons the high coefficient of expansion characteristic of aluminum and magnesium necessitates finishing the pistons considerably smaller in diameter than the inside of the cast-iron cylinders in order to avoid jamming by the greater expansion of the pistons when the parts are heated to operating temperatures. Thus, when the parts are cold, there is a clearance between the piston and cylinder which results in a loss in compression and sometimes difficulty in starting the motor. However, this is a condition which could possibly be alleviated by special design of the piston and rings.

The possibilities in the development of magnesium alloys of remarkable lightness and strength, together with the extensive occurrence of the ores, should offer every encouragement to metallurgists throughout the world for the evolution of a process for the production of the metal at a cost which would insure its application to industry on a scale commensurate with its admirable properties.

Lockport, N. Y.

Economies of Electric Iron and Steel Production in Scandinavia*

By Joseph W. Richards

During a tour of Scandinavia this summer I was particularly interested in inspecting electric pig-iron furnaces, in which I have been interested for a great many years, and had the opportunity to see eleven out of the twelve furnaces which are in operation. The first plant visited was at Trollhättan, where the original Jernkontoret furnace of 1912 is still in operation.[1] Mr. E. Nystrom is in charge of the plant. A second has been built alongside of it. Both are being run very steadily and uniformly on a medium-grade iron ore, making a pig iron which is going into commercial use, using only charcoal as a fuel.

This may be said about the use of the electric furnace as compared with the blast-furnace in Sweden: At the present time, charcoal is cheaper than coke, and therefore it is cheaper to run with charcoal; the electric pig-iron furnace thus has the advantage of working at its best, under conditions where the blast-furnace can hardly compete with it. Pig iron produced by those furnaces is costing, in Sweden, about $5 per ton less than their own blast-furnace pig iron.

I hardly think that any more blast-furnaces will be built in Sweden. Possibly a few may be in certain localities, but wherever water power is available for producing electricity, certainly the electric pig-iron furnace can operate more cheaply in Sweden than the blast-furnace can.[2]

The next plant visited was at Domnarfvet. They have four furnaces,[3] three of which were in operation. The fourth was idle on account of shortage of water power, it being the dry season. These furnaces show very plainly the successive development of the electric furnace. The first electric pig-iron furnace in Sweden was erected in Domnarfvet; that first one has been torn down and a more modern one is being erected in its place.

---

*Following a session on Iron and Steel at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, at which he presided, Dr. Richards made these remarks regarding Electric Iron Smelting, as he found it.

[1] Met. & Chem. Eng., vol. 9, 1911, pp. 368, 459, 503; vol. 10, 1912, p. 413.

[2] For a discussion of details of electric smelting of iron ore, see Met. & Chem. Eng., vol. 12, 1914, pp. 82, 225, 444.

[3] Met. & Chem. Eng., vol. 16, p. 509.

The four other furnaces show four successive steps in the electric pig-iron furnace development at that plant. The latest one is of 4500 kw., nearly 6000 hp. The whole plant is substantially erected, and gives one the impression of being around a modern blast-furnace plant. It is smaller, but the appliances are functioning so well and the uniformity of running is such as to give one the impression that here is a commercial running plant.

At Hagfors, 100 miles west of Domnarfvet, there are five electric pig-iron furnaces, and they are working very well. I spent half a day there with Mr. Bergquist, in charge, discussing all the points of the furnace plant. They have gradually changed first one thing and then another, widening out the neck of the furnace at the lower part, improving the holders, electrodes, etc. They have electrodes up to 30 in. diameter in use, and the replacement of the arch of the furnace when it becomes damaged is now well taken care of. There are other details of operation which were being mastered in about the same way that we are used to seeing around ordinary blast-furnaces.

It seems to me the experience which has been gained by the Swedish plants is sufficient to make them practicable in a great many parts of the world, and I expect to see in the near future a considerable extension of the use of these furnaces in such countries as Canada, Italy, Brazil, Mexico, Japan, or other places where high-grade iron ore is available and there is a good supply of charcoal and cheap electric power. Electric power in Sweden is now costing more than it did before the war, because the plants are requiring increased hydro-electric installations which cost much more to install now than formerly. The era of $8 a year horsepower is past. It is now averaging more nearly $10 to $12 in the developments which are now under way.

Electric Steel

As regards electric furnace steel, I visited the largest electric steel works in Norway. These works, at Stavanger,[1] have been for some years making very fine qualities of electric steel, melting down steel scrap in an open-hearth furnace and then refining in an induction electric furnace. Before the war they found it cheaper to do the melting in the open-hearth furnace than to do it in an electric furnace, even though power was costing them only $6 per hp.-yr. But with the increased price of coal during the war (it cost up to $80 and $90 a ton, but it is now down to $20) they have calculated that they can melt cheaper in the electric furnace than in the open-hearth furnace using coal. Therefore, that same company has put in two furnaces, one of the Frick type, and the other of the Heroult type, so that henceforth its practice will be to melt cold charges in the electric furnace instead of using its former duplex open-hearth-electric practice.

Labor Conditions

I found the labor conditions in Sweden better than in Norway, but in both countries it is much worse than here. Particularly in Norway, the labor element is extremely disquiet, especially among the younger unmarried men, between 20 and 25 years old. They go around with pipe in mouth, hat on one side, hands in pockets, and have the Bolshevist ideal of doing as little work as possible and getting impossibly high pay for it.

There also seems to be an almost entire lack of confidence and understanding between employers and employees. For instance, the employers may be trying to figure out whether they can keep the business running and make any profits, when the workmen come around with a demand for 50 per cent increase in pay and a 6-hr. day. The employers then throw their hands up and say that it isn't in it. Many of the plants operating in Norway cannot pay the demand of the laborers for wages and keep running, so that the workmen are killing their own chances for getting higher wages.

If it is said to these workmen that the industry cannot stand the high prices which they demand, they reply: "We don't believe it. They could give it to us if they wished to. It is merely greed that prevents the employers from making a profit; if they can't run it, let the government take it over."

That is the attitude of a large part of the labor element in Norway. It is certain that if private enterprise cannot operate and make a profit, then it is impossible for the government to do so.

Remedy for Labor Unrest

There seems to be a deadlock at the present time, which can only be solved in one of two ways; that is, either that the men get hungry and have to work, or that a re-establishment of confidence can be had between the employer and employee, by putting an employees' representative on the board of direction and working on the co-operative plan.

I believe that this will come. I talked with many men, some high up in governmental and industrial circles, and they seemed to think that it would be a good plan thus to have the workmen find out the actual condition of the business and the possibilities of wages, because, as one sees it now, there is absolutely no limit to the workmen's demands except the blue sky. If they demand so much and get it, they want more and more. The actual limit is necessarily imposed by the condition of the business itself. If the representative of the workmen upon the board advises the workmen that certain things are possible and others impossible, then it is hoped that the workmen may be reasonable enough not to demand what their own representative tells them is the impossible.

The near future, I think, will see this development. The cards will have to be placed on the table. The greed of some employers who want, if it is possible, to make 100 per cent off their capital in a year, and put it in their own pockets, will be blocked, and I think this will lead to a fairer distribution of the profits resulting from the co-operation of labor and capital. It seems to me that this offers the best prospect toward a re-establishment of confidence, and a return to intensive industrial operation.

[1] Met. & Chem. Eng., vol. 13, 1915, p. 64.

Foreign Commerce of United States for 1918

In compliance with recent legislation requiring that the annual report on the foreign commerce and navigation of the United States hereafter cover the calendar instead of the fiscal year, the Bureau of Foreign and Domestic Commerce has published statistics of United States trade with foreign countries for the year ended Dec. 31, 1918. The previous report published covered the fiscal year ended June 30, 1918, so, in order to provide a continuous record, the half-year period from July 1 to Dec. 31, 1918, is shown separately. Copies of this publication may be procured from the Superintendent of Documents, Washington, D. C.

Melting Point Methods at High Temperatures—II

A Description of the Determination of Melting Points of Metals, Alloys, Salts and Refractory Materials by the Use of Thermo-Electric, Resistance and Optical Pyrometers*

By LEO I. DANA AND PAUL D. FOOTE

On account of the low heat diffusivity and latent heat of fusion of salts and silicates, considerable difficulty is encountered because of the obliquity of the melting or freezing curves. Consequently it is necessary to use tall, narrow charges and slow rates of heating. Few salts can be heated in a reducing atmosphere, and hence graphite crucibles are prohibited. Porcelain and fire clay are attacked by most salts, so that metal crucibles must be employed. Of these platinum, platinum alloys, and nickel have the widest utility. The thermocouple protecting tube of porcelain must itself be protected by a thin metal sheath. In many cases salts do not attack platinum perceptibly, so that the thermocouple may be immersed directly in the molten salt. When this is done, the crucible must be free from volatile metals such as iridium, especially for work at high temperatures; otherwise the couple will become contaminated. If no protecting tube is employed, very small crucibles may be used, from 1 to 2 cm. in diameter and 2 to 4 cm. high. If the salt is quite volatile and the vapors distill into the furnace, an additional protection tube for the furnace heater is necessary. The melting or freezing points of the nitrates, chlorides and sulphates of the alkali and alkali earth metals may be determined as above.

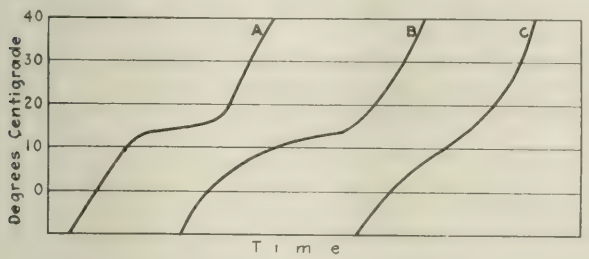


FIG. 12. SILICATE MELTING CURVES

The melting points of silicates and other compounds of metallic oxides are usually comparatively high, and their great viscosity when liquid, their slow melting, slow crystallization, and undercooling introduce many difficulties in the melting point determination. Many crystalline silicates which have a definite melting point do not show a definite freezing point on account of the high viscosity of the liquid, thus preventing the formation of crystal nuclei. The liquid supercools and the viscosity may so increase that a glass is formed; thus borax may be melted but once, and on cooling a clear glass results which with reheating shows no marked heat transformation at the melting point. Other materials acting in this manner to a lesser degree are diopside, $MgSiO_3.CaSiO_3$, melting at 1391 deg. C., and lithium metasilicate, Li_2SiO_3, melting at 1202 deg. C. Consequently in silicate melting point determinations the melting curves are almost exclusively considered. In Fig. 12 *A* represents about as good a curve as is usually obtained with a silicate.

In another class of silicates the melting requires a large time interval, probably on account of the high viscosity of the liquid, so that the material will easily superheat as well as supercool. Both the melting and freezing curves may be so oblique that no halt in the curves is perceptible. In Fig. 12 *C* shows a heating curve for a slow melting silicate, which gives practically no information as to the true melting point. Silicates of this class may be differentiated by studying the melting curves obtained for different rates of heating. If the faint trace of a halt in the melting curve shifts with rate of heating, it is fairly conclusive evidence that this method is not applicable. A method which has been employed for such materials by the Geophysical Laboratory is to heat the substance for a considerable time at various constant temperatures and after quenching in mercury, investigate the crystalline properties under a petrographic microscope. The crystalline structure is destroyed by the melting. Materials of this type are albite, $NaAlSi_3O_8$, melting below 1200 deg. C., orthoclase, $KAlSi_3O_8$, and quartz, SiO_2, melting at 1710 deg. C.

FIG. 13. Silicate Melting Point Apparatus

The apparatus used by the Geophysical Laboratory for silicate work is shown in Fig. 13. The marquardt or sillimanite porcelain tube *A* is jointed to a platinum sleeve *B*, 5 x 1.2 cm., into which tightly fits the platinum crucible containing the charge. The platinum thermocouple, carefully centered, is inserted with no protection. Great care must be taken to avoid the presence of impurities such as chips of porcelain from the tube *A*, etc., as the lowering of the freezing point by impurities is proportional to the square of the absolute temperature and becomes very serious at high temperatures. In Fig. 12 *B* shows a heating curve of a silicate containing an impurity.

White has found that in general the electrical leakage through the molten salt is not of serious importance. However, this must be considered for precision work at high temperatures, as well as the leakage from the furnace heating current to the couple. The latter may be diminished by preventing any part of the heated couple or crucible from coming into contact with the furnace wall. Thermionic leakage to the couple may be minimized by electrostatic shielding.

*Part I was published in CHEM. & MET. ENG., Vol. 22, No. 1, pp. 23-28, Jan. 7, 1920.

Leakage may usually be detected by moving the couple, and by reversing or cutting off temporarily the heating current.

The rate of heating should be from 2 to 8 deg. C. per minute. On account of the tendency of the melting curves to obliquity and on account of the small heat transformations involved, it is necessary to maintain a careful furnace control so that irregularities in heating will not appear on the melting curve. Even then it is possible that more sensitive methods of thermal analysis may be desirable, such as the inverse rate or the differential methods described elsewhere.[7]

Platinum-Wound Furnace

Since an oxidizing atmosphere is necessary, the furnace employed for high melting point work with salts and silicates must be wound with platinum. Fig. 14 shows a furnace suitable for temperatures up to 1550 deg. C. The tube *A*, of Norton alundum R. A. 98, 33 cm. long, 3 cm. bore, and 3 mm. wall, is wound with platinum or platinum-rhodium ribbon *B*, 1 to 2 cm. wide and 0.01 or 0.02 cm. thick with the turns about 3 mm. apart. The ends of the foil are bound with a turn of

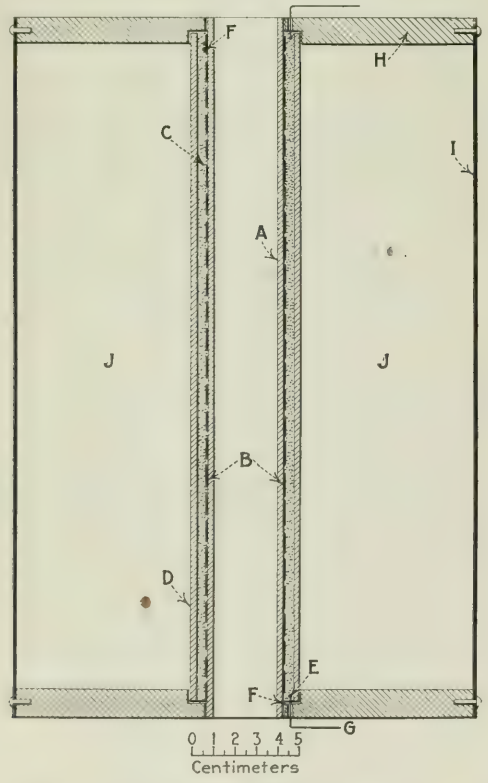


FIG. 14. PLATINUM-WOUND MELTING POINT FURNACE FOR SILICATES AND METALS

platinum wire *F*, to which are fused the heavy silver lead wires *G*. Around the tube *A* is a second tube *D*, and the space between the two tubes is packed with Norton R. R. alundum 120 mesh to prevent local heating of the ribbon. The space between the shell *I* and the tube *D* is filled with sintered magnesite.

Table of Melting Points. Table III gives the melting points of several salts and silicates determined at the Geophysical Laboratory.

Technical Melting Point Determinations. For ordinary technical testing in which an accuracy of 5 to 10 deg. C. is sufficient the general procedure is the same as that discussed for precision work except that less care is required in experimental details. When large couples are used it is necessary to procure much larger crucibles, approximately in the same proportion illustrated by Table I.† It is not a wise practice to immerse a bare base metal couple directly in a molten salt or

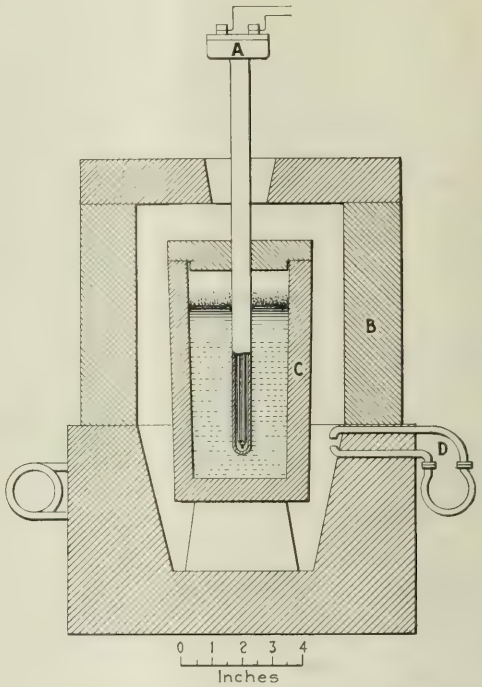


FIG. 15. GAS FURNACE FOR TECHNICAL MELTING POINTS

metal. The couple should be protected by a metal or ceramic tube, preferably of thin wall in order to reduce heat conduction. For metals, Dixon graphite crucibles, which are less susceptible to oxidation than the Acheson graphite, or pure fire clay (except for aluminum) are satisfactory, while for salts iron, calorized iron, nickel nickel-chromium alloys or Duriron are serviceable. For

TABLE III. MELTING POINTS OF SALTS, SILICATES AND OTHER COMPOUNDS

Substance	Formula		Melting Point Deg. C.
Sodium molybdate	Na_2MoO_4		687
Borax	$Na_2B_4O_7$		741
Sodium chloride	NaCl		801
Sodium sulphate	Na_2SO_4		884
Sodium metasilicate	Na_2SiO_3		1088
Lithium metasilicate	Li_2SiO_3		1202
Lithium orthosilicate	Li_4SiO_4		1255
Eutectic between diopside and calcium metasilicate	$MgSiO_3$. $CaSiO_3$ 60 per cent $CaSiO_3$. 40 per cent		1357
Penta-calcium tri-aluminate	$5CaO.\ 3Al_2O_3$		1382
Diopside	$MgSiO_3$. $CaSiO_3$		1391
Eutectic between calcium metasilicate and cristobalite	$CaSiO_3$. 77 per cent SiO_2. 23 per cent		1426
Calcium metasilicate	$CaSiO_3$		1540
Anorthite	$CaSiO_3$. Al_2SiO_5		1551
Magnesium metasilicate	$MgSiO_3$		1554
Calcium aluminate	$CaO.\ Al_2O_3$		1592
Cristobalite	SiO_2		1710

the checking of thermocouples, pots of commercial tin, lead, zinc, sodium chloride and copper of a fair degree of purity are sufficient. The melting points of these materials will rarely differ from those of the pure substances by 10 deg. C., and if close checks are required the melting points may be determined by means of an accurately calibrated couple. A gas furnace may be employed for heating, but the flame should not be allowed

[7] For further details on silicates see publications of the Geophysical Laboratory in the *Am. J. Sci.*, and Jaeger, "Physico-chemical Measurements at High Temperatures," Walters, Groningen, Holland, 1913.

† See CHEM. & MET. ENG., vol. 22, No. 1, p. 24.

to strike the crucible on one side only. If the burner is directed along a radius of the furnace instead of tangential to its surface, a baffle may be interposed before the crucible or the crucible may be mounted on a pedestal above the flame. Under these circumstances it is desirable to protect the crucible by an outer metal tube. An excellent form of gas furnace is the melter's furnace made by the American Gas Furnace Co. and illustrated by Fig. 15. For ordinary laboratory work size No. 3 is suitable. The furnace is provided with three burners *D*, only one of which appears in the drawing, mounted tangentially to the circumference in order to produce a spiralling flame. Excellent temperature uniformity is thus obtained.

Wire Method. The wire method of determining melting points of metals consists in inserting at the hot junction of the couple a small length of wire drawn from the material to be investigated. Usually a rare metal couple is employed. The couple is cut apart at the hot junction and the sample wire, preferably of about the same diameter as the wire of the couple and about 1 cm. or less in length, is fused (not soldered) in. The couple is then mounted in a narrow tube, which may be closed at the lower end, and inserted into a uniformly heated furnace as illustrated by Fig. 16. The temperature of the furnace is increased very slowly as the melting point is approached and the emf. of the couple is observed at the instant that the circuit is broken by the melting, evidence of which is shown by the galvanometer deflection of the potentiometer or of the simple indicator dropping to zero. The temperature corresponding to this emf. on the calibration curve of the couple is the desired melting point. The introduction of the short pieec of metal produces no effect on the thermo-electric circuit, provided it is at a uniform temperature. The two metals most satisfactorily employed with this method are gold and palladium, although many other metals could be used with the proper atmosphere. The experimental manipulation for palladium is a little difficult. A platinum-wound furnace similar to Fig. 14 must be used, and the two insulating tubes of the couple must not come into contact with each other or with the furnace walls; otherwise electrical leakage occurs. A leak between the wires of the couple produces a peculiar effect at the instant of melting of the palladium. Instead of the galvanometer showing zero deflection it will indicate the very large voltaic emf. developed when the porcelain acts as an electrolyte, since the metallic shunt of low resistance across this emf. is broken when the palladium melts. With proper care, results by this method are reproducible to 1 deg. C. It is frequently convenient to sight a microscope of low power on the loop of wire and observe the melting. If the rate of heating is slow, sufficient time elapses from the incipient melting to secure several reliable potentiometric readings before the circuit is broken.

FIG. 16. APPARATUS FOR WIRE METHOD

The wire method is occasionally employed for copper heated in air. The temperature so obtained, however, is not reliable. It may be any value from 1063 to 1083 deg. C., depending upon the rate of heating and hence upon the amount of oxide formed.

II. Use of Resistance Thermometers

The standard temperature scale as used and distributed by the Bureau of Standards is defined in the interval —40 to 450 deg. C. by means of platinum resistance thermometers calibrated in ice, and steam and sulphur vapor (444.6 deg. C.). Platinum of a high degree of purity is readily obtainable, and its purity is assured if the mean temperature coefficient of resistance of the thermometer between 0 and 100 deg. C. is not less than 0.00388 and if the constant δ of the Callendar equation used for expressing the relation between temperature and resistance is not greater than 1.52. The temperature scale from 450 to 1100 deg. C. is defined by the melting points of pure antimony, silver, gold and copper and interpolation between these points is based on the temperature scale defined by the rare metal couple (Pt-90 per cent Pt, 10 per cent Rh) calibrated at two of these fixed points, antimony and copper, and a third point, zinc, fixed by the resistance thermometer.

Advantages of Resistance Thermometers

It has been found that the scale defined by the resistance thermometer calibrated as above agrees with the thermocouple scale as closely as this may be reproduced, even up to 800 deg. C. Above this range the behavior of a resistance thermometer is likely to be erratic. The calibration is subject to changes on account of volatilization of the platinum and strains introduced by the warping of the mica frame upon which the wire is wound. Reliable precise measurements can be obtained only by inter-comparison of several thermometers. Below 800 deg. C., however, the temperature scale defined by the resistance thermometer is probably more closely reproduced by different resistance thermometers than is the thermocouple scale reproduced by different thermocouples. Hence when very high precision is required, 0.1 deg. C. or better, the resistance thermometer offers some advantages in the range 450 to 800 deg. C. Below 450 deg. C. the resistance thermometer is the most accurate means of temperature measurements, since its temperature scale is accepted as standard. In melting point work of the highest precision from 450 to 800 deg. C. there is some question as to whether the error resulting in a temperature gradient over the entire bulb of a resistance thermometer introduces as large an error as may arise with a thermocouple, which requires a much smaller region of temperature uniformity, for example the errors due to inhomogeneity of the wires of the couple.

The general technique to be observed in melting point determinations with the resistance thermometer is the same as that required in thermocouple work of the highest precision. The large size of crucible described in Table I is necessary since the bulb of the thermometer is from 5 to 8 cm. long. The most extensive paper on the application of resistance thermometers to melting point determinations is by Waidner and Burgess.[8] This paper contains a complete bibliography up to 1909. Later developments have been made only in the methods of measurement, such as bridges, etc., and are described by Waidner, Dickinson, Mueller and Harper and by Mueller.[9]

[8] Waidner and Burgess, Bu. of Standards, Scientific Paper No. 124.

[9] Waidner, Dickinson, Mueller and Harper, "A Wheatstone Bridge for Resistance Thermometry, Bu. of Standards, Scientific Paper No. 241. Mueller, "Wheatstone Bridges and Some Accessory Apparatus for Resistance Thermometry, Bu. of Standards, Scientific Paper No. 288.

III. Use of Optical Pyrometers

Metals and Alloys

Above 1400 deg. C. the difficulties involved in the use of thermocouples for melting point determinations are very great. Refractory tubes are attacked by the metals and are permeable to gases which contaminate the couple. The calibration of the couple changes, inhomogeneity develops and troubles arise from electrical leakage. For these reasons the use of optical pyrometers is desirable, and, above 1550 deg. C., necessary. The disappearing filament type of optical pyrometer is most satisfactory, since it is capable of high precision and requires a very small source upon which to sight. Special care must be given in the use of optical pyrometers to insure that black body conditions are closely approximated.

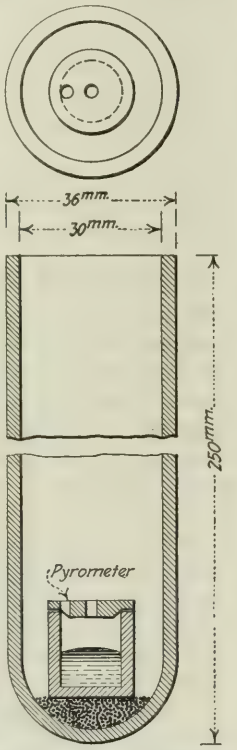


FIG. 17. APPARATUS FOR MELTING POINTS OF METALS AND ALLOYS WITH OPTICAL PYROMETER

For metals and alloys melting below 1750 deg. C. the experimental device shown in Fig. 17 is suitable. The outer tube is made of sillimanite porcelain, melting at 1810 deg. C., and constitutes the unit to be inserted into a furnace. The crucible inside this tube is about 18 mm. in diameter and 20 mm. high, and is provided with a cover having two holes, 2 to 3 mm. in diameter, in the positions illustrated. The pyrometer is focused on the outer hole, and the central hole is for observing the progress of a freezing or melting. If the metal in the crucible is molten, the central hole appears quite dark against a brighter background because the level metal surface reflects the image of the upper and cold part of the furnace. The surface under the side hole, however, is convex on account of the surface tension of the metal, and the V-shaped depression formed between the metal and the side wall affords a satisfactory black body upon which to sight the pyrometer. The outer tube should be uniformly heated for a distance at least twice its diameter, and the short crucible should be filled about half full with metal. Tall crucibles are not desirable, as they are less likely to be uniformly heated and any non-uniformity disturbs the black-body conditions. Although it is realized that such a system is not ideal for producing black-body radiation, especially when the temperature is continually changing, as is necessary in melting point determinations, still it may be concluded on the basis of many careful observations that the error in general does not amount to more than 2 or 3 deg. C. For more precise work it is possible to fix to the cover of the crucible a re-entrant tube immersed directly in the metal, and into which the pyrometer is sighted. This method is frequently employed for the standardization of an optical pyrometer by direct melting point determinations.[10]

TABLE IV.

Metal	Melting Point	Crucible Material	Atmosphere
Silicon	1420	MgO, Al_2O_3, or mixtures	Vacuum, N_2, H_2
Nickel	1452	MgO, Al_2O_3, or mixtures	Vacuum, N_2
Cobalt	1480	MgO, Al_2O_3, or mixtures	Vacuum, N_2
Iron	1530	MgO, Al_2O_3, or mixtures	Vacuum, N_2
Palladium	1550	MgO, Al_2O_3, or mixtures	Air
Chromium	1615	MgO, Al_2O_3, or mixtures	Vacuum, N_2
Platinum	1755	MgO, Al_2O_3, or mixtures	Air

Table of Melting Points. Table IV gives the melting points of several pure metals which with their alloys may be investigated by the above method.

Crucibles. Crucibles containing either graphite or silica must never be used for precision work with these metals and their alloys. Silica-free crucibles are not sold by the porcelain manufacturers, but can be made in the laboratory without much difficulty from magnesia, alumina, or mixtures of the two. Pure magnesia aluminate does not begin to melt below 1925 deg. C., and hence is sufficiently refractory for the above metals. Pure fused alumina and pure fused magnesia made by the Norton Co. are ground to 150 to 200 mesh and mixed in the approximate proportion 75 per cent alumina and 25 per cent magnesia (the exact proportion is immaterial). The powder is slightly moistened and compressed in a briquetting mold similar to that illustrated by Fig. 18 into a cylinder having the outside diameter of the crucible. This cylinder is fired in a graphite crucible at a temperature of 1700 deg. C. for a few moments. The Arsem furnace described later, or any carbon resistor furnace having a clean atmosphere and capable of maintaining this temperature, is satisfactory.

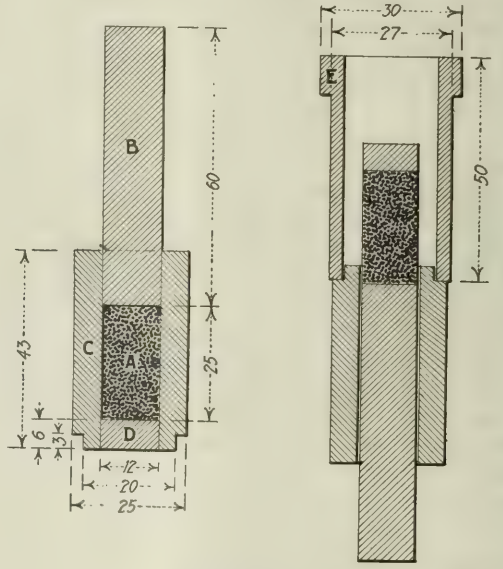


FIG. 18. BRIQUETTING MOLD FOR REFRACTORY MATERIALS

The cylinder sinters to a hardness sufficiently strong to be handled, and with care it is possible to drill out a hole large enough for the metal, with an ordinary twist drill. The crucible is then refired at a temperature between 1800 and 1900 deg. C. A cover is readily made.

For ordinary testing with metals other than palladium and platinum, the sillimanite crucible ("impervite" or "usalite") may be employed. These are of course attacked and must be discarded after each determination, but experiments indicate that the impurity introduced in the metal by a single heating affects the melting point less than 10 deg. C. Such crucibles are useful for ordinary work with steels and nickel-chromium alloys.

Furnaces. None of the metals or alloys of high melting point, except the rare metals, can be melted in air

[10] Kanolt, Bu. of Standards, Technical Paper No. 10. Foote, Met. & Chem. Eng., vol. 11, p. 97; 1913.

vithout serious oxidation. The use of a vacuum furnace, the residual gases being CO and N_2, is satisfactory except for palladium and platinum. Fig. 19 illustrates such a furnace designed by Arsem.[11] It is readily and accurately controllable and a clear atmosphere is assured. The graphite spiral *C* is mounted in water-cooled copper electrodes. *F* is a radiation shield of graphite filled with magnesia. The pyrometer is sighted through the glass window *D* into the sillimanite tube *B* (see also Fig. 17), which is suspended from the top of the furnace. In the place of *A* the crucible shown in Fig. 17 is mounted on a bed of alundum. The porcelain tube is fairly impermeable to the hot gases and carbon vapor. With the first heating in a vacuum furnace the liquid metal usually sputters on account of evolution of gases, and may throw off the cover of the crucible, but after the first melting satisfactory readings can be taken. Suitable rates of heating or cooling near the melting point are from 10 to 20 deg. C. per minute. In this range, temperature measurements should be made very frequently, every 10 seconds if possible. Fig. 20 illustrates typical freezing curves for pure iron and chrome steel by this method.

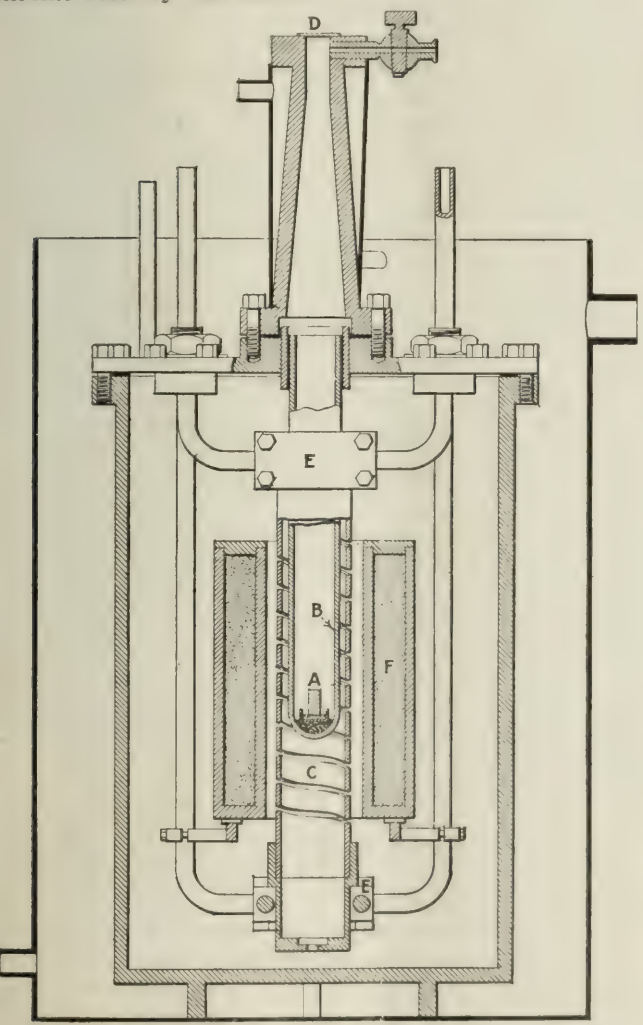


FIG. 19. ARSEM GRAPHITE RESISTANCE VACUUM FURNACE

For temperatures below 1550 deg. C. the sillimanite tube of Fig. 17 may be heated in a platinum-wound furnace if desired. The proper atmosphere for the metal can be obtained by fitting the sillimanite tube with a

[11]Arsem, *J. Am. Chem. Soc.*, vol. 28, p. 921; 1906. Kanolt, Bu. of Standards, Technical Paper No. 10, Scientific Paper No. 212.

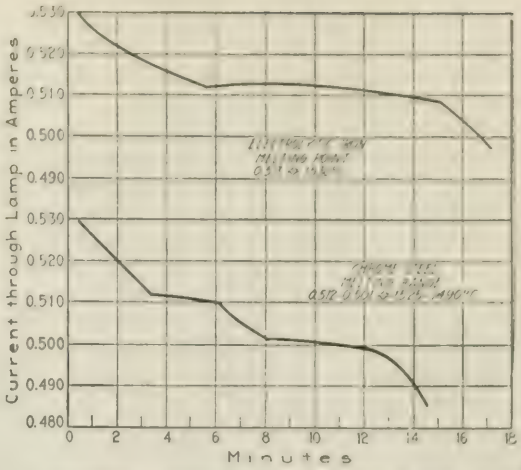


FIG. 20. FREEZING CURVES OF ELECTROLYTIC IRON AND CHROME STEEL

metal top containing a window and two side tubes through which N_2 is drawn. Another method is to insert a long porcelain tube through the furnace, in the center of which is mounted the crucible. Gas is led in at the top of this tube and out at the bottom.

Crucible melts of palladium and platinum are seldom made. Both of these metals must be melted in an oxidizing atmosphere, since in a reducing atmosphere the slightest trace of silica, which is present in nearly every type of furnace, is disastrous. Palladium may be heated in a lime, alumina, magnesia, or magnesia aluminate crucible in a platinum-wound furnace. Platinum could be melted in a furnace wound with a platinum-rhodium alloy, but the method has never been attempted. In several cases a furnace consisting of an iridium tube in which the tube serves as the resistor element has been used. The method is open to serious objections, however, on account of the rapid volatilization of iridium even when the material is coated with a protective paint such as a refractory earth mixture.[12]

Other Methods. For metals melting much above the range of platinum a modification of the wire method may be used. The material in the form of wire or ribbon is mounted as a filament of an electric lamp and is gradually heated electrically until it melts. The apparent or brightness temperature is measured by an optical pyrometer at the instant of melting. In order to correct the observed temperature to true temperature the value of the emissivity of the material must be known. This involves a separate and difficult experiment. In some cases the material in sheet form is folded into a wedge and electrically heated, and the pyrometer is sighted into the opening of the wedge, the radiation from which is approximately black. Various other methods are employed, such as sighting on a bead of the molten metal in an electric arc, extrapolation of the temperature-current curve for a lamp filament, etc.[13]

Micropyrometer. In order to determine the melting points of microscopic samples of materials Joly devised the meldometer. This consists of an electrically heated platinum strip the linear expansion of which is a measure of its temperature. The relation between elonga-

[12]Waidner and Burgess, Bu. of Standards, Scientific Paper No. 55.

[13]Waidner and Burgess, Bu. of Standards, Scientific Papers Nos. 40, 55. *J. d. Phys.*, vol. 6, p. 830, 1907. Forsythe, *Astrophys. J.*, vol. 12, p. 361; 1911. Mendenhall and Ingersoll, *Phys. R.*, vol. 25, p. 1; 1907. Pirani and Meyer, *Verh. d. Phys. Ges.*, vol. 14, p. 126; 1912. Wartenberg, *Verh. d. Phys. Ges.*, vol. 12, p. 120; 1909. Langmuir, *Phys. R.*, vol. 6, p. 152; 1915. Worthing, *Phys. R.*, vol. 10, p. 377; 1917.

tion and temperature is determined by placing samples of pure materials on the strip and observing the melting point through a microscope while the elongation is measured by a vernier screw adjustment. A more satisfactory method is by use of the Burgess[14] micropyrometer, which operates on the same principle as the disappearing filament pyrometer except that the lamp is mounted in a microscope instead of a telescope. (See Fig. 21.) This is sighted on a platinum strip, and on the strip in the field of view is placed a sample of the material to be melted, usually from 0.1 to 0.001 mg. in weight. The strip is enclosed in a water-cooled container having a clear glass window, and a reducing or neutral atmosphere is maintained. The temperature of the platinum strip is measured at the instant of melting, which is indicated with unmistakable evidence, since the material either gathers into a ball or spreads out on the strip. The pyrometer is calibrated by employing metals of known melting points. A natural question which arises is whether the sample actually takes up the temperature of the strip. If the sample were heated by radiation alone, since it receives radiation from a solid angle 2π and radiates through a solid angle 4π, it can be shown on the basis of the Stefan-Boltzmann law that the absolute temperature of the

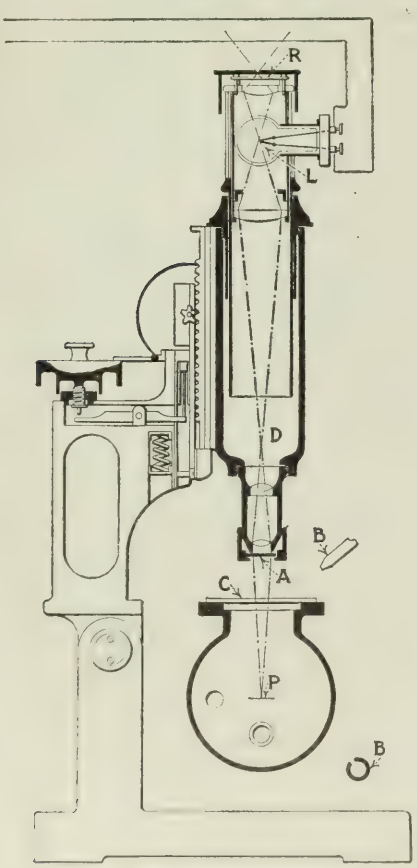


FIG. 21. MICROPYROMETER

sample would be roughly only 0.8 that of the strip. On the other hand, the microscopic sample acts as a shunt on the platinum strip and more heat is developed at this point, tending to increase the temperature. Thermal conduction along the strip reduces this effect. The fact that samples of different sizes appear to give the same value for the melting point indicates that these effects are very small and that the sample actually assumes the temperature of the strip, the heat conduction and gas convection compensating for the deficiency in the direct radiation. The method must be used with caution, however, when applied to other materials than metals, especially in a vacuum. It has been found that errors of 50 deg. or more resulted when gold was heated on a graphite strip in vacua.

[14]Bu. of Standards, Scientific Papers Nos. 198, 205, 242.

Refractory Materials

Refractory Oxides. Refractory oxides are the basic constituents of minerals and of ceramic refractory materials. Their melting points are very high, and it is necessary to adopt special precautions to avoid contamination and to eliminate the smoke produced by the vaporization of the oxide. The Arsem furnace shown in Fig. 19 was used by Kanolt[15] for determining the melting points of magnesia, lime, alumina and chromium oxide. In each case heating curves by the temperature-time method were obtained with an optical pyrometer, and the results were confirmed by examination of the materials heated above and below the observed melting points. The rate of heating was about 100 deg. C. per minute near the melting point.

Table of Melting Points. Table V is a summary of Kanolt's work.

TABLE V.

Oxide	M.P. Deg. C.	Crucible Material	Atmosphere
MgO	2800	Graphite	Stream of CO and N_2 at atmospheric pressure.
CaO	2570	Tungsten, CaO	Stream of H_2 at atmospheric pressure.
Al_2O_3	2050	Tungsten, graphite	CO and N_2 vacuum; stream of CO and N_2 at atmospheric pressure.
Cr_2O_3	1990	Tungsten, graphite	CO and N_2 vacuum.

Magnesia was melted in a special form of graphite crucible, Fig. 22, which was mounted in the Arsem furnace. The pyrometer was sighted through the tube *B* on the bottom of the tube *A* immersed in the magnesia. CO and N_2 at atmospheric pressure were passed through *BCD*, thus clearing the field of view from smoke. Lime was melted in a similar container except that the parts in contact with the lime were made of tungsten. Fig. 23 shows another method employed for lime. The tube *O* compressed from pure lime was suspended in the furnace and a stream of hydrogen was passed in at *P* and out at *Q* to avoid the presence of smoke. Alumina was melted in vacuo in the same form of crucible used for magnesia and also in a graphite crucible shown by Fig. 24. This latter method with crucibles of both graphite and tungsten was employed for chromium oxide.

Firebricks and Ceramic Materials[16]

Refractory materials such as firebricks, fire clays and minerals are composed of compounds of the refractory metallic oxides, solid solutions of the oxides, pure oxides, and mixtures of these classes, together with a variety of chemical compounds. The oxides silica and alumina occur most commonly in refractory materials, and frequently in combination with these are the oxides of the alkali earth, the alkali, the iron group and the rare earth metals.

Meaning of the Melting Point. In the case of refractory materials which are either amorphous or heterogeneous mixtures of oxides and other substances there is no definite melting point. The change from the solid

[15]Kanolt, *loc. cit.*

[16]For a more detailed discussion, see L. I. Dana, Bull., A. I. M. E., September, 1919.

state to one in which the material will flow is gradual over both a temperature and time interval. In addition, physical and chemical reactions which are not equilibrium reactions often take place during melting. These phenomena practically prohibit the use of melting curves, and for ordinary technical purposes the criterion of marked flow, although indefinite from the pure scientific standpoint, is adopted. Accordingly, the practical definition of the melting point of a refractory material is that temperature at which under specified conditions a marked and distinct flow of the material begins. In terms of the deformation of a cone or cylinder the melting point is midway between the temperature at which the deformation begins and the temperature at which the material fuses into a lump or ball, or is completely bent over. The softening or fusing point of a refractory should be defined in the same manner, making the three terms synonymous. If the refractory is a pure crystalline compound it possesses a true melting point, but often, as for example with quartz and albite, the change of state takes place so slowly at the melting point that the substance may be superheated. Thus with quartz the viscosity is so high that a marked flow is not perceptible until the material is superheated by 40 or 50 deg. C.[17] For technical testing the criterion of marked flow is usually taken to define the so-called melting point even for pure crystalline compounds, and thus on the basis of such a definition the melting point of quartz is about 1750 deg. C.

Conditions Affecting Observed Values of the Melting Point. The results obtained on the basis of the above definition of melting point are influenced by a number of experimental factors as follows:

(*a*) Chemical composition.

(*b*) Size of the particles, and size, shape and orientation of the sample.

(*c*) Time and rate of heating.

(*d*) Pressure and chemical nature of atmosphere.

The relations between these factors are so complex that in most cases it is not possible to predict the magnitude or sign of the change in melting due to a variation in one or more of the above conditions. It must be noted that the melting point in actual use of the refractory material may differ considerably from that observed in the laboratory on account of the fact that the conditions of test in the laboratory are not reproduced. Thus contamination of the refractory by molten metals, slags, flue dust, etc., may alter the melting point because of the chemical reaction; also the time and rate of heating may be different. Under load the softening or melting point of a refractory is lowered on account of plastic flow. For this and other reasons the value of the melting point determined in the laboratory is not the only factor, as far as failure is concerned, to be considered in the choice of a refractory for an industrial installation.

Procedure to Determine Melting Point

Sampling, Grinding and Molding. Firebrick and other refractories of non-uniform texture and composition or with particles larger than 30 mesh should be carefully sampled. It is accordingly necessary to grind the material and mold the powder into the form of a cylinder or cone. If the refractory is of fine and uniform texture, however, a piece may be chipped off and shaped to the proper form. Fine refractory powder may be briquetted directly. Since the size of the particles may affect the melting point, the degree of fineness should be specified, at least approximately. For a large variety of substances grinding to pass an 80-mesh screen has proved satisfactory. The material is then slightly moistened and compressed into a cylinder about 2.5 cm. high and 1.2 cm. in diameter by means of the brass or polished steel mold shown in Fig. 18. In this

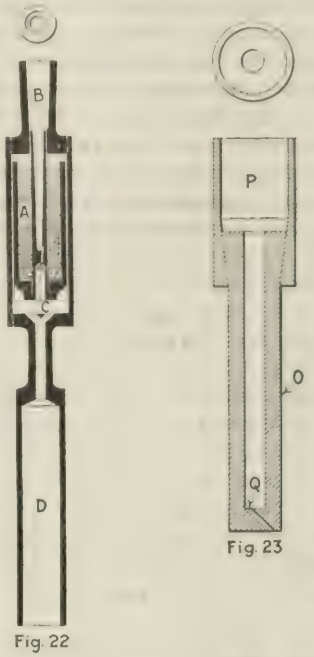


Fig. 22

Fig. 23

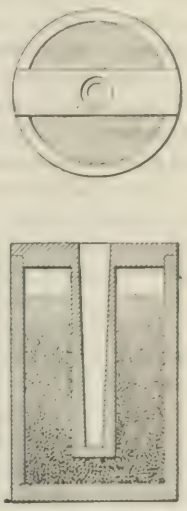


Fig. 24

FIGS. 22 TO 24

Left—Arrangement for melting magnesia. Center—Arrangement for melting lime. Right—Crucible for melting alumina and chromium oxide.

figure *C* is a cylinder, *B* the piston, *D* a plug and *A* the powder. In order to remove the compressed cylinder the mold is inverted, the cylinder *E* is placed on top and the sample is slowly pushed out.

Time and Rate of Heating. The rate of heating from room temperature to about 1000 deg. C. for substances melting above 1500 deg. C. may be very rapid. A satisfactory total time of heating is from thirty minutes to two hours with a rate of from 5 to 10 deg. C. per minute from about 50 deg. below the melting point and during melting. Since the observed melting point depends to some extent upon the rate of heating, it is necessary to specify the temperature-time curve in order that results be reproducible. The following table illustrates the manner in which this may be done with sufficient exactness:

Temperature Interval	Time in Minutes
Room temperature to 1000 deg. C.	20
1000 to 1650 deg.	25
1650 to 1700 deg. M.P.	5

Type of Furnace and Conditions Existing Therein. A furnace for melting refractories should be capable of easily maintaining a temperature of 1800 deg. C., and means must be provided for close temperature regulation. The atmosphere within the furnace must not react appreciably with the specimen; otherwise the material must be protected. Graphite or carbon tube and spiral resistance furnaces operated in air oxidize rapidly, but may be somewhat protected by passing a neutral or reducing gas through them. The gas may

[17] Quartz begins to flow at 1750 deg. C. (Kanolt, Bu. of Standards, Technical Paper No. 10), while its true melting point is 1710 deg. C. (Ferguson and Merwin, *Am. J. Sci.*, vol. 46, p. 1; 1918.

also serve the purpose of carrying away smoke so that accurate optical temperature measurements may be made. Crushed carbon, graphite, kryptol, or carbon plate resistor furnaces do not permit of very precise regulation. Some forms of furnaces are so constructed that it is difficult to use an optical pyrometer. The vacuum furnace of the Arsem type, although requiring greater accessory apparatus, is more desirable on account of its freedom from smoke and because good control is possible at extreme temperatures, even at 2500 deg. C. Furthermore, the atmosphere can be made much less reducing than that in an ordinary graphite furnace. Many refractories are seriously attacked in a carbon and carbon monoxide reducing atmosphere and it is usually not possible to judge by simple inspection of the melted sample whether or not the reduction is appreciable. In many cases the surface of the specimen is attacked and a shell of higher melting point is formed, so that while the inner uncontaminated material may have been melted there is no outward evidence of this fact. In general the sample should be protected from the reducing atmosphere by a refractory tube of low porosity. In the Arsem furnace the sample *A*, Fig. 19, is protected by the sillimanite tube *B*. For temperatures beyond 1800 deg. C. no suitable protection tubes have been made. In certain special cases it may be desirable, if possible, to determine the melting point of a refractory under the atmospheric conditions to which it is subjected in actual use. Indirectly the pressure of the atmosphere may affect the melting point. For example, in a vacuum the more volatile and fusible substances, such as alkalis, may distill and thus cause a rise of melting point.

There appear to be some possibilties in the development of gas furnaces for high melting point determinations. With a suitable construction and air pressure of 10 lb. and more, temperatures of 1650 deg. C. may be maintained with illuminating gas and 1800 deg. C. with natural gas. By recuperating the waste heat or by preheating the gases the above temperature limits may be increased. It should be pointed out that for reliable melting point work it is necessary to maintain a high temperature not on a restricted small surface but throughout a considerable volume.

Temperature Measurements. Pyrometric cones have been employed as a rough measurement of the melting temperature of refractories. The refractory is thus said to have a softening point corresponding to a certain cone number. Seger and similar cones serve a useful purpose under slow rates of heating in measuring heat effects during the firing of ceramic products, but in the laboratory, when the rates of heating are comparatively rapid and may vary considerably, the determination of the cone softening point is not of much significance. For it has been repeatedly shown by numerous investigators[18] that the softening point of Seger cones depends upon the nature of the atmosphere and especially upon the time and rate of heating. Usually the more rapid the rate of heating the higher the softening temperature, variations of 50 deg. C. being easily obtained. In order that the indications by a Seger cone possess reliability it is necessary to specify the atmosphere and the time-temperature curve in the manner illustrated above for refractories. Thus in the ordinary use of Seger cones a variable factor is introduced in the temperature scale defined by the cone numbers which may have no relation to the properties and characteristics of the refractory being tested. Hence it is essential to use a strictly fixed and reproducible temperature scale. This is best accomplished by means of the disappearing filament type of optical pyrometer.

A very slight departure from black-body conditions enables one to discuss the specimen and to watch the progress of melting. It is important to keep the eye fixed on the sample in order that the melting may be observed with certainty. Sintering and vitrification take place on heating, sometimes producing shrinkage and bending; this must not be confused with the change in shape on melting. As in the case of metals, the pyrometer should be focused on a surface of the sample oblique to the line of sight, but it must be assured this surface is not reflecting light from a hotter section of the furnace, thus causing too high a reading. After the determination the sample is removed from the furnace, broken apart and inspected. The inside surface should appear homogeneous and amorphous or glassy. When the sample has been melted in a vacuum furnace a cellular structure is usually apparent, due to gases evolved during melting.

Softening Temperature of Coal Ash. The clinkering of coal ash is closely related to its softening temperature. Consequently the determination of this temperature is of considerable practical importance. The Bureau of Mines has made a complete investigation of the factors and conditions affecting the fusibility of coal ash.[19]

TABLE VI. MELTING POINTS OF COMMON REFRACTORY MATERIALS

Material	Temperature, Deg. C.
Fire Bricks:	
Fire clay	1500–1750
Silica	1700–1750
Magnesia	2150
Bauxite	1600–1800
Chromite	2050
Clays and Sands:	
Kaolin, $Al_2O_3 . 2SiO_2 . 2H_2O$	1740
Fire clays	1400–1740
Bauxite clay	1800
Bauxite, $Al_2O(OH)_4$	1820
Chromite, $FeO . Cr_2O_3$	2180
Silica	1750
Silica sands	1700–1750
Miscellaneous:	
Coal ash	1100–1500
Alundum cements	1750–2000

The following procedure is recommended. After thoroughly roasting the coal, the ash is ground to 200 mesh and roasted again in a current of oxygen. Using a 10 per cent dextrine solution as a binder, small triangular pyramids, 20 mm. high and 6 mm. wide at the base, are made from the powdered ash. These are placed vertically in a muffle or crucible.

A yellow flame burning at least 15 cm. above the cover is maintained, and the rate of heating before and during softening should be from 5 to 10 deg. C. per minute. The softening temperature is the point at which the cone fuses down to a lump or ball.

Table of Melting Points of Refractory Materials. The melting points in Table VI were determined at the Bureau of Standards principally by Kanolt, under conditions approximating those described in the section on refractory material. With the exception of pure kaolin and silica, different samples of the same general type of material may have melting points considerably different from the values tabulated.

[18] Sosman, *Trans.* Am. Cer. Soc., vol. 15, p. 182, 1913.

[19] Fieldner, Hall and Field, Bureau of Mines Bulletin No. 129.

The Eventual Retort Plant for the Distillation of Oil Shales

By Louis Simpson

IN THE Aug. 15, 1919, issue of this journal, in an article treating upon Oil Shales and upon the Scotch Dual Purpose Retort, the principles that underlie successful retorting have been discussed at length.[1] In the Jan. 7, 1920, issue the question as to where it is commercially desirable to recover the nitrogen content of these shales has been answered.[2] It seems probable that many of those interested in the exploitation of oil-yielding shales have by this time arrived at the conclusion that the Scotch dual purpose retort is not the most economical retort possible to construct and operate for the eduction of the oil gases. Yet owing to certain qualities of shale containing by-products which it is desirable to recover because of the large quantity present or from local conditions that make their recovery profitable, it is necessary to consider the construction of a plant specially adapted for the recovery of one or more of such by-products as may be found in the spent shale. For those with such a problem this article is written.

It is probably admitted by those who seek the truth and who possess an unbiased mind that the most efficient retort for generating oil gases will be one specially designed for that purpose, without having regard to the recovery of nitrogen or of any of the possible by-products. The present problem to be considered therefore is how best to recover such by-products from the spent shale, that is, from the shale as it leaves the retort after the oil gases have been driven off.

Suggestion That Two Machines Be Used

There seems to be no special reason other than that it has been a matter of convenience that the recovery of the oil gases and the recovery of the nitrogen should have been attempted on one and the same machine, even if essayed in different sections of the machine. This convenience seems to have existed in the method adopted for heating the Scotch dual purpose retort, but herein is found the great weakness of the retort.

The Scotch designers of the retort had a glimmering of the situation. They knew that the temperatures created by the combustion of the fuel used, whether solid or gaseous, were too high for the best evolution of oil gas, and so arranged to use the higher range of temperatures available for the recovery of the nitrogen, using the lower range for the eduction of the oil gases. This seemed to be a satisfactory solution of the difficulty, but in truth they placed themselves between the horns of a dilemma. If that section of the retort in which the nitrogen gases are driven off as ammonia gas was subjected to the comparatively high temperatures required, that section of the retort was soon put out of commission, and further provided a temperature far too high for satisfactory eduction of the oil gases in the other section of the retort. With such comparative high temperatures, the hydrocarbons were cracked, with the result that permanent gas was formed and the yield of oil was reduced. If, on the other hand, the temperature in the nitrogen recovery section be reduced to the safety point, so that the retort may not be burned out too quickly, then the recovery of nitrogen is very much less than the maximum possible.

Another point will be evident to the careful thinkers, viz., that the shale when it is passed to that section of the retort in which the recovery of the contained nitrogen is attempted is not in the best physical condition to give a maximum recovery, nor is it so placed, within the section, that each and every particle of the shale is submitted to the like high temperature. That disabilities exist is evidenced from the recoveries obtained, which do not exceed and usually fall under 60 per cent of the content.

Under these conditions it is surely evident that it is not possible to secure from the shale an economical extraction of the by-products, after the oil gases had been driven off, in the Scotch dual retort and that such extraction should take place in a machine especially designed for the purpose and constructed so as to withstand the necessary high temperatures.

Requirements of Machine to Extract By-Products

The requirements of such a machine would be:

1. Capability of withstanding the comparative high temperatures necessary, without breaking down.
2. Every particle of shale under treatment must be subjected to the same heat treatment.
3. The spent shale, when under treatment, should be in a very finely disintegrated condition.

To obtain economically the high temperatures necessary, to provide that every particle of the shale shall receive the like heat treatment, the method of heating the spent shale has to be radically different from that used in the Scotch retort, and seeing that, at this stage, the shale has been freed from its hydrocarbon contents, there has ceased to be any reason why the shale should not be subjected to heat, *directly applied*, instead of as in the Scotch retort, indirectly applied.

Fortunately it is not necessary to invent any new machinery to meet the requirements of the case. The horizontal revolving kiln, so long and successfully used in the manufacture of portland cement to burn the "mix" into cement clinker, which is a perfected machine, seems to be peculiarly adapted for the work to be done.

In the manufacture of portland cement the "mix" (generally a mixture of clay and lime), finely ground, is subjected to temperatures of 1550 deg. C. (2820 deg. F.) and over. In the Scotch dual retort, the shale in the nitrogen recovery section is supposed to be exposed to a temperature somewhat around 1600 deg. F., but as there must be a great variation in the temperatures next to the walls of the retort and in those found in the center of the retort, it is difficult to ascertain just what temperatures are used. It is, however, now known that to obtain the recovery of the maximum yield of nitrogen as ammonia gas, every particle of the spent shale should be exposed to a temperature of 1125 deg. C., or 2060 deg. F. It is also known that a decrease of comparatively few degrees of temperature will result in a very large and entirely disproportionate decrease in the yield, while an increase in temperature over the critical temperature increases the yield only slightly.

Horizontal Revolving Kiln to Handle Spent Shale

It will be noticed the critical temperature for the recovery of nitrogen as ammonia gas is between the temperature required for the burning of cement clinker and the temperatures now found in the nitrogen re-

[1] Chem. & Met. Eng., vol. 21, No. 4, p. 176.
[2] Chem. & Met. Eng., vol. 22, No. 1, p. 20.

covery section of the Scotch dual purpose retort. It is therefore evident that the horizontal revolving kiln, as constructed for the burning of cement clinker, will be capable of handling spent shale.

Fixed Carbon in Spent Shales

In all spent shale there remains some fixed carbon. This fixed carbon content may be as low as 2 per cent and as high as 25 per cent of the original shale. The quantity present in the spent shale will depend upon the treatment received by the shale during the process of distillation, and it must not be forgotten that during the distillation the weight of the shale is considerably reduced, the amount of reduction depending upon the richness of the shale. The percentage of fixed carbon in the spent shale will in most cases be largely increased, especially when the shale is rich.

To illustrate, certain shales upon analysis were found to contain fixed carbon in the following amounts: No. 1, 8 per cent; No. 2, 5½ per cent; No. 3, 2⅓ per cent. If through distillation no fixed carbon be lost, the spent shale would contain: No. 1, 12¾ per cent; No. 2, 8 per cent, and No. 3, only 3¼ per cent. The difference is of importance, because while it is evident that some shale may contain sufficient fixed carbon to produce, by itself, upon combustion, the temperatures required, other spent shales do not, and in such case the carbon in the shale will have to be supplemented by powdered coal, fuel oil, or gas. The question of fuel, therefore, may be in some cases the determining factor as to whether it would be profitable to recover by-products from the spent shale.

Probability of Production of Increased Quantities of Ammonia Gases

It would appear probable that spent shale burned at the correct temperature, in a horizontal revolving kiln, in the presence of low pressure superheated steam, will produce largely increased quantities of ammonia gases, and that such increase may exceed one-third of the present yields. The production will be helped by the fine crushing of the spent shale before burning, and this can be done at a low cost, because the spent shale possesses physical characteristics which will permit of its being easily crushed so that 98 per cent will pass through a 200 mesh, as is done with the "dry mix" from which portland cement is made. It should also be noted that with this preliminary crushing, and by the use of the kiln at the temperatures stated, it becomes possible to recover any potash that may be in the shale. When potash recovery is desired it may be necessary to increase the temperature, because it is stated (see page 130, R. K. Meade's "Portland Cement") that the whole of the volatile contents of the "dry mix" is "not driven off until the clinker is completely burned and about to leave the kiln," and that then less than 1 per cent remains. From this it is evident that for potash recovery a high temperature within the kiln is essential. It is fortunate that the high temperature so required will not interfere with the recovery of nitrogen.

Opportunity for Pioneer Work on Potash in Shales

It is known that potash in economic quantities has been found present in some shales, but it has not been ascertained whether its presence is universal or even if, when its presence has been discovered, it persists throughout the bed of shales in which it has been found. Much useful pioneer work might be done in this connection, now that an economical method of recovery is available.

Method for Recovery of Potash

The *modus operandi* for the complete process is as follows:

1. Eduction of oil contents of shale in retort expressly designed for that purpose.
2. Grinding of the spent shale so that 98 per cent will pass through a 200 mesh.
3. The ground spent shale is burned in a horizontal revolving kiln into which low pressure superheated steam is suitably introduced, the burning being obtained by the combustion of the contained carbon, supplemented, when required, by powdered coal, fuel oil, or fuel gas, but preferably fuel gas.
4. The fumes driven off are passed through a Cottrell dry separator, in which the dust and also certain portions of the potash are removed.
5. The fumes then pass through a specially constructed waste heat steam boiler, the product of which is low pressure steam, most of which is used in the kiln.
6. The fumes then pass to scrubbers, in which machines the remainder of the potash and the ammonia are recovered. The water from the scrubbers containing the potash and the ammonia is then treated with sulphuric acid, producing a salt which would make a very valuable chemical fertilizer.

Product Is a Concentrated Fertilizer

Though commercial mixed fertilizers are looked upon with disfavor by many, the above-mentioned mixture need not necessarily come under such strictures. As a concentrated fertilizer, in a form that is readily soluble, it would have much to commend its use.

It need hardly be pointed out that the Scotch dual purpose retort cannot provide the temperatures necessary either for a full recovery of the nitrogen or for the recovery of such potash as may be found, in commercial quantities, in some shales.

Spent Shales as Raw Material for Portland Cement

Lastly, it has been suggested that the spent shale could, in part, be used as raw material for the manufacture of portland cement. Mr. R. K. Meade in 1911 reported to the Canadian Government, page 25, Summary Report of Mines Branch of the Department of Mines, for year ending 1911: "These analyses indicate that satisfactory portland cement can be made from a combination of any one of the first three limestones and the residue from the oil-bearing shale," tested by him. Should it be desirable to produce portland cement and should the composition of the spent shale be found suitable for the production of portland cement, with or without the addition of lime to the spent shale, a comparatively small addition to the revolving kiln plant would make that part of this plant suitable for the manufacture, but it is possible, though by no means certain, that the requirements of such manufacture might be found to interfere with the recovery of the nitrogen.

In the plant as indicated there are the possibilities of great flexibility of operation. Such possibilities are entirely absent from the Scotch dual purpose retort, although, because it was a dual purpose retort, flexibility was a most important requisite.

Electric-Resistance Furnace of Large Capacity for Zinc Ores*
I. Description of Furnaces and Process

Details of the Experimentation Work With Electric-Resistance Furnaces of Commercial Size Based on the Author's Well-Known Plan of Making Briquets With the Zinc Ore to Be Treated and Using These Briquets as Resistors for an Electric Furnace

BY CHARLES H. FULTON†

EXPERIMENTAL work on the process was begun on a laboratory scale at Cleveland, Ohio, in 1914, and transferred to East St. Louis, Ill., in 1916, where a commercial sized furnace was in technical operation until January, 1918. The essential steps are:

Oxidized zinc ore or roasted zinc concentrate is mixed with crushed coke and coal-tar pitch and formed into briquets 9.25 in. in diameter and 21 in. long in a manner similar to that used in the manufacture of graphite or carbon electrodes, except that much less care and time are required. The composition varies with the nature of the ore. These briquets maintain their form and volume during and after the distillation of the zinc. This object is gained by using coke as the matrix and coal-tar pitch as the binder; this pitch becomes coke on heating and unites the ore particle and the original coke particle into a continuous mass. The briquet is an electrical conductor, but only to such a degree that it can be used as a resistor.

The size of the ore, as in the present practice of zinc metallurgy, ranges from fine material, such as flotation concentrate, to coarse table and fine jig concentrate. The process is not restricted to any particular kind of ore, but is applicable to pure high-grade ores, ores high in iron, and complex zinc-lead ores, since the residue from the distillation is held immovably in place within the briquet. In the case of complex zinc-lead ores, the distillation is conducted with a carefully regulated temperature so that a high percentage of lead is retained in the distilled briquet, which may then be smelted for its lead content. In present zinc smelting practice, the reduction fuel is from 40 to 50 per cent of the weight of the ore. In the briquet, it is from 60 to 85 per cent of the ore; but unless the ore is exceptionally high in residue, the distilled briquet may be used over again as coke, or as a high-ash coke for fuel purposes in power production.

SIZE OF BRIQUETS AND FURNACE CHARGE

Baked briquets are hard and tough and may be handled roughly without danger of breakage. In regular commercial work, they may be manufactured by means of extrusion on other suitable presses, after the manner in which electrodes are made, and the process be carried out continuously from the mixing to the finished briquet. The briquets weighed about 90 lb. and contained approximately 50 lb. of ore, which is about the amount in a retort charge in present zinc-smelting practice. It is proposed to make briquets 12 in. in diameter and 72 in. long, which will weigh about 600 lb. On distillation, the briquets lose from 30 to 50 per cent of their weight, but maintain their form and volume. The zinc may be completely distilled from the briquet, traces only remaining, no matter what type of ore is used. The completeness of distillation is due to the intimate mixture of ore and reducing agent maintained throughout the operation.

The second step of the process consists in making the briquet a part of an electric circuit and heating the same by an electric current to such a degree that the zinc is distilled. During this operation, the briquet is covered by a movable retort and the zinc vapor and carbon monoxide are conducted to a condenser in which the zinc is condensed. During the distillation, the briquet acts as a continuous resistor and maintains itself unaltered between the terminal electrodes. As the furnace is not limited to the interposition of one briquet between the terminal electrodes, a large number may be interposed, thus giving a large unit furnace. While direct current may be used, alternating current is preferable on account of the ease of voltage control by means of transformers. The furnace of East St. Louis held a charge of 36 briquets, arranged in twelve columns of three each, set within a circle and operated on a three-phase circuit,

FIG. 1. SET UP BRIQUET CHARGE
Column 9.25 in. diam., 66 in. high, 12 columns. *A*, Bottom graphite connector blocks; *C*, Special fire-clay base; *D*, Top. Graphite connector blocks; *E*, Graphite disks

*A paper read at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, Sept. 24, 1919.

†Professor of metallurgy, Case School of Applied Science, Cleveland, Ohio.

four columns in each phase, connected in the customary Y connection. The amount of charge in this furnace varied between 3100 and 3200 lb, the amount of ore being approximately 1700 lb. The time of distillation was about 6 hr.; the total time, including the placing and discharging, was 8 hr., or three charges worked off in 24 hr. The capacity of the furnace was 5100 lb. of zinc concentrate per 24 hr. A proposed larger furnace, taking nineteen briquets weighing 600 lb. each, will have a capacity of about 8.5 tons of zinc concentrate per retort per 24 hours.

Early Experimental Work

Experimental work was begun at the Case School of Applied Science, in Cleveland, in May, 1914, for the production of a zinc-ore briquet from which the zinc could be practically completely distilled, and leave the briquet of the same volume and shape as before distillation. The experiments were carried on with all sizes of briquets ranging from 1 in. in diameter and 1 in. long up to 9 in. in diameter and 20 in. long, and with spherical briquets up to 8.5 in. in diameter. Satisfactory briquets were made from practically every type of zinc-bearing material.

The "indestructible briquet" was intended for an automatic externally fired furnace,[1] but in 1915 experiments were begun using the briquet as the resistor. The first briquets were 1 in. in diameter and 1 in. long, but later the briquets were 3 in. in diameter and 4 in. long; the furnace held from 48 to 56 arranged in eight columns 6 or 7 briquets high, set up very much in the manner shown in Fig. 1 and operated in one continuous circuit. At first, direct current was used; later, alternating current. The distillation, in almost every instance, could be carried to completion, even with the many electrical contacts in the furnace, demonstrating that the indestructible briquet made a perfect resistor if properly made. On the basis of this work the East St. Louis plant was planned, not as a commercial plant, but as an experimental plant for the purpose of working out the technical details of a commercially sized furnace.

The Briquet

The briquet must form an intimate mixture of the roasted ore, reducing agent, and binder. A particle of ore should be in contact with a particle of reducing agent and both should be surrounded with a film of binder to unite all the particles into a coherent mass. In known applications of briquetting to ores, the briquet is destroyed during the operation that extracts the metal. In this particular case, the briquet must preserve its form and be practically of the same volume after the extraction of the metal as it was before in order to maintain passage of the electrical current. If the briquet should collapse during the distillation process, the furnace would become inoperative. Another advantage of the indestructible nature of the briquet, in the case of such ores as lead-zinc, zinc-copper, or franklinite, is that the residue is in the form best suited for further metallurgical treatment.

The briquets are made with an excess of the reducing agent, coke, so that after distillation there will remain sufficient matter to maintain the original volume of the briquet. In general this condition is obtained if the weight of the distilled briquet is not less than 40 to 50 per cent of the original briquet.

[1] D. B. Jones, U. S. Patent No. 1,292,330

Zinc ores and zinc-bearing materials differ widely in the nature and amount of mineral residue left after the distillation of the zinc, as shown in Table I. The nature and amount of the residue left by the ore have great influence on the stability of the briquet during and after distillation.

TABLE I. AMOUNT OF MINERAL RESIDUE IN ZINC ORE

Name of Ore	Per cent of Residue, by Weight	Character of Residue
Mascot, Tennessee	12.5	Largely silica with a little iron oxide.
Wisconsin ore, No. 1	15.8	Largely iron oxide, some silica.
Wisconsin ore, No. 2	18.3	Same as above.
Missouri ore	20.9	Largely iron oxide, some silica.
Canyon City, concentrate	27.9	Mostly iron oxide and silica.
Willemite zinc ore, from Franklin Furnace, N. J.	36.7	Mostly silica.
Franklinite zinc ore, Franklin Furnace, N. J.	55.58	Chiefly iron and manganese oxides.
Zinc dust, zinc oxide	None	

Coke Contents of Briquet

Enough coke must be added to the ore to furnish the necessary carbon for the reduction of all the reducible oxides in the ore, plus such an amount that the weight of the briquet, after distillation, will be not less than 40 to 50 per cent of the original briquet. Ores that leave a small amount of residue require more coke than ores that leave much residue. As the briquet must at all times be an electric conductor, there must always be present sufficient carbon in the coke, by which the current is chiefly carried.

The nature of the residue also is of great importance. If the residue is siliceous in character, like that of the willemite, which after distillation is in the form of comparatively sharp angular grains fused only on the edges, less coke is needed for a strong briquet than if the residue is of the nature left by franklinite, which is in the form of round fused globules. The sharp angular grains are bound into a suitable network with the coke grains, while the round fused globules must be held by the coke skeleton and in themselves give no strength to the structure they are part of. In the case of franklinite, the residue consists largely of small globules of an iron manganese alloy, which aids in the conductivity of the mass; in the case of willemite, the siliceous residue is a non-conductor.

From the standpoint of non-conductivity, a lime residue is most objectionable, as, under certain circumstances, this lime will form calcium carbide with the briquet, giving rise to high resistance. An ore containing a high lime residue will make an excellent briquet that will act normally in the furnace until a certain temperature is reached, after which, due to to the combination of lime and carbon, the resistance will increase and the briquet become locally overheated and break down. This difficulty can be overcome by an extra amount of coke. The proper amount of coke for different types of ores is, approximately, as follows:

	Per Cent of Weight of Ore
Willemite[2]	30 to 40
Franklinite	70 to 80
Pure Mascot ore	70 to 75
Canyon City ore	60 to 70
Missouri silicate ore	85
Zinc dust	70

Pitch Content of Briquet

The grains of ore and coke must be surrounded by a film of binder, which should have an appreciable thick-

[2] This proportion makes a strong briquet that will withstand distillation in an externally fired retort, but for electrical distillation the coke must be increased.

ness. As the binder must cover a certain amount of surface, the smaller the ore and coke particles the greater is the surface to be covered; therefore the amount of binder varies directly with the fineness of the ore and coke. By experiment it was found that a satisfactory briquet can be made if the amount of binder is between 10 and 15 per cent of the weight of the ore plus coke. More binder than this is detrimental, as the excess will be squeezed from the briquet during pressing; less, in most cases, will not give a satisfactory briquet. The percentages given apply to moderately fine ore, such as will pass through a 65-mesh screen, and to moderately fine coke, such as will pass through a 10-mesh screen. If the zinc-bearing material is excessively fine, as for instance zinc oxide or leaded zinc oxide, more binder must be used.

Size of Ore Particles

Within certain limits, the size of the ore has relatively little influence on the final strength of the briquet; neither has it much influence on the rate of distillation of zinc from the briquet or the completeness with which the zinc is extracted. Ore that passes through a 10-mesh screen and 86 per cent of which is coarser than a 35 screen gives practically no different result from ore all of which passes through a 200-mesh screen. Usually the material furnished the zinc smelter is comparatively fine and sometimes is very fine. Experiments with material coarser than 8-mesh have not been made. The ore or concentrate usually is made up of particles ranging in size from approximately $\frac{1}{10}$ in. down to an extremely small size. This mixture is an advantage, although good briquets can be made from very fine ore. In the case of ores that give a fused residue in the form of little pellets or globules, as for instance franklinite, the coarser ore does not give as good results as the fine ore, as the first gives opportunity for these fused globules to segregate and coalesce within the briquet. Small globules are more permanently held in place by the coke skeleton. The size of ore particles has such little influence on the ultimate stability of the briquets because the particle is practically destroyed during distillation, since it loses in the case of most zinc ores by far the greater part of its weight.

Size of Coke Particles

The size of the coke particle has a very decided influence on the strength of the briquet. Very fine coke gives a much stronger briquet than moderately fine or comparatively coarse coke. For example, a cylindrical franklinite briquet, 3 in. in diameter, 4 in. high, made with 100 parts ore, 70 parts coke, and 20 parts pitch, but in each case with different sizes of coke, had the following crushing strengths: 20-mesh, 15 lb. per sq.in.; 48-mesh, 200 lb. per sq.in.; 100-mesh, 610 lb. per sq.in. When it is desired to obtain an especially strong briquet, relatively fine coke should be used. However, as the coke increases in fineness and fine ore is used, the amount of binder will increase, which is undesirable from a commercial standpoint.

Character of Coke Used

The coke used must be firm and hard, not soft and spongy. It should have a relatively low ash content, particularly if it is used with ore containing much residue. If it is to be used with relatively pure ore, or with blue powder, the ash content may be high Good, screened coke breeze, such as gashouse breeze or by-product oven breeze, is suitable if the ash content is not too high.

Character of Pitch Used

The character of the coal-tar pitch used is all important. The chief points to be noted are the character of the coke left after the distillation of the volatile matter, the percentage of coke remaining after distillation, and the melting point of the pitch. In general, a high melting-point pitch, 170 to 200 deg. C., leaving a high percentage, 55 to 60, of good firm coke is best. Since the briquet is molded hot and is taken from the mold while warm, it is weak, and the lower the melting point of the pitch the weaker is the briquet. A briquet made with a high melting-point pitch is quite strong and stands handling when taken from the mold.

High melting-point pitches obtained by mixing rather low melting-point pitch with fine amorphous carbon will yield a high percentage of coke, but they are weak and do not give good, permanent binding properties; neither have they good initial binding properties.

Methods of Making Briquets

A number of methods may be used for making briquets. The first method used in the experimental work was to thoroughly mix the coke, ore, and pitch (in powdered form) and heat this mixture, on a large hot plate, to between 175 and 200 deg. C., or until yellow fumes appeared from the pitch. when it is granular and somewhat plastic, but not sticky. It was then molded in cylindrical steel molds, with a slight taper, the material being compressed by means of a steel plunger, the bottom of the mold being closed with a small disk to hold the material in place. The pressure varied between 500 and 1000 lb. per sq.in. For the best results the mold should have a temperature between 75 and 90 deg. C. when a high melting-point pitch is used. Under these conditions the briquet will come from the mold with a smooth exterior and sharp edges. The briquet, immediately after expulsion from the mold, is somewhat weak, but becomes strong and firm on cooling.

The second method, used for making briquets 9.25 in. in diameter by 22 in. long, employed at the East St. Louis plant, is as follows: The ore and coke in proper proportions are thoroughly mixed, slightly damp, in a knife-blade mixer and then stored in bins and fed as needed to a Bartlett-Snow kiln drier, provided with plows. Here it was heated to about 250 deg. C. and discharged into a hopper at the end of the drier, from which it was drawn into a hopper car in lots of approximately 500 lb. This hopper was picked up by the crane and discharged into the knife-blade mixer, where the proper amount of molten pitch was immediately added and the contents mixed for 3 to 5 min., after which the mixture was discharged into a small, flat, brick-lined car kept at a temperature of about 250 deg. C. This car was transferred to the tamping machine, made of a 3.25-in. Ingersoll rock drill

The tamping tool was a three-arm steel casting provided with cylindrical steel teeth 3 in. long, which were replaced when necessary. The arms of the tamping tool freely cleared the sides of the mold, which was made of heavy cast steel, in three parts longitudinally, the parts being held together, during molding, by hinged bolts fitting into slots. A specially shaped heavy steel base plate under the tamping machine insured a constant

and fixed position of the mold during tamping. The bottom of the mold was closed by a steel disk 1.5 in. thick, which was set in a circular depression 1 in. deep in the steel base plate, causing the disk to project about 1 in. below the bottom of the mold while the walls of the mold rest on the base plate. The mold was then tamped nearly full of the mixture, which at the molding place has a temperature of 160 to 175 deg. C. The mixture was fed into the mold by a long narrow scoop shovel and tamped in, the tamping

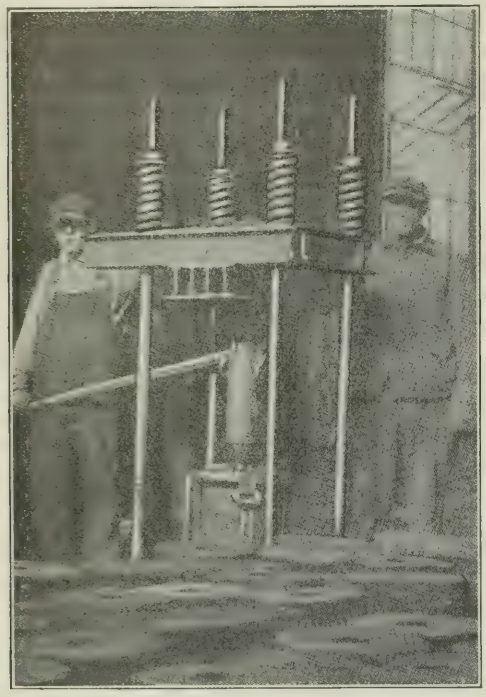


FIG. 2. BRIQUET PRESS

and feeding being simultaneous. As the mold filled, the tamping tool was raised by the feed device of the rock drill.

The mold and its contents were then transferred to the adjacent finishing press, which was made from a railroad jack and used in the inverted position (see Fig. 2). A special plate under the jack permitted the mold to be placed accurately in position. The remaining space in the mold was filled with the mixture, a top steel disk put into place, and the contents of the mold compressed until the pressure reached 1000 lb. per sq.in., the pressure being determined by the contraction of the springs of the press. The weight of the mold and its contents, as it was placed under the press, rested on the bottom disk, which projected about 1 in. below the bottom of the mold. By this means both top and bottom pressure were obtained, which is preferable to pressure being applied from the top only. After the pressing, the bolts holding the mold together were slid out of place and the parts of the mold removed from the briquet, which was then placed on a car, where it is allowed to cool and become firm.

Small briquets have also been made on a laboratory scale by the method of "cold mixing." The ore and coke are mixed with powdered pitch and then moistened with zinc-sulphate solution and pressed into briquets. A typical mix is represented by 100 parts ore, 70 parts coke, 20 parts powdered pitch, and 20 parts of 5 per cent zinc-sulphate solution. These briquets are fairly strong as they come from the mold and on baking become very firm. It is questionable whether they are as good as the hot molded briquets, and the method has not been tried on a large scale.

Substituting Coal for Coke

The base of the briquets is coke, but briquets have been made by replacing coke with coking coal, the idea being that the coking coal will furnish the carbon necessary for reduction and the excess required, as well as the binding effect of the pitch. Such briquets, however, require some binder and, after baking, are shrunken and warped; for this reason they cannot successfully be used in the electric furnace. The replacement of pitch by coking coal, if it were possible, would materially cheapen the briquetting process.

Briquets have also been made with anthracite coal, which were excellent from the standpoint of strength and non-warping quality; these briquets, however, do not become conductors of the electric current until a high temperature is reached, about 1150 deg. C. This requires too great a degree of preheating. Ordinary coke briquets are conductors at 500 deg. C.

Replacing Pitch With Coal

Pitch in the briquet may be partly replaced by coking coal with good results. For instance, a mix made of 100 parts ore, 50 parts of 10-mesh coke, 40 parts of 80-mesh Pocohontas coking coal, and 10 parts powdered pitch, and one made of 100 parts of ore, 25 parts of coke, 70 parts of Pocohontas coking coal, and 10 parts of powdered pitch made good briquets after baking and gave good results on distillation. These briquets are made on the theory of replacing part of the coke and part of the pitch by coking coal, the coal acting as a binder and furnishing a part of the carbon; by this means the quantity of pitch required is reduced one-half. The proportions of coke and coal are calculated so as to leave the proper amount of excess carbon, taking into consideration the volatile matter of the coal. However, one serious objection to the use of any appreciable amount of coking coal is the fact that the products of the distillation of the coal are objectionable during the distillation of the zinc, and the relatively small saving of cost gained by its employment may be more than counterbalanced by the increased difficulties of condensation.

Baking the Briquets

The purpose of baking the briquets is to coke the pitch; the temperature required to do this varies somewhat with the time of baking. For a 9.25- by 22-in. briquet, a baking period of 6 hr., and 500 deg. C. for 2 hr. near the finish, is about equivalent to a baking period of 8 hr. with a temperature of 450 deg. C. for the last few hours of the operation. The briquets must be kept from oxidizing during the baking; that is, they must be under neutral or reducing conditions. Baked briquets have a density of 98 to 115 lb. per cu.ft. dependent on the ore and on the proportions of the mixture.

At the East St. Louis plant, the briquets to be baked were stood on end on platform cars holding twenty briquets. Each briquet was set within a light sheet-iron cylinder 12 in. in diameter and 26 in. high, and the space between the briquets and the cylinders was filled with crushed coke. The car was then placed in one of the ovens, which formed part of the drier. The two ovens were near the head of the drier, which

was the firing end. The products of combustion passed both over and below the baking oven by specially constructed flues. When a load of briquets had been baked, the car was withdrawn and replaced by another. The period of baking was about 7 hr., and the maximum temperature reached at the end approximately 500 deg. C. A briquet that has been baked for the proper length of time at from 450 to 500 deg. C. is very hard and firm and may be thrown violently from the car to the floor while hot without injury.

The briquet during the baking passes through a weak stage, which is due to the condition of the pitch and continues during the baking until a temperature of about 300 deg. is reached. From this temperature up to 500 deg., there is a constant increase in strength as the pitch becomes coke. It would be desirable to eliminate the baking of the briquets as a separate operation and conduct the process by placing the raw briquets on the furnace base and do the baking as part of the furnace operation. In the operation of the furnace, the highly heated retort from a finished charge is transferred by the crane to the new charge on the second base. The heat stored in the retort is sufficient to bake a charge of raw briquets, but the weight of a column of briquets is such that the bottom briquet of the column will collapse in the weak stage. When the rate of heating is very rapid, a hard shell is formed on the briquet's exterior columns of the furnace charge immediately adjacent to the hot retort walls before the interior becomes sufficiently heated to be weak; this shell will sustain the briquet during the critical stage. The interior columns of the charge, however, are heated more gradually from the retort walls and do not form the hard shell, therefore they will collapse at the critical stage. It may be possible, under certain circumstances, to make a briquet that will not have to be baked in a separate operation.

Resistivity of Briquets

The resistivity of hot briquets (900 to 1100 deg. C.) depends on the amount of coke used and the nature of the residue of the ore; it will range from 0.015 to 0.04 ohm per cu.in. The resistivity of the raw briquet is very high (26 to 30 ohms per cu.in.). This resistivity drops slowly until the pitch is coked at about 450 to 500 deg. C., when there is a sudden sharp drop to 0.6 to 0.7 ohm per cu.in. Fig. 3 shows a typical resistivity curve of distilling briquets.

Briquets made from ore, coke, and pitch become practical conductors at between 450 and 500 deg. C. Briquets in which part of the coke is replaced by bituminous coal do not become conductors until a temperature of 620 to 750 deg. C. is reached, depending on the proportion of coal used. Briquets where the coke is replaced by anthracite do not become conductors until about 1150 deg. C. is reached. This is too high for the proper working of the process, for the briquet would have to be reheated, even after baking, to this temperature by means of retort before the electric current would pass, and 1150 deg. C. is the temperature at which distillation is very active.

The East St. Louis Plant

The large-scale experimental work was carried out in specially erected buildings in East St. Louis, Ill.[3] The main building and annex thereto were constructed of steel and tile, the main building being of sufficient height to permit of the operation of a 12-ton electric crane for the lifting of retorts and the handling of materials. The annex contained a small, complete machine shop, and part of the electric equipment. A separate small wooden building was provided for an experimental laboratory, and contained the small testing furnaces and the chemical laboratory. There were also bins and storage sheds for ores, coke, pitch and general supplies.

In one end of the main building was placed the coke crushing plant, consisting of a 7-in. and 10-in. Blake crusher, a 20- by 12-in. set of rolls, an inclined screen, and a return bucket elevator. Adjoining the crushing plant was a Bartlett & Snow kiln drier, which dried ore and coke, heated the ore-coke mixture, and contained two ovens for baking briquets. This drier was fired at one end by an oil burner. The drier was

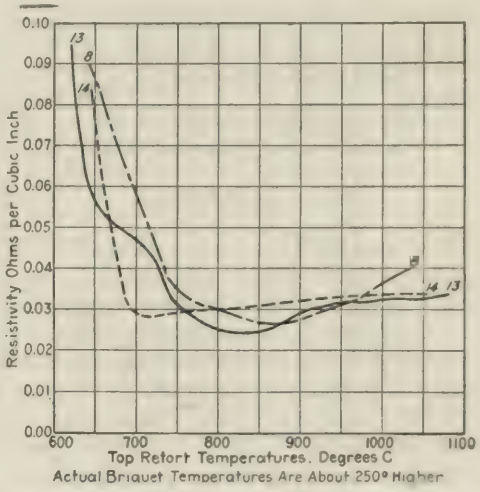


FIG. 3. RESISTIVITY CURVE OF DISTILLING BRIQUETS

especially designed as regards the setting and served the various purposes indicated. In a commercially operated plant the drying, heating, and baking would be done in separate apparatus. Adjoining the drier was the knife-blade mixer and the pitch melting kettle. Adjoining these was the tamping machine, briquet press, and tracks for the various transfer and platform cars for baking briquets. The rest of the space in the building contained the electric furnaces, the main transformers, and other electrical equipment.

Furnace C

Furnace C is the designation applied to the first furnace built. It consists of a specially constructed three-part firebrick base, the center part holding the condenser structure, and the end parts containing the electrodes and serving to support the briquet charge and the covering retort. Figs. 4 and 5 show the features of construction.

The briquet charge was set up on the left-hand base *b*, Fig. 4, the retort *a* lowered into place by the crane, the current turned, and the charge distilled. In the meantime another charge was set up on the right-hand base *c;* when the left charge was finished, the red-hot retort was immediately transferred to the right-hand base and this charge distilled. While the second charge was distilling the spent briquets on the left-hand base were removed and a new charge set up, and the operation repeated. Oil burners were provided at four places under the vapor boxes *o*, the products of com-

[3] See "Fulton's Electric Zinc Furnace," Met. & Chem. Eng., vol. 18, p. 539 (May 15, 1918); also vol. 16, p. 158 (Feb. 1, 1917).

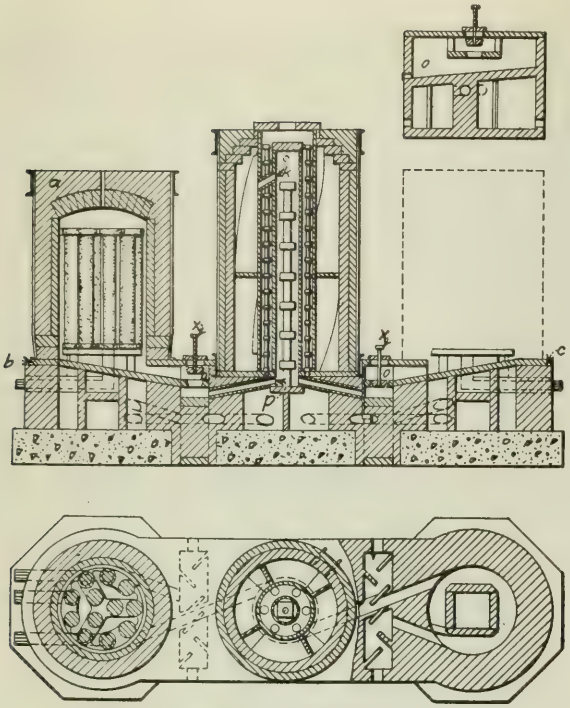


FIG. 4. FURNACE C

bustion from two of these burners passing by flues under the electrode supports in the retort bases, thence through the central flue in the condenser structure, to the air. The products of combustion from the other two burners passed from under the vapor boxes directly to the central flue of the condenser. The idea was to preheat the retort bases and the condenser to the proper temperature for the distilling operation and prevent the formation of blue powder in the condenser at the start.

The necessity for proper temperature conditions for successful spelter condensation in the condenser were fully recognized. In case radiation from the condenser walls should be insufficient to maintain proper temperature conditions within the condenser during the continuous operation of the furnace, due to the heat involved by the condensation of the large volumes of zinc vapor, the heating flues could be turned into cooling flues by the shutting off of the oil burners and closing the two retort base flues. The volume and surface of the condenser were designed on the basis of the relation of these factors to the amount of vapor, as found in the present-day retort and condenser of the standard zinc-distilling furnace. The condenser was provided with three platinum-rhodium thermocouples, one at the top and one at the bottom of the central chamber *p* (Fig. 4), and one at the bottom of the outer annular chamber. The retort was provided with two pyrometers, embedded with the refractory lining within ½ in. of the interior surface, one at the top and one at the bottom. The readings of the retort pyrometers were about 250 to 300 deg. C. below the actual briquet temperature but, with this correction known, these readings served as a perfect guide in the operation of the furnace.

Details of Construction

The retort consisted of a 0.25-in. steel shell stiffened at the top by a 12-in. channel, to which were bolted heavy cast-steel hooks, which engaged the chains of the bail by means of which the retort was lifted by the crane. The bottom of the shell was drawn in 1 in. and then flanged outward for stiffening; the contraction was for the purpose of holding the refractory lining firmly in place. The bottom of the lining was a circle of firebrick blocks 9 in. high and 13.5 in. wide, the full thickness of the lining. On these was built the interior lining of high-grade firebrick, 4.5 in. thick, the space between these and the steel shell being filled with 9-in. sil-o-cel brick and loose sil-o-cel. The roof was a firebrick dome, covered with loose sil-o-cel. The interior diameter was 48 in., and the interior height from the base to the lowest point of the dome was 72 in. The clearance between the briquet columns and the lining of the retort was 2.5 in. The clearance between the columns was about 2 in.

The electrode construction is shown in Figs. 6 and 7. Four graphite electrodes *F*, Fig. 7, 6 in. square and finished to cylindrical ends for the attachment of the electrode holders *G* passed into the furnace base through the opening *E*. On these electrodes were set 6-in. graphite risers, which reach the level of the furnace base through the openings *A*, Fig. 6. These plugs were later replaced with 9-in. plugs. A seal was made by filling in the space between the plugs and the walls of the openings with finely crushed carbon. In the first operation of the furnace, a special firebrick block was set on the base of the furnace, as shown at *C*, Fig. 1, through which the vertical plugs passed to make contact with the graphite blocks *A*, on which the columns of briquets were set. The purpose of this firebrick was to prevent a short circuit in the case of a condensation of zinc on a cool base. It was found unnecessary, so the graphite blocks *A* were set directly on the base in contact with the vertical riser plugs.

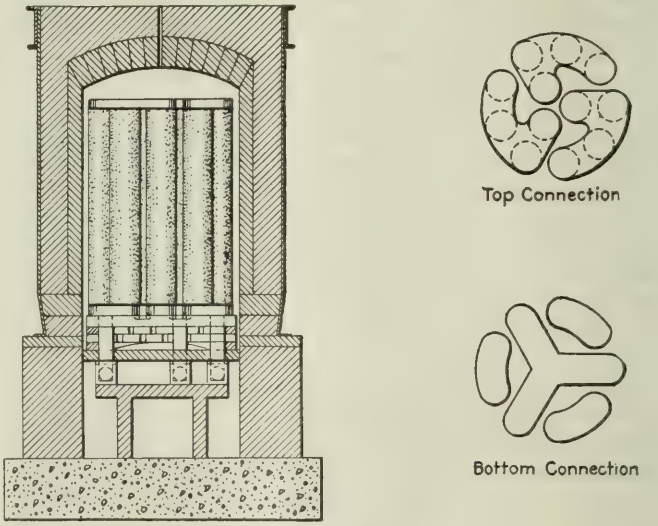


FIG. 5. FURNACE C

The top connections are also made by 5-in. graphite blocks *D*, as shown in Fig. 1. Fig. 5 shows the arrangement of the bottom blocks and of the top blocks on the "Y" connection. As shown in Figs. 6 and 7, the furnace has four electrodes. One of these is the neutral, which is brought to the exterior of the furnace to provide for an extra connection in case of a breakdown.

In order to insure perfect contact between briquets, a paste consisting of 50 parts tar oil and 35 parts of finely ground graphite was rapidly applied, hot, to the ends of the briquets by a stiff broad brush or a trowel. It had excellent adhesive properties and when

FIG. 6. BASE OF FURNACE C

baked was as good a conductor as the briquet, or better. A number of charges built up of whole briquets and briquets broken into a number of pieces, making numerous contacts with the use of this material, passed through the distillation perfectly. This is a very severe test of the process from an electrical standpoint.

Electrical Equipment

The electrical equipment for furnaces designated as C, D, and E was the same, and consisted of a General Electric 150-kw., three-phase transformer and a polyphase induction regulator. Sixty cycle current at 1300 volts was stepped down to 220 volts by transformers outside of the building and passed to the regulator placed in one corner of the main structure. From this, cables in underground conduits led to the transformer pits located at the end of each retort base. The transformer was placed in this pit and connected to the primary cables from the regulator and the secondary leads of the transformer to the furnace electrodes. When a charge was distilled, the connections were broken and the transformer lifted by the crane and transferred to the pit at the other retort base. The secondary terminals of the transformer were brought out to a terminal board attached to the transformer and were so arranged by means of heavy copper links, which could be rapidly changed in position, that the three main secondary taps leading to the electrodes of the furnace by heavy flexible cables could be at voltages of 27.5, 55, 110, and 220. By means of the regulator, the voltage adjustment between these ranges was practically continuous and a maximum voltage of 262 and a minimum of 22.5 could be obtained with a primary line voltage of 220. The power company employed boosters on its line so that a line voltage of 300 volts was sometimes available. The voltage at the electrodes with the Y set up was, when beginning operations with a cold charge, sometimes as high as 300. With hot retorts, however, the voltage would be about 150 at the start, with an energy input of 120 to 150 kw., and lowered to from 75 to 90, and the energy input used was from 122 to 184, the latter for only short periods of time, as this intensity overloaded the transformer. The electrical equipment was somewhat under capacity and the furnaces could easily take 200 to 250 kw., as was demonstrated later with new equipment on furnace F. The low kilowatt input for furnaces C, D, and E accounts for the somewhat higher distillation periods (more than 8 hr.) and also the larger power consumption, due to increased radiation losses on account of the unnecessarily long time. All electrical instruments and switches were located in the shop annex, and the furnace was electrically operated from this place.

(Part II, dealing with the operation of the furnaces and general characteristics of the process, will be published in our next issue.)

FIG. 7. ELECTRODE CONSTRUCTION FURNACE C

Sulphur to Compete With Iron Pyrites

Changed conditions since the war will bring about very shortly the substitution of brimstone for much of the sulphur which heretofore has been recovered from iron pyrites, it is believed in Washington. The amount of labor with its attending cost, which must be expended in the mining and treatment of pyrites is the more important factor contributing to the change. The high transportation rate is also a factor, especially in the case of pyrites imported from Spain.

On the other hand, the mining of sulphur by the Frasch process requires a much smaller proportionate expenditure for labor. The erection of the large plant on the newly opened sulphur deposits at Matagorda, Tex., as well as the large capital expenditures represented by the plants in Calcasieu parish, La., and at Freeport, Tex., is expected to necessitate the operation of these properties. It is believed that the pure sulphur from these sources can be sold from this time on in successful competition with pyrites.

It has been in the past the attitude of the Union Sulphur Co., which operates the Louisiana properties, to restrict its sales of sulphur to the industries requiring high-grade material. That company never has shown a disposition to enter the field where the lower-grade material has sufficed as well. In this stand the company has had the encouragement of the United States Geological Survey. There always has been much uncertainty as to the reserves of pure sulphur, and it has been a very general desire to safeguard this material against future needs. The development of seemingly very large sulphur deposits in Texas and the fact that no signs of exhaustion are appearing in Louisiana, despite the enormous output, are tending to overthrow efforts to reserve this sulphur for the higher class uses. In addition, there is the important economic question of securing a return on the money invested in these sulphur properties.

Fusibility of Coal Ash From Eastern Coals*

By W. A. Selvig, O. C. Brown and A. C. Fieldner

THE Eastern coal province, which includes the anthracite regions of Pennsylvania and Rhode Island, the Atlantic coast region of Virginia and North Carolina, and the great Appalachian region, contains the best known and most extensively mined coals in the United States.

Previous papers[1] gave a description of the standard gas furnace method used by the Bureau of Mines in making ash fusibility tests, a discussion of the relation of fusibility tests to clinker formation, and tables giving results obtained for West Virginia, Pennsylvania and Mid-Continent coals.

This paper includes a table giving the results obtained for all coals tested from the remaining States of the Eastern coal province and includes coal from Ohio, eastern Kentucky, Virginia, Maryland, Tennessee and Alabama.

No coals from Rhode Island, North Carolina or Georgia are represented. The States of Rhode Island and North Carolina are of little commercial importance as coal producers.

Interpretation of Fusibility Table

The samples represented are standard mine samples collected by representatives of the Bureau of Mines, the U. S. Geological Survey, or by the various State Geological Surveys, according to the methods used by the Bureau of Mines.[2]

*Published by permission of the Director, U. S. Bureau of Mines.

[1]Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals," Chem. & Met. Eng., vol. 19, No. 12, 1918, pp. 826-828.
Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash From Pennsylvania Coals," Chem. & Met. Eng., vol. 20, No. 12, 1919, p. 629.
Selvig, W. A., Ratliff, W. C., and Fieldner, A. C., "Fusibility of Coal Ash," Chem. & Met. Eng., vol. 20, No. 6, 1919, pp. 274-276.
For complete tables giving results obtained for each mine tested see: Selvig, W. A., "Fusibility of West Virginia Coal Ash," *Coal Age*, vol. 15, No. 1, 1919, pp. 12-16; Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash From Pennsylvania Coals," *Coal Age*, vol. 15, No. 24, 1919, pp. 1086-1089; Selvig, W. A., Ratliff, W. C., and Fieldner, A. C., "Fusibility of Ash From Coals Found in the Interior Province," *Coal Age*, vol. 15, No. 16, 1919, pp. 698-703.

[2]Holmes, J. A., "The Sampling of Coal in the Mine," Technical Paper 1, Bureau of Mines, 1911, 18 pp.

FUSIBILITY OF COAL ASH FROM EASTERN COALS

State, Bed	No. Mines Sampled	Total No. Samples	Av. Softening Temp. Deg. F.	Ash in Dry Coal, Av. Per Cent.	Sulphur in Dry Coal, Av. Per Cent.
OHIO					
Anderson (Bakerstown) Bed.	1	1	2120	10.86	3.92
Lower Freeport Bed.	8	16	2280	9.55	2.95
Lower Kittanning Bed.	4	4	2120	9.24	5.72
Mahoning Bed.	1	1	2040	6.59	3.67
Meigs Creek (Sewickley) Bed	5	5	2330	13.02	4.23
Middle Kittanning Bed.	6	6	2450	8.00	1.86
Pittsburgh (No. 8) Bed.	10	14	2210	8.47	3.58
Uniontown Bed.	2	2	2230	16.10	3.58
Upper Freeport (No. 7) Bed.	10	14	2280	8.48	3.09
Washington Bed.	1	1	2520	21.90	2.98
Waynesburg Bed.	4	4	2400	15.92	3.15
EASTERN KENTUCKY					
Alum Bed.	1	1	2940	4.37	0.61
Elkhorn Bed.	8	22	2470	3.83	0.68
Fire Clay (Dean or No. 4) Bed	9	25	+2790	5.35	0.82
Flag (No. 7) Bed.	1	4	2880	7.52	0.83
Harlan Bed.	3	8	+2700	3.94	0.85
Hazard (Haddix or No. 6) Bed	1	4	2460	8.56	0.79
Hickory Bed.	1	4	2340	5.37	1.07
Jellico Bed.	1	4	2460	6.92	1.56
Kellioka (C) Bed.	1	1	2230	2.21	0.49
Lower Bolling Bed.	1	1	2880	11.65	1.01
Lower Hignite Bed.	1	3	2440	4.57	1.10
Lower Standiford Bed.	1	1	2260	5.24	1.81
Mason Bed.	3	11	2320	3.93	1.14
Miller Creek (No. 1) Bed.	6	13	2160	4.23	1.90
Poplar Lick Bed.	1	4	2670	5.30	1.05
Rawl (Gas or No. 2) Bed.	2	2	+2680	7.53	1.90
Straight Creek Bed.	4	16	2110	3.40	1.17
Thacker Bed.	1	1	2430	4.42	1.39
Upper Hance Bed.	1	4	2330	4.74	1.61
TENNESSEE					
Angel Bed.	1	1	2160	5.80	1.94
Battle Creek Bed.	2	3	2520	9.68	1.52
Billygoat Bed.	1	1	2600	3.26	1.12
Blue Gem Bed.	14	23	2100	3.32	1.34
Bon Air No. 2 Bed.	8	21	2180	10.27	3.24
Castle Rock Bed.	2	2	2260	10.78	2.68
Catoosa Bed.	1	3	2250	7.11	2.59
Coal Creek Bed.	22	53	2260	6.30	2.37
Frozen Head Bed.	1	1	2580	6.92	0.92
Grassy Ridge Bed.	1	1	2470	3.75	1.87
Hooper Bed.	1	1	2330	2.58	0.69
Jellico Bed.	14	38	2350	4.95	1.87
Jordan Bed.	3	6	2320	3.33	0.90
Kelley Bed.	2	2	2530	7.63	1.33
Lower Dean Bed.	1	1	2340	3.69	0.72
Mingo Bed.	6	19	2390	4.25	1.27
Monarch Bed.	1	4	2320	11.29	2.77
Morgan Springs Bed.	2	2	2260	11.05	3.46
Mud Slip Bed.	1	1	2640	4.21	0.92
Nelson Bed.	3	7	2340	18.73	1.11
No. 4 Bed.	2	5	2220	9.08	3.62
No. 10 Bed.	1	3	2150	11.42	3.14
Old Eagle Bed.	1	1	2290	3.57	1.39
Old Etna Bed.	1	1	2140	2.63	0.76
Paint Rock Bed.	6	6	2420	6.03	1.74
Poplar Lick Bed.	4	11	+2610	8.36	1.84
Red Ash Bed.	4	13	2570	6.13	1.13
Rex Bed.	2	10	2230	5.59	1.07
Richland Bed.	3	6	2590	10.53	0.92
Rich Mountain Bed.	5	12	2370	3.03	1.29
Sandstone Parting Bed.	1	1	2380	10.34	1.26
Sewanee Bed.	22	40	2460	10.02	1.20
Soddy Bed.	5	9	2580	6.78	1.16
Upper Dean Bed.	1	3	2290	12.02	2.29
Walden Ridge Bed.	2	2	2580	8.17	0.92
MARYLAND					
Bakerstown Bed.	5	5	+2560	10.26	1.70
Bluebaugh Bed.	3	3	+2770	12.99	1.63
Brush Creek Bed.	1	1	2470	9.61	1.26
Clarion (Parker) Bed.	2	2	2280	9.61	2.42
Franklin Bed.	1	1	2410	8.48	1.36
Gallitzen Bed.	3	3	2140	12.15	3.33
Grantsville Bed.	1	1	2490	8.23	1.22
Little Pittsburgh Bed.	1	1	+3010	7.95	1.18
Lower Freeport Bed.	1	1	2150	20.51	4.11
Lower Kittanning Bed.	15	24	2440	10.76	2.26
Mercer (Mount Savage) Bed.	3	3	+2620	18.14	3.28
Pittsburgh (Big) Bed.	6	20	+2930	7.67	1.03
Quakertown Bed.	1	1	+3010	17.03	2.92
Split-six Bed.	1	1	2220	12.42	2.55
Upper Freeport Bed.	5	5	2500	10.72	2.03
Upper Kittanning Bed.	2	2	+3010	9.50	0.86
Upper Sewickley (Tyson) Bed	6	9	+2840	6.65	1.09
Waynesburg Bed.	1	1	2410	13.75	2.58
ALABAMA					
Black Creek Bed.	3	12	2530	3.31	0.83
Clark Bed.	2	6	2350	8.68	1.06
Coal City Bed.	1	3	2250	4.35	1.10
Gholson Bed.	2	7	2240	6.64	0.73
Harkness Bed.	3	8	2460	11.51	1.57
Helena Bed.	2	6	2420	8.91	0.46
Jagger Bed.	3	8	2690	9.81	0.67
Jefferson Bed.	1	4	2120	7.45	2.80
Mary Lee (Big) Bed.	4	14	2830	9.90	0.74
Maylene Bed.	2	5	2350	8.29	0.45
Montevallo Bed.	1	4	2330	7.24	0.76
Nickel Plate Bed.	1	5	2620	4.73	0.75
Pratt Bed.	1	7	2430	5.49	1.59
Thompson Bed.	3	10	2230	8.85	0.52
Upper Straven Bed.	1	2	2340	7.45	0.88
Yellow Creek Bed.	3	5	2370	13.90	2.91
Youngblood Bed.	2	6	2130	8.62	1.08
VIRGINIA					
"B" Bed.	1	1	2420	17.73	2.21
Big Bed.	3	3	2420	19.89	0.57
Big A No. 2 Bed.	1	2	2320	6.34	0.60
Big Town Hill Bed.	1	2	2240	11.84	0.48
"C" Bed.	1	2	2210	10.26	1.40
Clintwood Bed.	1	1	2670	3.26	0.87
Duncan Bed.	1	1	2160	6.65	0.88
Glamorgan Bed.	1	2	2160	5.86	1.22
Imboden Bed.	2	3	2420	11.47	1.56
Jawbone Bed.	1	1	2240	19.86	1.03
Kennedy (Widow Kennedy) Bed.	5	8	2190	7.95	1.09
Large Bed.	5	7	+2880	20.19	0.62
Little Bed.	1	1	+3010	21.29	0.49
Little Town Hill Bed.	1	2	2440	8 40	0.56
Lower Banner Bed.	3	8	2280	6.37	0.72
Lower Bolling Bed.	1	1	2720	8.74	1.12
Meadow Bed.	1	2	2480	12.92	0.62
Milner Bed.	1	1	2120	5.89	1.69
Mohawk Bed.	1	2	2160	3.49	1.32
No. 4 Bed.	1	3	2180	6.58	0.49
Pardee (Parsons) Bed.	1	2	2460	8.04	1.59
Pocahontas No. 3 Bed.	5	28	2420	4.26	0.54
Pocahontas No. 5 Bed.	1	1	2090	5.19	0.82
Red Ash Bed.	1	2	2240	5.96	0.64
Small Bed.	1	1	+3010	42.98	0.34
Splash Dam Bed.	1	2	2720	5.77	0.65
Upper Bed.	2	2	+3010	29.72	0.38
Upper Banner Bed.	6	20	2420	6.43	0.67

NOTE.—A plus sign (+) placed before a given value denotes that the true value is above that indicated.

The arrangement in the table of the coal beds in each State is alphabetical. The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur in the dry coal are tabulated for each bed tested. Average values for each mine were computed from the individual samples, and from these values averages representing each bed were obtained. It is evident that the greater the number of mines sampled, the more representative are the average values for the beds. This should be kept in mind, as in many instances the average values given for the beds represent only a few mines, and are then not truly representative of the coal bed.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010), and used as such in figuring the average values for the mine from which the average values of the beds were computed.

For convenience in discussion, the order of fusibility of coal ash from the various coals of the country may be divided into three groups, as follows:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening at a temperature below 2200 deg. F.

Conclusion

The coals of Ohio which were tested gave ash of medium fusibility; the average values of the different beds come mainly in class 2. The softening temperatures of the ash from coals of eastern Kentucky and Virginia cover a wide range of fusibility, from readily fusible ashes coming in class 3 to refractory ashes coming in class 1. Many of the coal beds of Maryland which are represented give coal having a refractory ash coming in class 1 or in the upper part of class 2. The coals tested from Tennessee and Alabama come mainly in class 2, giving ash of medium fusibility, though both class 1 and class 3 are represented.

Fuels Chemical Laboratory,
Pittsburgh Experiment Station,
Bureau of Mines.

Legal Notes

By Wellington Gustin

Who Has Title to This Benzyl Chloride?—Matters of Agency and Title Discussed

IN AN action for the purchase price of 4700 lb. of benzyl chloride and for the cost of 44 carboys purchased at the request of and for the benefit of the defendant, the defendant set up that it acted only as agent of a disclosed principal, M. Naef & Co., of Switzerland. The court said this claim was not sustained by the evidence. The oral contract as testified to by the plaintiff was confirmed by a note written by the defendant, as follows: "We hereby guarantee to pay for 2 tons benzyl chloride 97 per cent at $1.75 per lb., f.o.b. New York, to be shipped to Messrs. M. Naef & Co., Geneva, Switzerland, as per instructions, upon presentation of bill of lading or dock receipt." (176 N. Y. S., 850.)

The substance of this note is the agreement of defendant to pay upon presentation of the documents. The use of the word "guarantee" does not necessarily import a secondary obligation, said the court. It is only an inference that might be drawn from the use of that term to indicate that the defendant was acting as agent for the Swiss firm. There is nothing on the face of the contract to indicate such to be the fact. It takes more than this to require the determination, as a matter of law, that plaintiffs, in the troubled times of war and the uncertainty of ocean transportation, were entering into a contract with a foreign house, said the court. At the most it was a question of fact for the jury to determine, and it having decided that the Swiss house was not a principal its verdict on that point was not disturbed.

Provisions of the Contract

The contract provided that the price was to be paid upon presentation of a bill of lading or dock receipt; but there was evidence that the defendant, not having received shipping instructions, directed the plaintiffs to place the goods in a public warehouse for it and to "bring up the documents." This was a warehouse receipt, and it is upon an alleged compliance with this direction that the plaintiffs recovered a judgment for the price of the goods in the lower court. Now, on Aug. 30, 1915, the merchandise was on storage under a non-negotiable warehouse receipt issued to plaintiffs. The plaintiffs tendered this receipt to defendant and demanded a fulfillment of the contract. The defendant refused to accept the receipt, claiming the goods already to be its property. It made the additional claim that such refusal was justified on two grounds, first, because the plantiffs had already defaulted and the defendant had rescinded, and second, because the receipt was non-negotiable.

Rulings of the Court

To the first claim the court answered that there had been no default on plaintiffs' part. For on Aug. 13, the defendant required a sample of the goods to be submitted to a chemical test, and told the plaintiffs that the test would require a week or 10 days. Thereafter, on the 16th, the defendant appeared with a certified check for the purchase price, which he tendered to plaintiffs and demanded immediate performance. The inference is reasonable that the defendant, having learned that plaintiffs had not the goods then, made the tender for the purpose of putting plaintiffs in default. On this point the court held that the plaintiffs, in the circumstances, had a reasonable time for compliance, and that the demand without notice was ineffective.

As to the second claim of defendant the court said that since it was agreed that the delivery should be made by a delivery of the warehouse receipt, it could be made as well by a non-negotiable as a negotiable receipt. To place defendant in possession of the goods, a written order by plaintiffs, as well as the non-negotiable receipt, was necessary. But the refusal to accept, on the ground that the goods were the property of the defendant, waived all other objections which could have

been obviated at the time. Said the court: "As the objection that plaintiffs had defaulted rested on an unreasonable tender and demand by defendant, not made in good faith for the purpose of carrying out the contract, but in an artificial attempt to put plaintiffs in default, so the objection that a non-negotiable receipt would not give defendant possession without a written order is an afterthought without substance."

However, said the court, the case turns on the question of title to the goods. If the plaintiffs offered a warehouse receipt that covered their own goods, the tender was sufficient to pass title. If the goods were already the property of the defendant, or if the plaintiffs did not own them, the tender was obviously ineffective. The fact that plaintiffs had possession is presumptive evidence of ownership, but the presumption may be rebutted. On Aug. 16 these goods were on storage with the Continental Warehouse Co. under a negotiable receipt issued to the Behre Chemical Works, which manufactured the goods. On the same day that receipt was voided and another issued to the Franco-American Chemical Co. The defendant offered evidence that it had purchased the goods from the Franco-American company and paid for them. The plaintiffs, under a writ of replevin, seized the goods, took them from the custody of the Continental Warehouse Co., stored them in the Knickerbocker warehouse, obtained a warehouse receipt for them, and tendered it to defendant in fulfillment of the contract.

Possession Only a Presumption of Ownership

Plaintiffs' possession of the goods establishes only a presumption of their ownership. Plaintiffs took the goods from the possession of the defendant by a writ of replevin which is provisional only and does not determine ownership in itself. The plaintiffs claim that they bought the goods from the Behre Chemical Works, which manufactured them; that the defendant secretly diverted them to itself by connivance with the chemist of the Behre Works; that by several pretended sales, one by the Behre Works to a man named Brett, another by Brett to the Franco-American company, another by the Franco-American company to defendant, the appearance was created that defendant owned the goods, having acquired title from the Behre company; but that as matter of fact the plaintiffs had secured title to the goods from the maker, and none of these acts and sales could divest their title; but they offered no evidence sufficient to establish the crucial fact—that is, that they obtained title from the Behre Chemical Works.

Plaintiffs Had No Title to Pass

Were these charges true, it would indicate as truth what the lower court referred to as defendant defeating plaintiffs' performance with the purpose of cutting out their profits. But this was not an issue in the case. This action was for the price of goods sold. In it the plaintiffs must show that the sale passed the title from them to the defendant. On this crucial test the court held that the evidence was lacking to show that they had any title to pass. The plaintiffs did not show a contract with the Behre Chemical Works whereby they obtained title to the goods. No witness was called from that company. Certain telephone conversations between the parties to this suit were not evidence of the point here involved. Therefore the court granted a new trial to clear up title.

Fumes and Gases From Smelter

In an action to recover damages for injuries to growing crops and live stock alleged to have been caused by fumes and gases from defendant's smelter, the Supreme Court of Kansas held that the facts were sufficient evidence to sustain the findings and judgment for plaintiff. (179 Pacific, 342. Courtney vs. American Zinc, Lead & Smelting Co.)

From the facts it appears that plaintiff was in possession of a 12-acre tract adjoining defendant's smelter on the east which he had rented for a number of years and upon which there was growing an acre of strawberry plants, a number of bearing grapevines and various other crops. On another tract near by were bearing peach trees and an orchard. Three or four blocks west of the smelter he owned several lots upon which there were growing strawberry plants. Another tract of 40 acres was used by plaintiff as a pasture.

The petition alleged and plaintiff's evidence tended to prove that smoke and fumes were blown over each of these tracts at different times and that smelter smoke contains sulphur, arsenic, lead and zinc in various combinations, all of which are likely to poison animals and to destroy growing vegetation.

Defendant contended that because plaintiff's evidence showed that his strawberry plants were in excellent condition when they were mulched down in the fall of 1916, the jury was not justified in arbitrarily saying that they must have been injured by something from the smelter because they did not produce a good crop in 1917. It further contended that its demurrer to the evidence should have been sustained because of the absence of any evidence that the animals died from any poison that came from the smelter and because of the testimony of plaintiff's two veterinarians, who were careful not to state their positive opinions, on cross-examination, that the animals died from smelter poisoning.

The court, however, said these two witnesses were not called to testify as to their opinion upon the disputed fact, but to show that fumes given off by smelters sometimes contain sulphur, arsenic, lead and zinc and their combinations, and that any and all of these might poison animals. It was for the jury to say, in view of all the testimony, including that of the experts, whether or not the symptoms exhibited by the animals were caused by smelter poisoning.

The Rule of Law Applicable

The court announced the rule of law applicable: "A plaintiff sustains the burden of proof when he shows that at the time his plants were destroyed and damage suffered the defendant's factory was freely emitting fumes, gases and acids which are destructive of plant life, and that the wind was blowing the fumes, etc., toward his premises, some 900 ft. distant, and that there was no other known agency of destruction existing in the vicinity."

It was further urged that the evidence of the veterinarians, that in their opinion the stock in the vicinity of the smelter had been made sick from smoke and fumes from the smelter, was incompetent without proof that the smoke and fumes contained deleterious substances, or until there was expert evidence showing zinc, lead or sulphur emanated from the stacks. The court held it unnecessary to show the precise nature of the gases and fumes which came from the stacks of the smelter.

Synthetic Cast Iron*

A Continuous Process of Rapid Carburization During Melting of Steel Turnings, Producing Cast Iron and Semi-Steel of Exceptional Purity and Exact Chemical Analysis for Manufacture of Heavy Shells and High-Grade Castings

By CHARLES ALBERT KELLER

SYNTHETIC cast iron is the term by which, since the commencement of its manufacture in the electric furnace, the author has always described the iron obtained by the recarburizing melting of steel turnings. This term has since passed into metallurgical currency, and has now become generic.

The novelty of the manufacture of "synthetic cast iron" consists in carburizing iron and steel scrap, and more particularly turnings, by melting these materials in the presence of carbon, which is introduced simultaneously with them in the melting appliance. The electric furnace is plainly indicated as best fulfilling all the conditions required for the carrying out of this metallurgical operation.

From the outset of the manufacture of steel in the electric furnace there had been obtained, incidentally and without any practical importance being attached to it, the carburization of steel to cast iron composition. Apart from this, and indeed long before it, the process of carburizing iron up to saturation point was well known. No advantage was, however, derived from these facts, as the carburization of a bath of steel in a covered-in furnace, obtained by the various known methods of carburization, such as the introduction of dense conglomerates of carbon and iron (carburite) or pressed blocks of carbon and cast iron, was only practiced with the object of obtaining steel, and moreover, these processes are neither convenient, practicable, nor economical when carburization is carried to the extent of producing cast iron. Only a process of continuous carburization, effected during the course of melting a mixture of steel turnings and carbon,[1] could conduce to an economic method of producing synthetic cast iron with a commercial future capable of development as other than a mere war emergency.

Advantages of Continuous Carburization

The preliminary melting of steel turnings in a bricked-in furnace necessitates, indeed, the consumption of an amount of energy corresponding with the temperature which has to be developed in order to melt the steel. It must further be remembered that the thermal efficiency of a furnace of this type is lower than that of an open type furnace constantly replenished with materials for melting, and the walls of which are much cooler. On the other hand, charging turnings into a closed-in furnace, with doors, involves technical difficulties. These disadvantages are, however, but small in comparison with those accompanying the actual carrying out of the carburization in the two instances. The carburization of turnings, after melting, can only be effected by solution brought about between the upper layers of the metal and the carburants. It becomes the more difficult and the slower, the higher the percentage of carbon rises. The dense carburants employed are expensive, and the consumption of energy resulting from the slowness of the carburization becomes considerable. As the furnace has to be emptied after each heat, there must likewise be taken into consideration the heat losses inseparable from this operation, as well as the repairing of the hearth, sides and roof, none of which arises in the continuous running of an open furnace.

In an electric furnace charged with steel turnings mixed with carbon the carburization is not only absolutely controlled by the known reactions of the substances present, but it should be noted, as an important economic advantage, that the combination of the carbon with the iron begins in the upper parts of the charge long before actual fusion. Cementation intervenes from a temperature of 650 deg. upward and becomes more rapid in proportion as the temperature rises, owing to the descent of the charge.

Carburization of the iron takes place subsequently, by the contact between the solid carbon and the partially carburized metal in the course of melting, and becomes complete on full melting, the temperature of which is determined by the nature of the iron, so that casts can readily be obtained in the electric furnace at temperatures of 1200 to 1300 deg. C.

The proper working of the process in the electric furnace involves, however, other considerations. The mixture of steel turnings and carbon possessing, in itself, very high conductivity, it would become necessary, to insure normal working in the electric furnace, to use so low a potential that higher currents than those ordinarily in use must be employed. On the other hand, it would be a pity to employ electric fusion without profiting by the metallurgical advantages involved, in order to effect desulphurization. The introduction of basic slag into the charge meets these two requirements and accomplishes two results, subsidiary and supplementary to the carburization and necessary to the complete practical success of the process, namely:

(1) The lowering of the conductivity of the mass to be treated by the introduction of a non-conducting material among the conductive materials (turnings and carbon), thus enabling fusion to take place under ordinary thermo-electric conditions, and

(2) Complete and easy desulphurization of the resulting metal.

Thus carried out, the process may be described, from the metallurgical point of view, in the following terms:

The iron obtained in the presence of a sufficiently basic slag, which combines with the small amount of silica introduced, will contain practically all the substances contained in the charge, except the sulphur. There will be no increase in the silicon, and the carbon in the charge will be used up solely in carburization, without

*Abstracts from a paper read before the Iron & Steel Institute (British), September, 1919.

[1]French patent, Charles A. Keller, No. 405277 of Nov. 10, 1908, and certified addition No. 19358 to patent of Sept. 11, 1913, and English patent No. 22692 of Oct. 8, 1913.

any appreciable intervention of the silica. White cast iron can thus easily be obtained with ordinary steel turnings. With turnings containing 0.44 per cent of silicon, 0.55 per cent of manganese, and 0.07 per cent of sulphur, a white iron of the following composition was obtained:

	Per Cent		Per Cent
Carbon	3.55	Manganese	0.48
Silicon	0.52	Sulphur	traces

Hence control of the percentages of silicon and of other elements becomes easy; for example, extra silicon will result from introducing more silica into the charge, along with a corresponding amount of carbon for reducing it. The percentage of silica in the slag will vary according to the percentage of silicon in the iron.

The certainty with which the above considerations can be relied upon allows of the process of manufacture described by the author being regarded as complying absolutely with the predetermined calculation of the charge, and as corresponding absolutely with the estimated amount of the elements contained in it. He can afford a proof of the truth of this conclusion by adducing an instance of an electric furnace with a capacity of 80 to 100 tons per 24 hr., which has not given rise, over a month's working and while specially watched for that purpose, to variations exceeding 0.25 in the results of carburization and of siliconization respectively.

Help of Chemical Laboratory Necessary

It will have been thoroughly understood from what has been said that control of the composition of the slag must be strictly exercised; also that the amount of carbon introduced must be accurately known. The process, being one of great accuracy, is correspondingly highly sensitive. It is necessary, therefore, to rely entirely on the help of the chemical laboratory.

The carbon employed for carburizing should correspond, so far as its physical condition is concerned, with the size of the steel turnings, so that the contact between the particles may be as perfect as possible, and so as to facilitate carburization in the higher portions of the furnace charge. Small coke is highly suitable, and so is wood charcoal. Either may be used, according to price and to the degree of purity sought.

Simplicity of Operation

The system that has been described is one of extreme simplicity. It does not require any skilled workman, as the results sought are independent of any technical manipulation except in so far as the preparation of the charge is concerned, and depend entirely on an accurate knowledge of the composition of all the components.

The electric furnace, fed continuously by the charge, works regularly and with very small losses, as the heat transmitted by the electric hearth situated immediately beneath the charge is, to a very large extent, utilized in heating up the materials, and effects a preliminary carburization prior to melting. This enables the consumption of electrical energy to be reduced to as little as 675 kw.-hr. per ton of pig in a 2500-kw. furnace of 80 to 100 tons. Maintenance of a furnace, working in the manner described, is barely appreciable, seeing that with a six months' campaign at Livet the above furnace did not require any repairs either to linings, shell, or any other part. The lining only needed some attention when the furnace was put out of action owing to the water power supply failing.

The author feels it unnecessary to emphasize too minutely the advantages arising from the profound difference that exists between obtaining casting metal by the slow carburization of previously melted metal by contact between carbon and the bath (solution of carbon in liquid steel), and obtaining casting metal by the method described, based more especially on contact, at a high temperature, between solid or pasty metal and solid carbon. They are determining factors both from the standpoint of economics and of metallurgy.

Economic Considerations

The fundamental economic considerations in the manufacture of synthetic pig are as follows:

1. The electrode consumption can be lowered to as little as 6 kg. per ton, with electrodes of good quality.
2. The consumption of unoxidized turnings is 1050 kg. per ton of iron, a figure which, even with moderately rusty scrap, becomes only a little over 1100 kilograms.
3. The amount of coke with 80 per cent fixed carbon required to produce a ton of strong pig iron with 3 per cent carbon and 1.75 per cent silicon, starting with normal turnings of shell steel, is about 80 kilograms.
4. A furnace of the 80- to 100-ton type should be provided with mechanical appliances for upkeep and charging, so that its operation does not require more than fifteen workmen, for the preparation of the charge by hand, for charging, and for regulating the furnace.
5. Tapping, and loading on trucks as required, need seven men per unit, and handling in the stockyard another two men.

Commercial Applications of Synthetic Cast Iron

The general economy of the process, combined with the simplicity of the method of carrying it out, leads the author to believe that while synthetic iron found a very wide field of application during the war, owing to the very large production of steel turnings derived more particularly from shell manufacture, it will find no less a field after the war in, for example, producing those steel-like qualities of material required for highly resistant mechanical parts.

The most obvious plan to adopt is to lay down a foundry for such parts adjacent to the synthetic cast-iron plant, as has been done at Livet. In such a case the foundry iron from the primary furnace may, if preferred, be made use of by transferring it to an electric mixer which can mix several casts and thus keep any quantity of metal ready for castings.

The manufacture of malleable cast iron is likewise easily accomplished in the electric furnace, as the general quality of the steel turnings enables the low percentage of silicon and manganese required to be readily obtained, the reduced percentage of carbon present being dependent on the composition of the charge. It will also be seen that synthetic iron may find a further field of application in the manufacture of special pig, by means of special additions, such, for example, as nickel, chromium, etc. In such cases benefit will be derived, in making this kind of iron, from the absence of hydrogen, nitrogen, carbonic oxides and occluded air.

The materials required for national defense were generally confined to cast irons whose purity, in regard to phosphorus, corresponded practically with that of the steels used in the production of synthetic cast iron, seeing the sources whence these steels were derived. After the war the situation will be altered. Steel turnings will

come from a variety of sources, and will no longer be under the same guarantees, so that very often it will be their dephosphorization which will be of chief importance when a cast iron of high quality is required.

Dual Process for Dephosphorization

The metallurgical value of the results obtained by the process alter completely when it becomes a question of dephosphorization, which the author has practically accomplished by means of a dual process.

In the first place, the steel turnings are melted in the presence of a small quantity of carbon and of a basic oxidizing slag. It is necessary to aim at a critical carburization which must be as high as possible, in order to lower the temperature of working and to facilitate the casting of the metal, while at the same time effecting dephosphorization. A percentage of 1 or slightly over realizes this object.

This first-stage dephosphorized metal, containing low percentages of silicon and manganese, is, according to circumstances, either cast into small ingots which are subsequently melted in an open furnace, mixed with the necessary additions of carbon and a desulphurizing slag composed of materials containing exceedingly little phosphorus, or else poured into a second furnace of the bricked-in type, and covered with a layer of anthracite for recarburizing. The synthetic cast iron produced is controlled in respect of its silicon and manganese percentages by the addition of oxides and of a corresponding amount of reducing carbon, in the ordinary way. This mode of working somewhat increases the cost of production during the first phase, and further necessitates, in the second phase, a converting-cost equivalent to that of manufacturing ordinary synthetic cast iron. About 1500 kw-hr. must be allowed for the two operations.

The higher costs of manufacture are balanced by the higher value conferred on the synthetic cast iron by reason of its extreme purity in regard to phosphorus, and likewise its purity from sulphur and its uniform composition in respect of silicon and manganese. From the commercial point of view such material can compete with Swedish iron.

Alternative Process for Steel From Steel Turnings

The author concludes this account of the chief metallurgical results obtained with synthetic cast iron by describing an alternative process which he has been led to contemplate in connection with the manufacture of steel from steel turnings.

As in the preceding example, the steel turnings are melted in an open furnace fed by the charge, but the slag, instead of being oxidizing, is desulphurizing, and the quantity of carbon introduced with the charge should be sufficient to reduce the oxides in the turnings and to carburize the metal to an extent distinctly above the percentage of carbon sought in the steel, so as to facilitate the pouring of the desulphurized metal and to allow of an oxidizing working in the second stage of the operation.

For example, if a steel with 0.5 per cent of carbon be required, the metal in the primary furnace may be poured at 1.5 per cent of carbon. It will, as has been said, have been freed from sulphur during melting.

The secondary operation, which can be either in an open-hearth furnace or in an electric furnace, refines the metal and brings it to the required carburization, while at the same time dephosphorizing it. It then remains to bring the metal to the proper carbon content in the ordinary way by final additions.

Operations at Keller Leleux Co. Works

The production of synthetic cast iron during the war has been considerable. It is not possible for the author to estimate at the moment how much has been produced at works other than those administered by the Keller Leleux Co. at its works at Livet, Nanterre, and Limoges. The production of these three works alone exceeded 150,000 tons, while it should further be pointed out that Nanterre has been devoted to other manufactures within the last eight months. It goes without saying that such an output could not be obtained solely from existing plants, but required a special industrial effort for the creation of new plants.

Early in 1914 a scheme for a works for the manufacture of malleable iron by this electric process was about to be carried out. This was, however, interrupted by the war. Directly after the specifications for projectiles of semi-steel appeared, the author took steps to produce a metal complying with the conditions laid down by the French Ordnance Department. By November, 1914, such an iron had been produced and investigated, corresponding with the following composition:

	Per Cent		Per Cent
Carbon	2.9	Phosphorus	0.05
Silicon	1.75	Sulphur	traces
Manganese	0.50		

The test results obtained were as follows:

Tensile strength, 50 kg. per sq.mm. (71,000 lb. per sq.in.); impact resistance, 60 blows (equivalent to fall of a 12-kg. tup from a distance of 89 cm. on a test-piece measuring 40 by 40 mm., resting on two knife edges 16 cm. apart, the distance of fall increasing 1 cm. at a time until rupture occurs), whereas the ordnance requirements only specify a minimum of 25 kg. per sq.mm. for the tensile strength and 18 blows (equivalent to 44 cm.)

Works at Livet

The first electric furnace, of 20 tons, was started in 1914. The uniformity of the iron and the tensile qualities obtained led to its being immediately considered from the standpoint of shell manufacture. The Ordnance Inspection Department, after due examination, showed itself favorable, and before the end of 1914 the first series of 220-mm. shells of semi-steel yielded excellent results at the Bourges proof range.

Orders from the Department were the immediate result of these favorable trials. The manufacture of 220-mm. shells of synthetic semi-steel was thus undertaken at Livet on a commercial scale from the commencement of 1915. A complete foundry was erected and furnished with electrical furnaces for the refining of the iron, and the production, which was in the first instance at the rate of 50 shells per day, was raised in 1916 to three hundred 220-mm. shells, together with ten high-explosive 400-mm. shells requiring 55,000 kg. (60 tons) of raw metal.

Use of Electric Mixer Furnaces

In order to comply with the best practical conditions for running the foundry, the iron obtained in three primary furnaces is run into a ladle of 5 tons and poured into three 7-ton electric mixer furnaces, each taking

400 kw., to reheat the metal if necessary, and in any case to keep it hot during the period that iron is being used, and to check the quality. Despite the very uniform composition of the primary furnaces, a carbon test, which only takes 20 minutes, is carried out by the foundry staff before pouring, in addition to ascertaining the quality by a quench test which serves more particularly to check the silicon.

The mixer-container furnaces for steel are of the Charles A. Keller type, that is to say, they have a roof and doors. The electric current enters by a vertical electrode, and leaves through the conducting hearth, of the reinforced-puddle type (vertical bars plunged into tamped magnesite). A conducting hearth of this description is practically unwearable, being non-susceptible to any cracking (Fig. 1). If the bottom conducting

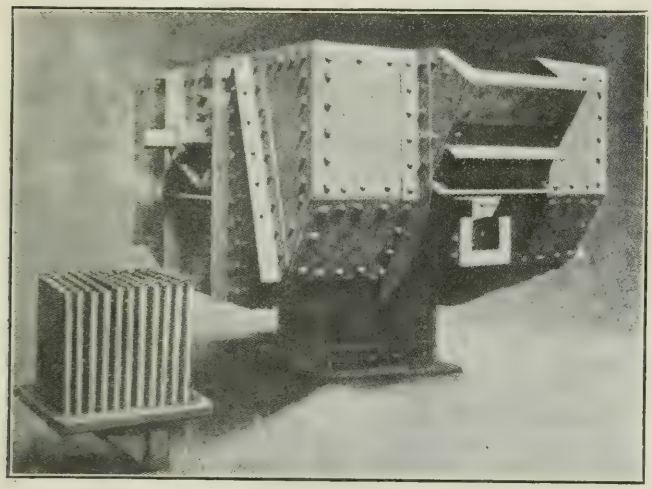


FIG. 1. FURNACE SHELL, CONDUCTING BOTTOM SHOWN SEPARATELY ON LEFT

surface of the hearth wears gradually lower, repairs are very easily effected by spreading over the bottom, while still hot, a special conducting puddle consisting of magnesite and fragments of iron mixed in tar. All holes are thus easily filled up without either the framework or the working of the hearth being interfered with in any way. From a metallurgical point of view this method of repairs corresponds in principle with that employed for the hearths of open-hearth furnaces. The furnaces are, of course, of the tilting type which allows of any quantity of metal, no matter how small, being drawn off.

The liquid iron poured in is covered with basic slag, which forms a protecting layer, preventing oxidation and breaking the electric arc. When pouring is to be done, this layer is easily retained by a little brickwork or sand pocket at the entrance of the furnace spout.

Practice has shown the advisability of interposing these mixer furnaces, which keep the metal so that it can be checked from time to time by the technical staff, who thus acquire a high degree of skill, seeing the ease with which the metal can be held waiting. Generally speaking, it may be said that the metal remains an hour in the mixer furnace, including the time of pouring, for the filling up of these furnaces is carefully adjusted to correspond with casting operations in the foundry. The metallurgical adjustments are very easily carried out, as any additions, as well as the withdrawal of the test samples, are effected through the working door. The practice described gives complete satisfaction; in particular it invariably insures uniform metallurgical results, thus eliminating all rejections due to insufficient tensile strength.

The upkeep of the mixer furnaces is but trifling. The interior lining of the mixer lasts a couple of months, and the roof over three months. The electrode consumption is on an average 2 kg. per ton of iron; the average power consumption is from 50 to 100 kw-hr. per ton, according to the conditions prevailing in the foundry. A single workman is required for the working of the furnaces, and he also looks after the tapping, the electrical manipulation of the tilting arrangements, and the taking of samples.

Uniformity and Good Quality of Product

The capacity of the electrical foundry at Livet could not keep pace with the output of casting metal, which began at 20 tons per day, was subsequently increased to 60 tons, and later on reached not less than 300 tons during the period of maximum water-power supply. Several outside works manufacturing shell were supplied with the surplus output. These firms all testify to the uniformity and excellent quality of iron supplied. The quality of the iron supplied to outside firms corresponds with the following composition, which complies with the best metallurgical practice: Carbon about 2.75 per cent and silicon about 2 per cent; so that after a cupola melting the artillery specifications could almost be met without any addition of steel, as both recarburization and reduction of silicon accompany fusion in this type of furnace. Each carload sent out was accompanied by an analytical report showing what additions of steel and of ferrosilicon might be needed. Very often no such additions were required.

This method of working usually conduced to obtaining good metallurgical results in shell foundries. The care with which the analyses were made was carried to such a point that qualities specially standardized for carbon and silicon were supplied to smelters in order to check abnormalities due to remelting in certain cupolas.

Even the enlargement of the existing Livet works has now become insufficient to deal with the increased demand for this quality of iron.

New Works at Livet

New special works were laid down in November, 1915, some hundreds of yards from the original works, with which they were connected by railway. The new works were started on July 12, 1916, first with a furnace of 80 to 100 tons, and were subsequently enlarged. The building occupied an area of 12,500 sq.m., and comprised more particularly four parallel shops. The first shop, which was 300 m. in length, and was alongside the railway, served for unloading the raw materials and more especially the steel turnings, which are handled by means of a powerful electromagnet suspended from a high-speed crane. The turnings are either used at once in the cycle of operations, or put into stock in a deep trench occupying a portion of the length of the shop, from which they are withdrawn by the same means. By this arrangement a 12-ton car can be unloaded in 20 minutes.

The second shop, which was situated between the unloading shop and the electric furnace shop, served for the preparation of the charges, which are mechanically raised by large bucket elevators to the furnace platform,

where they are tipped on to the latter by small carloads at a time and heaped around the electrodes.

The transformers are housed in sheds built on reinforced concrete foundations on the level of the platform of the electric furnaces. This arrangement possesses the advantage of leaving the second shop entirely free, and also reduces secondary distribution to a minimum. Each shed contains the transformer panelboard which is connected with the central supply by means of an armored cable, leading to a long upper gallery of reinforced concrete, in which are housed the busbars and all the switches (registering meters and watt meters). This gallery, which is just beneath the roof, is capacious enough to allow of easy access, while its position isolates it as completely as possible from dust, and prevents any danger arising to the staff.

The third shop contains five Charles A. Keller furnaces of the "electrodes in series" type arranged in line, four being of 2000 kw. and one being of 2500 kw. (Fig. 2.) The output capacity of this installation is 300 tons of synthetic iron per day. This output could not be maintained, particularly in 1918, owing to various circumstances which were, however, quite independent of the plant itself.

Loading the iron in cars is effected by means of an electro-magnet suspended from an overhead electric crane, which serves a line of railway parallel with the front of the electric furnaces. By this means a 10-ton car can be loaded in 15 minutes.

Layout of the Works

The layout of these works provides for a complete unit of manufacture, in transverse section, for each pair of furnaces, this arrangement being repeated along the whole length, and thus securing the best possible arrangement for the supply of raw materials, and for the removal of the manufactured products, each unit having lines of railway along its sides and being thus connected up with both ends of the works. The haulage of cars is effected by electrical capstans placed throughout the plant. At one end of the works a shop at right angles to the shops just described has been laid down to house electrical converter furnaces to serve a steel foundry. The special synthetic iron employed for this conversion is poured into a ladle on the side of the furnace furthest away from the pig beds. The ladle can thus be conveyed along a longitudinal pit by an electric overhead crane, so that its contents can be poured into the converting furnaces. This arrangement for casting from both of the opposite sides of the electric furnace enables the material to be cast, very conveniently, either into pigs or poured into the ladles.

At the end of the plant are two large shops intended ultimately to serve as rolling mills and to house the accessory appliances.

National Gun Foundry of Nanterre

At the end of 1916 the author was commissioned to lay down and equip the works at Nanterre for an output of 300 tons of synthetic cast iron per day, employing power derived from the sector of the Société d'Energie Electrique de la Région Parisienne.

The electrometallurgical works, known as the National Gun Foundry of Nanterre (Fonderie Nationale d'Artillerie de Nanterre), comprises seven furnaces, of which six are in operation, requiring 10,000 kw. They were built in 182 effective working days, with the wonderfully active and energetic help of the Société Générale d'Entreprises for all contract work. They were put into operation on July 3, 1917. The works, which were designed for the manufacture of synthetic steely-iron for shell manufacture, at once realized this industrial purpose. The anticipated results were, indeed, surpassed, and the quality of the iron was greatly appreciated by iron-founders on account of its uniformity and purity.

The consumption of materials per ton of pig for the 1650-kw. type of furnace employed was as follows:

Steel turnings, kg	1133	Electrodes	6.1
Coke, kg	89–95	Kilowatt-hours	815

The electrometallurgical works, which were connected to the Havre Railway, comprised an important network of sidings intended to accommodate 40-car trains. The works themselves are composed of three sets of buildings, of which the largest consists of three parallel aisles each of the same length, and the arrangement is practically the same as at Livet, which has already been described. At Nanterre, however, the electric furnace bay and the unloading bay are combined and furnished with a long-span overhead crane, which further accelerates working. The handling arrangements have been

FIG. 2. FURNACE ROOM AT LIVET WORKS

divided into two sections of 150 tons per day, each furnished with an overhead electric crane, for unloading raw materials, with an electromagnet for the turnings and a bucket grab for the other materials, while in the furnace shop there is an overhead crane for loading the pigs. The stocks of steel turnings for current use are stored at the two ends of the third aisle, and are carried to the charge-mixing shop and dropped from the electromagnets into intermediate hoppers made of reinforced concrete. The various materials, such as coke and the slag constituents, are stored in the center portion of the raw materials shop. They are crushed, after unloading from the wagons, and hoisted in large

reinforced-concrete bucket hoppers, whence they are delivered through holes in the bottoms to the trucks. The coke employed for carburization goes from the crusher to a rotary fan drier, which reduces the moisture to less than 1 per cent. Two bins are always in use for holding the coke, one full for current manufacturing purposes and the other in process of being alternately filled. This system allows of the amount of fixed carbon, as coke, which is in course of consumption being accurately known. The charge-mixing shop is adjacent to the raw material storage sheds, and comprises a longitudinal pit in which run the service trucks. These are raised by electric hoists to the electric furnace platform, each hoist serving two furnaces.

Electric Furnace Equipment

The electric furnaces are charged by the trucks being tipped on to cast-iron traveling bands, which take the material to the electrodes. The furnaces are built in line at a distance of 30 m. apart from center to center. The transformers are housed in sheds on the level of the charging platform. The distributing system for the 3-phase 5000-v. electric current consists of armored cables carried in a subterranean chamber alongside the longitudinal pit in which the trucks run, so that the manholes open into the side of the pit. Connection with incoming current and with the power station is by means of seven armored cables of 800 sq.mm. in section, of which one serves as a relay.

The electric furnaces are controlled from a control station situated between each pair and is effected by hand, the variations being slight. The arrangements for lowering and raising the electrodes are likewise mechanical. The electric furnaces are of the Charles A. Keller monophase type, with the electrodes in series.

The manufacturing plant proper ends with a shop where the electrodes are prepared, agglomerated in sets of four, the individual rods being connected with the lead-in piece by a fused joint. The blocks so formed are taken by an electric hoist to the smelting shop, and discharged on the end of the electric furnace platform, whence they run on rails to the different furnaces.

In order to provide for future urgent needs the power supply of the electrometallurgical works at Nanterre has been increased to 15,000 kw., to be used in the nine monophase 1560-kw. furnaces housed in a melting shop 175 m. in length.

The Limoges Works

Simultaneously with the undertakings created at Livet, the Keller Leleux Co., in co-operation with the Société Générale d'Entreprises, established a works for the manufacture of synthetic cast iron, the power supply being the surplus energy developed at the Eymoutiers Hydro-Electric Works, belonging to the Departmental Railway Co. of Haute-Vienne.

The electric furnace, which is one of 1000 kw., was worked in 1916 in parallel with the tramway system, practice having shown that the use of this arrangement is advantageous.

Villefranche Works

A similar plant, the power capacity of which is 2000 kw., has been laid down by the Keller Leleux Co. at Villefranche, to use the surplus power developed by the Midi Co. on its line from Perpignan to Bourg-Madame. This works has only just been completed.

It is incontestable that the war has stimulated extremely rapid development of the manufacture of synthetic cast iron owing to the abundance of steel turnings and the practical difficulties of using them before 1916, with the result that a considerable quantity of French steel turnings used to be exported, chiefly to Italy and Spain. Since that time blast-furnaces have become large consumers, and the problem of what is their best mode of utilization—either in the blast-furnace or in the electric furnace—now deserves further investigation. Questions of transport now play so considerable a part that in this as in all other cases it is necessary carefully to determine from time to time which is, nationally, the most economic method of using them.

Whichever way the question may be decided, there is no doubt that a recarburizing fusion by electric power derived from water-falls constitutes the most economical mode of utilizing such turnings, in so far as it involves a complete economy of coal. It is therefore toward electrical furnaces supplied by water power that we must look for the utilization of steel turnings, although the post-war conditions may modify the existing situation.

The possibilities connected with the manufacture of synthetic dephosphorized iron must depend in the first place on the supply of steel turnings, but ultimately on the difference between the cost of coal and the cost of developing water power. The whole of the conditions will have to be reviewed later, when war conditions have yielded to conditions of normal equilibrium, but respecting which, for the moment, all forecasts are at present speculative. It will be seen, none the less, that synthetic cast iron has filled a useful gap in the production of pure iron and has rendered valuable help to the cause of national defense.

Thermit Welding

An important development of Thermit welding in American shipyards is anticipated by the recent approval by the American Bureau of Shipping of the Thermit process for welding stern frames, rudder frames and other heavy sections on ships registered under its classification. The only qualification is that this Bureau be notified sufficiently in advance to have a surveyor in attendance during the welding operation as well as to inspect and test the weld when completed.

While the Thermit process has been used since 1903 for making marine repairs and has a great many successful welds of this nature to its credit, the process was never officially approved by the American Bureau of Shipping and most of the repairs were made on vessels not classed by it. It is due entirely to the unbroken record of successful marine welds that the Bureau now accords its official sanction to the process. According to a statement by the Metal & Thermit Corporation, there has never been a single failure of a Thermit marine weld so far as it has been able to ascertain in all the years that the process has been used under this company's jurisdiction.

Now that the United States promises to have one of the largest mercantile marines in the world and as practically all of the ships which have recently been constructed and which will be constructed in the future will be registered with the American Bureau of Shipping, the recognition of the Thermit process by that Bureau bids fair to result in many important Thermit marine welds from now on.

Recent Chemical and Metallurgical Patents

American Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Steel Refining.—WILLIAM R. WALKER of New York City patents the method of refining basic low-carbon steel by maintaining it in the ladle at a proper pouring temperature for a sufficient time to de-gasify the melt and yet under a slag so modified that rephosphorization will not result. Thus when the open-hearth is tapped the metal runs into a ladle of such size that the most of the slag overflows. The remainder may be skimmed mechanically and replaced by a molten phosphorus-free slag, or if the furnace-slag be low in phosphorus, lime may be added in the runner so it is intimately mixed with that portion of the slag remaining in the ladle, thus increasing its viscosity and consequently decreasing the rephosphorizing action at the surface of the metal. During the time the metal is in the ladle it is kept hot, preferably by electrical currents induced by a high-frequency coil placed about the ladle. (1,309,162; July 8, 1919.) The same inventor patents a quadruplex process for making acid steel of purity comparable to that of Swedish or crucible steel. After bessemerizing in an acid converter to remove nearly all the silicon in the pig, the metal is transferred to a basic open-hearth when the carbon has been reduced to about 0.5 per cent. In this way the phosphorus is removed under the ordinary basic slag of lime and iron oxide. The next step is done in a basic electric furnace, and nearly all the sulphur and remaining phosphorus can be removed under a slag mostly of lime containing from 10 to 35 per cent of silica depending inversely upon the amount of sulphur to be removed. Finally the molten metal is transferred to an acid electric furnace, and worked under a siliceous slag, containing just enough lime for fluidity yet not enough to attack the furnace lining (perhaps 75 per cent SiO_2, 25 per cent CaO or basic equivalents). This "dead melts" the metal, adding silicon reduced from the slag, which in turn replaces metal in any oxide existing in the bath. When the whole has been sufficiently deoxidized and siliconized, it is tapped and cast. (1,309,496; July 8, 1919.)

Barium Hydroxide From Barium Sulphide.—When a solution of barium sulphide of 8 to 10 deg. Bé. at 15 to 20 deg. C. is rapidly cooled with constant agitation until the temperature is reduced to 0 to 5 deg. C., almost pure crystals of barium hydroxide are deposited. These may be purified by washing with a saturated solution of barium hydroxide at the same temperature or by re-crystallization. If, however, solutions of a strength above 10 deg. Bé. be employed, the barium hydrate will be contaminated with barium sulphide in proportion to increasing strength employed. On the other hand, if solutions of a strength below 8 deg. Bé. are used, too small a proportion of pure hydroxide is obtainable. On drying the crystallized barium hydroxide in air which is free from carbonic acid, or *in vacuo*, the dehydrated barium hydroxide $Ba(OH)_2$ is obtained in absolutely pure form and can be used for the production of absolutely pure barium peroxide (BaO_2) by the usual methods. (1,316,133; EDWARD A. BARNES, South San Francisco, Cal.; Sept. 16, 1919.)

Strawboard Lining for Cyanamide Furnaces.—Originally the charge of finely ground carbide was introduced into the furnaces in a metal container. The great wear and tear on the metal containers when subjected to the high temperatures used have proved a source of serious trouble and expense, the containers becoming dented and battered through handling, making it difficult if not impossible to discharge the solid cake of cyanamide therefrom. To obviate this difficulty, particularly during the war, when the cost of the metal containers became excessive, a substitute was sought and found, consisting of a paper sleeve which was inserted into the oven and then filled with carbide, after which nitrification was started in the usual manner. This paper sleeve must be manufactured from stout paper and of definite dimensions, and even with the greatest care it would not infrequently tear or split from the pressure of the contained powdered carbide. Further, it was necessary that an annular space be left between the paper and the oven for inserting the proper equipment for placing the paper and holding it in place during filling with carbide, as well as to assist in distribution of nitrogen, and this space appreciably reduced the capacity of a given sized oven and also increased the cost of equipment and housing. By merely lining the furnace with corrugated strawboard, WILLIAM H. MIDDLETON of Niagara Falls, Ontario, finds that a given oven will hold 35 per cent more carbide than when the paper sleeve is used and 50 per cent more than when the metal container is used. The usual cylinder around the resistor is provided and, in addition, tubes of corrugated strawboard extend from the nitrogen inlet to the resistor space and to the top of the charge, so that effective distribution of the nitrogen is obtained. During nitrification the mass sinters and shrinks away from the walls, so that the ingot can be withdrawn by means of two iron hooks placed in the top of the charge before heating. (1,315,678; assigned to American Cyanamid Co.; Sept. 9, 1919.)

Purification of Partly Oxidized Resins.—As raw material for producing common resin (colophony), turpentine or natural resin in a fresh state, as obtained by collecting the same from conifers, has hitherto been used. After such collection deposits of old resin are successively formed on the trees, said resin not being adapted to be utilized rationally, since on treating the same according to known methods it gives a colophony of less or no value. This is also the case with old resin flowing out by itself and available to be collected in the woods of conifers. It has been customary to extract the old resin with alcohol, but the resin recovered in this manner is dark colored and only party soluble in oil of turpentine and linseed oil. JOHN R. KÖHLER of Stockholm, Sweden, finds that the old resin consists of a mixture of oxidized resin acids and crystallized resin acids, both constituents being soluble in alcohol. Such solvents as benzene and oil of turpentine, however, dissolve only the valuable cyrstallizable resin acids, which may be recovered as light-colored colophony of high quality. (1,316,842; Sept. 23, 1919.)

Manufacture of Hydrofluoric Acid.—Fluorspar and sulphuric acid in suitable proportions are fed into a hot stationary inclined still or retort at the upper end through a hopper. In the retort the mixture is kept constantly in motion by revolving paddles, and gradually stiffens as it moves slowly down into the hotter parts. Finally it breaks up, part into powder and part into small balls or rounded lumps. Meanwhile, the reaction between the calcium fluoride and the sulphuric acid goes on, yielding hydrofluoric acid in the form of vapor, and calcium sulphate ($CaSO_4$) as a solid residue. The former goes off through a lead pipe, while the residue falls into a water-sealed pit and is removed from time to time in any convenient way. The temperature inside the retort should not be less than 315 deg. C. at the hottest parts. The shaft carrying the paddles may be made hollow to permit cooling by water or other medium. The hydrofluoric acid being given off gradually as the mixture progresses, the process is in effect continuous, even when the raw materials are supplied intermittently. (1,316,569; EDWIN S. FICKES of Pittsburgh, Pa.; Sept. 23, 1919.)

Synthetic Steel.—CHARLES A. KELLER of Paris, France, patents a continuous duplex method of making high-grade steel from light turnings or other steel scrap. He uses an open-top shaft furnace with a non-carburizing lining, charging the iron continuously as it settles below the top. With the iron he charges granulated basic slag for desulphurizing, and enough carbonaceous material to reduce any iron oxide present with a surplus to make a fluid high-carbon steel, easily tapped from the furnace. This molten material is then transferred to a closed electric or open-hearth furnace, and held under an oxidizing slag, whereby the carbon is reduced to the required amount. Dephosphorization proceeds simultaneously in this refining furnace. (1,316,724; Sept. 23, 1919.)

Personal

Captain W. E. BROPHY, formerly of The Barrett Co. and later of the Chemical Warfare Service, U. S. A., has joined the engineering staff of Arthur D. Little, Inc., Cambridge, Mass. In the early part of the war Captain Brophy had charge of the construction and operation of the plant at Astoria, L. I., for the manufacture of high-absorbent carbon for use in gas masks, and later he designed, constructed and operated an additional unit at San Francisco.

HARLAN A. DEPEW, formerly research physical chemist of the Firestone Tire & Rubber Co., Akron, Ohio, is now with the New Jersey Zinc Co., Palmerton, Pa., engaged in experimental work on rubber compounds.

Colonel BRADLEY DEWEY of the Chemical Warfare Service has associated himself with Charles Almy, Jr., in the Dewey & Almy Chemical Co., North Cambridge, Mass., for the manufacture of chemical specialties and mill supplies.

E. W. ENGLEMANN has been appointed consulting research engineer for the Utah Copper, Chino Copper, Ray Consolidated Copper, and Nevada Consolidated Copper companies, with headquarters at Salt Lake City.

Dr. ALEXANDER L. FEILD, formerly with the National Carbon Co., Cleveland, Ohio, is now with the Electrometallurgical Co., Niagara Falls, N. Y.

Dr. LOUIS J. GILLESPIE, for the past six years investigator in the Department of Agriculture, Washington, D. C., is now professor of physical chemistry at Syracuse University, Syracuse, N. Y.

J. HARRY HUGHES, of Mobile, Ala., who served in France with the Rainbow Division, has become assistant superintendent for the Ranier Mines Corp., Wenden, Ariz.

G. E. IRONS has left the U. S. Bureau of Standards to accept a position with the American Dressler Tunnel Kilns, Inc., at New Castle, Pa., as thermal engineer.

GRINNELL JONES has severed his connection with the U. S. Tariff Commission to become a member of the faculty of Harvard University, Cambridge, Mass. He is still retained, however, on the staff of the Tariff Commission in a consulting capacity.

Lieutenant ROBERT F. LABARRON, formerly of the U. S. Field Artillery, has joined the staff of Arthur D. Little, Inc., Cambridge, Mass. Mr. LaBarron was sent to Paris after the armistice to the Ecole Supérieure des Mines, at which time he was afforded unusual opportunity to investigate the potash situation in Alsace and the general metallurgical and mining conditions of the Saar Basin with representatives of the French Government.

Dr. IRVING LANGMUIR is to be awarded the William H. Nichols medal at the March meeting of the American Chemical Society, for his paper, "The Arrangement of Electrons in Atoms and Molecules," which is the outstanding contribution to the *Journal* of the American Chemical Society, during the past year.

A. L. MERCER, for several months assistant director of sales of the War Department, has resigned to accept the presidency of the Needham Tire Co., Charles River, Mass. Mr. Mercer entered the Ordnance Department of the Army in 1917 and was commissioned Lieutenant-Colonel in the Ordnance Reserve Corps on his discharge. Prior to his military service he was associated with the B. F. Goodrich Rubber Co., Akron, Ohio.

Dr. ARTHUR W. NIXON has been appointed associate professor of chemical engineering on the faculty of Columbia University, New York City.

CHARLES F. WILLIS has become editor of the *Arizona Mining Journal*, published at Phoenix, Ariz.

WILLIAM W. WINSHIP, American manager of the Thermal Syndicate, Ltd., left on Jan. 3 for a business trip to England to visit the home office at Wallsend-on-Tyne.

C. A. WRIGHT of the Moscow, Idaho, office of the Bureau of Mines, is to succeed F. G. Moses, resigned, as hydrometallurgist at the Salt Lake City station.

Obituary

JAMES MCLEAN, vice-president of the Phelps, Dodge Corp. and director of many other companies, died on Jan. 7 of pneumonia.

Current Market Reports

The Non-Ferrous Metal Market

New York, Jan. 5:—Copper is active at 19½c. for near-by delivery, 19¾@20c. for future delivery. There has been very little trading in tin, the February-March quotation being 61¾c. Lead and zinc are both firm.

		Cents per Lb.
Copper, electrolytic		19.50
Aluminum, 98 to 99 per cent		33.00
Antimony, wholesale lots		10.12½
Nickel, ordinary		42.00
Nickel, electrolytic		45.00
Tin, Straits, spot		64.00
Lead, New York, spot		8.00
Lead, E. St. Louis, spot		7.75
Zinc, spot, New York		9.60
Zinc, spot, E. St. Louis		9.27½
Silver	(Dollars per oz.)	1.33

RARER METALS

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	85.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.00
Copper sheets, cold rolled (over 14 oz.)	31.00
Copper bottoms	37.50
Copper rods	30.00
High brass wire and sheets	26.00
High brass rods	25.00
Low brass wire and sheets	28.75
Low brass rods	28.75
Brazed brass tubing	37.25
Brazed bronze tubing	42.00
Seamless copper tubing	33.50
Seamless bronze tubing	38.00
Seamless brass tubing	32.00

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23½ @ 24½
Aluminum, sheet scrap	22½ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp	14½ @ 14¾
Copper, heavy and wire	13½ @ 14
Copper, light and bottoms	12½ @ 12¾
Copper, heavy cut and crucible	15½ @ 16
Brass, heavy	7½ @ 8½
Brass, casting	10½ @ 10¾
Brass, light	5½ @ 6½
No. 1 clean brass turnings	8¼ @ 8½
No. 1 comp. turnings	11¼ @ 12
Tea lead	4.65 @ 4.75
Lead, heavy	6.00 @ 6.25
Zinc, scrap	4¼ @ 4½

The Iron and Steel Market

Pittsburgh, January 9, 1920.

Visible signs are unabated of a shortage of steel, in consumers scouring the trade for any steel in stock they may uncover or any rolling space for the next 30 or 60 days. In many cases price is scarcely an object, as some manufacturing consumers are losing business through not having enough raw material for full operation. As to late deliveries, there is little interest and the market is quiet. Buyers are not anxious to act for late deliveries at this time, when steel is scarcer than it is assumed it will be later, while the mills are unwilling to sell.

Production of pig iron and steel is increasing at a more rapid rate than was expected. Despite the coke shortage, which was very acute during part of December and is not entirely ended yet, pig-iron production in December was at about 6½ per cent greater rate than in November, while the rate now is about 10 per cent above the December rate. Steel production has gained correspondingly or more. A few steel works are drawing upon pig iron stocks they chance to have. An indication that steel mill operations in the valleys now promise to be heavier in the current quarter than was anticipated is furnished by the fresh buying movement in heavy melting steel scrap in the valleys. In the past week there have been fairly heavy purchases in the district, sufficient to put the market up $1@$2 a ton, heavy melting steel being now quotable at $26@$27, delivered Pittsburgh or valley districts. Some of the valley mills had previously been taking rather a gloomy view of first quarter prospects, estimating their average operation in the quarter at not over about 75 per cent.

Any appraisal of the steel situation and prospects would be altogether incomplete, and perhaps very misleading, if based only upon the present famine conditions existing in steel and without regard to the interesting and important fact that by comparison with present very active conditions in industry generally and with the productive capacity the order books of steel mills are very light. Never before in active times have the steel mills as a whole had such a small volume of business on books in proportion to their capacity as at the present time. The Steel Corporation is sold the farthest ahead, and yet it has some open capacity for second quarter in certain products. So far as is known not an important independent is moderately well filled for second quarter, and many have practically no second quarter tonnage yet entered.

This condition arises from the pursuit of certain policies by the various producers. In general, the mills that have hitherto catered to railroad demand have been reserving capacity for the railroads when they are again joined to their owners. Few institutions have been the subject of so much idle talk in the past few years as the railroads of the United States. It is almost everybody's avocation to talk about railroads without previously seeking information, and the talk in some quarters about the railroad companies being unable to place orders involving steel when they regain possession of their lines March 1, on account of the rolling space having been pre-empted by other buyers, has this characteristic. The steel mills have experienced no difficulty whatever in seeing that it is their duty not to leave their former great customer in the lurch when he is restored to the position of being able to offer orders. Railroad business will be taken care of, and at March 21 prices.

In the case of the Steel Corporation a restricted sales policy has been necessary not only for self-protection but for the protection of regular customers, to whom the Steel Corporation purposes furnishing as much steel in the future as in the past, and at March 21 prices. Freely open order books on the part of the Steel Corporation in the past three months would have resulted in its being swamped with orders from all quarters. Then, as to the independents who have adhered nominally to March 21 prices, there has been a hope, probably diminished by now, that the Steel Corporation would advance its prices, and advantage of the advance could then be taken. Some independents have sold scarcely anything of late, and are operating for the present quarter on business held over from 1919 on account of the strike. Other independents, who have advanced prices, have been unable to sell except for early deliveries. Taking the steel industry as a whole, practically all the first quarter output is sold even if the output attains the limit of the most sanguine expectations, but not more than about half the second quarter output, at an outside estimate, is sold. Many reservations or promises, however, have been made.

Mill Operations

January opened with steel mills operating at about 80 per cent of capacity, or at the rate of about 40,000,000 gross tons of ingots, or 30,000,000 gross tons of finished rolled steel, a year. Everything is in favor of the rate of operation increasing sharply and no valid reason can be assigned for a prediction that production will be at less than 90 per cent of capacity in March. The discomfort of steel consumers has been so enjoyable to some steel mills, not the majority in point of tonnage capacity by any means, that prospects of better operation have not been regarded with the satisfaction usually obtaining in connection with such an outlook. The philosophy in some quarters appears to have been that it would be enterprising to jack up prices on account of scarcity produced by light operation and then reap the extra profits accruing from full output and a correspondingly lowered cost of production. The United States Steel Corporation's policy in combating this philosophy has been wise and beneficent.

Ferro-Alloys

Domestic producers of ferromanganese have made another $10 a ton advance, and some have gone another $10, making present quotations $140@$150, delivered, and on 76 to 80 per cent alloy instead of the former 78 to 82 per cent. English is now held at $140, c.i.f., though some sales were made recently at $125. Spiegeleisen has continued to stiffen, being now quotable at $45, furnace, for spot and $45@$50 for futures.

Electrolytic ferrosilicon is easy, consumers being apparently well covered, with quotations at $85@$90 for 50 per cent and $140 for 75 per cent, delivered Pittsburgh, valleys and Cleveland. Bessemer ferrosilicon remains at $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. Jackson, Ohio.

The Chemical Market

New York, January 9, 1920.

The heavy chemical market during the past week has remained firm in price, with little actual trading. Consumers seem to be averse to stocking up beyond immediate need, and at present there is a general scarcity in all lines of material in second hands. *Cream of tartar* has been in fair demand in small lots and is quoted at 56@60c. per lb. *Borax* continues firm in price since the jump of 1c., and is now being sold at 8½@9c. per lb. *Roll brimstone sulphur* has been active and came up from $2.95 to $3.20 per 100

lb., while *sulphur sublimed flour* jumped from $3.10 to $3.35. Inquiries on this item are both foreign and domestic. *Epsom salts* has been flurrying and is selling at $2.15 per 100 lb., against a low mark of $2 for last week. The price on *sodium bichromate* at present is 19c. per lb., but owing to the rather heavy demand and small supply the market remains uncertain. Demand continues strong on *caustic soda* and the present supply is reduced to a minimum, while the quotation remains $4.10@$4.35 per 100 lb. A sale has been recorded as high as $4.40, but the Association price is still fixed at $4.25. *Barium chloride* still holds at $85@$90 per ton, while *bromine* advanced from 65@75c. per lb. of last week to 90@95c. There has been considerable inquiry on *iodine resublimed* at $4.10@$4.30 per lb. lately. All quotations on *alcohol* remain nominal and until after Jan. 16 this item will be uncertain both in supply and demand. There is some spot denatured and methyl to be had in small lots but at prices different from those quoted. *Formaldehyde* has a nominal quotation of 20@45c. per lb., due to scarcity. The solution of the alcohol situation would place this item on a firm footing.

Coal-Tar Products.—Demand continues brisk, with most sales being made on forward delivery. Supplies still lag behind and the excessive demand by the automobile trade has not helped the situation. There is a scarcity of *crude solvent naphtha.* The present quotation is 19@24c. per gal. *Dimethylaniline* remains firm at 90c.@$1 per lb., with heavy inquiry. *Pyridine* at $2@$2.50 per gal. and *resorcin* at $3.75@$4.50 per lb., are practically unobtainable at present. *Paranitrotoluol* remains firm at $1.35@$1.50 per lb. and *toluol* is quoted at 29@32c. per gal.

Waxes have been quiet with no change in prices, buying being confined to small orders. *Paraffines* still lag behind demand and all orders are being made for future delivery. Foreign interest in the paraffines has not let up greatly.

Crude turpentine, sp.gr. 0.900-0.970 jumped from $1 to $1.30 per gal. The entrance of the varnish industry as buyer of flotation oil has cramped this market, but the mining industry is still receiving first choice in orders filled.

Naval Stores

The past week has been classified by one who has been engaged in this industry a number of years as "the busiest week in his experience." Although an individual opinion, it is nevertheless an indication of the steadily increasing activity among the naval stores. Prices seem firm for the time being at least and buyers are not scarce, the only thing to be desired being a settling back to normal conditions among the Southern laborers. There is scarcity of some grades of *rosin,* noticeably the D-H grades, quoted at $17.55@$18.25 per 280 lb. I-K are to be had in spot quantities at $19.75@$22 per 280 lb., against $23 as a high mark for last week.

Turpentine has been rising steadily, and although the demand has not been great, the present quotation is $1.76 per gal. It is predicted by some that $2 will be reached before a break will occur. The supply has improved greatly during the past week. A reason advanced for the high price is the condition of the London market, where the price has already reached $2. There is no available spot to be had in England.

Linseed oil is coming back to normal, the current price being $1.77 per gal. For the past few days this item has been resting after the sudden rise. The jump was counteracted by a drop in both domestic and Argentine flaxseed, but with the activity anticipated by the paint industry and the increased construction work, the future looks bright for this market. The activity in price on *soya bean oil* has been accounted for principally by speculation. Many contracts were written last July for January delivery which suddenly increased the demand on this oil. Sellers had been holding off in the hope of easier prices and now to prevent trouble have been buying in large quantities to fill these contracts. The present quotations are, *soya bean Manchurian,* 19@20c. per lb. and 17¾@18c. tank cars f.o.b. Pacific coast.

Crude rubber has been easier, owing to the fact that manufacturers have not completed their inventories. *Para-upriver, fine,* dropped to 48@50c. per lb., against 50@51c. of last week. *Plantation-first latex crepe* came down from 54½c. to 53½c. per lb.

Ores and Semi-Finished Products

The *ores* and *semi-finished products* continue firm, with practically no new business in *molybdenum. Tungsten* was active on inquiry, but there has been nothing of importance outside of that. The quotation at present is $7.50@$10 per ton for *wolframite. Petroleum coke* is quoted at $14 a ton and the Government prices on foundry and furnace grades still prevail. The transportation difficulties have not been relieved by the cold weather, which has further added to the car shortage, and the freezing over of the Monongahela has shut off another outlet. Production is from 30 to 60 days behind and the holiday season still further curtailed output. Added to this the coke makers have shown a dislike to ending the vacation.

Among the miscellaneous materials *barytes* still continues active at $35@$40 per ton, and there is no immediate relief in sight. Manufacturers of this item will not quote beyond a month, so that a quotation may be changed to meet new circumstances which are constantly arising. *Fuller's earth* is practically unobtainable at present and the nominal quotation of $25@$30 per ton domestic still holds.

St. Louis, January 6, 1920.

Good demand for certain of the heavy chemicals, with the exception of sulphuric and muriatic acids, is reported by local works. There is a feeling of firmness about the market that it lacked a short time before the beginning of the year, and while there have been no appreciable price advances, producers look for the present level to hold good for some time.

Approximately the same amount of contract business was consummated at the beginning of the quarter, and a number of concerns that had been buying on a hand-to-mouth basis since the coal strike changed their tactics and made long-term contracts, undoubtedly on the assumption that prices have dropped as low as they will go. There is still a fair amount of spot business, enough to keep prices up.

Sulphuric Acid.—The demand for sulphuric has never gotten back to normal since the coal strike, though several spasmodic attempts have been made to hold it up. The demand is growing slowly, nevertheless, and producers look for it to become normal again by the end of the month. Winter falling-off in drilling operations in several Texas and Louisiana oil fields and the consequent lessened demand for "torpedoes" have had their effect. Fertilizer manufacturers are still taking a large part of the output, on contract this time instead of spot buying. The 60 degree grade is quoted at from $12@$14 a ton, according to quantity, a slight falling off in price on the larger purchases; 66 degree is quoted at $18 a ton. Oleum is quoted at $25 a ton and is in slightly better demand than the two other grades.

Muriatic Acid.—There is a fair movement in this line, though not so good as that of a month ago. Practically only contract business is being done in it at present, though there are a few inquiries. The price remains at $22 a ton for the 18 degree grade.

Sodium Sulphate.—A lessened movement in this branch of the market is reported, though there is enough spot buying to keep the price up, one sale being reported at $20.50 a ton, though most of the sales were made at $19.50@$20.

Sodium Bisulphate.—Just as with the sulphate, there is only a fair movement in this department, some deals having been made at as low as $2.50 a ton, and others at $3 a ton, a falling off of 20 per cent in the last six weeks.

Zinc Chloride.—There is practically no demand for this chemical at all, due to the fact that the present is an off season. The quotation at present for 38 Bé. is 10@10.5c. per lb., but producers look for this price to rise soon.

Zinc Oxide.—Demand continues good, with prices firm. Quotations are: Lead free, 9@9¼c. per lb.; 5 per cent leaded, 8½@8¾c.; 20 per cent leaded, 8@8¼c.; 35 per cent leaded, 7¾@8c.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.60 – $0.65
Acetone	lb.	$0.20 –	.21 –
Acid, acetic, 28 per cent	cwt.	2.50 – $3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	–	2.25 – 2.50
Hydrofluoric, 52 deg.	lb.	.12 –	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	–	4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.06½ – .07	.08 –
Oxalic, crystals	lb.	.31 – .32	.32 – .35
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	–
Sulphuric, 60 deg., drums	ton	– 30.00	–
Sulphuric, 60 deg., carboys	ton	–	–
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	–
Sulphuric, 66 deg., drums	ton	–	–
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	25.00 –	30.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	32.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P.	lb.	–	1.35 – 1.45
Tannic (tech.)	lb.	–	.42 – .55
Tartaric, crystals	lb.	–	.69 – .74
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 4.95	5.50 –
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	–	.80 – .82
*Alcohol, denatured, 190 proof	gal.	–	.76 – .78
Alum, ammonia lump	lb.	– .04½	.04½ – .04¾
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¼ –	.09½ – .10
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	–	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½ – .14	.13½ – .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	–
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	–	–
Barium chloride	ton	85.00 – 90.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 –
Barium nitrate	lb.	.09½ – .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½ – .04
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.90 – .95	–
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	–	.04½ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	–	2.50 – 3.75
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.	–	.25 – .30
Carbon bisulphide	lb.	.05½ –	.06 – .09
Carbon tetrachloride, drums	lb.	.10¾ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.75 –
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Cobalt oxide	lb.	–	1.50 – 1.55
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	–	.28 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.07¼ – .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	2.15 – 2.20
Formaldehyde, 40 per cent	lb.	–	.20 – .45
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.10 – 4.30
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.75
Lead acetate, normal	lb.	–	.20 – .23
Lead arsenate (paste)	lb.	–	.13 – .17
Lead nitrate, crystals	lb.	–	.30 – .35
Litharge	lb.	–	.09½ – .10½
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	–	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	–	.75 – .90
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	–	.56 – .60
Potassium bromide, granular	lb.	–	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.25 –	.30 –
Potassium chlorate, crystals	lb.	.16 – .20	.21 –
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .42
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	.65 – .95
Potassium prussiate, red	lb.	–	1.10 – 1.20
Potassium prussiate, yellow	lb.	–	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	–
Rochelle salt (see sodium potas. tartrate)		–	–
Sal ammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)		–	–
Salt cake (sodium sulphate)	ton	15.00 – 21.00	–
Silver cyanide	oz.	–	1.25 –
Silver nitrate	oz.	–	.81½ – .82½
Soda ash, light	100 lb.	2.05 –	2.25 –
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.05½ – .06½	.07 – .08
Sodium bicarbonate	100 lb.	2.35 –	2.75 – 3.00
Sodium bichromate	lb.	.18 – .19	.22 – .25
Sodium bisulphate (nitre cake)	ton	3.00 – 8.00	10.00 –
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	– .08	.08½ – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	–	4.10 – 4.35
Sodium hyposulphite	lb.	–	.03½ – .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	– .18
Sodium peroxide, powdered	lb.	–	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04	.04½ – .05
Sodium potassium tartrate (Rochelle salt)	lb.	–	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¼ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.03½ – .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.15 – 1.25	1.50 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	–	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.43 –	.60 –
Zinc carbonate, precipitate	lb.	–	.20 –
Zinc chloride, gran.	lb.	.12½ –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	–	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.34 —	.37
Aniline oil, drums extra	lb.	.34 —	.37
Aniline salts	lb.	.43 —	.48
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.75 —	–
Benzidine, base	lb.	1.10 —	–
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.31
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.18 —	–
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.75 —	.80
Cresylic acid, 95-97%, dark, in drums	gal.	.72 —	.75
Cresylic acid, 50%, first quality, drums	gal.	.60 —	–
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	2.25
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-bensol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.70 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	12¾ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 —	.60
Salicylic acid, U.S.P.	lb.	.45 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70	— $2.50
Toluidine, mixed	lb.	.45	— .55
Toluol, in tank cars	gal.	.28	— .....
Toluol, in drums	gal.	.29	— .32
Xylidine, drums, 100 gal.	lb.	.44	— .50
Xylol, pure, in drums	gal.	.37	— .45
Xylol, pure, in tank cars	gal.	.35	— .....
Xylol, commercial, in drums, 100 gal.	gal.	.37	— .45
Xylol, commercial, in tank cars	gal.	.23	— .27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	— $0.45
Beeswax, refined, yellow	lb.	.47	— .48
Beeswax, white, pure	lb.	.63	— .68
Carnauba, No. 1	lb.	.80	— .88
Carnauba, No. 2, regular	lb.	.65	— .78
Carnauba, No. 3, North Country	lb.	.43	— .48
Japan	lb.	.18½	— .20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06	— .07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	— .06½
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	— .09¾
Paraffine waxes, refined, 128-130 m.p.	lb.	.09¾	— .10½
Paraffine waxes, refined, 133-135 m.p.	lb.	.....	— .12
Paraffine waxes, refined, 135-137 m.p.	lb.	.....	— .13
Stearic acid, single pressed	lb.	.23	— .26
Stearic acid, double pressed	lb.	.28	— .29
Stearic acid, triple pressed	lb.	.32	— .33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.30
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.30
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.49

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl.	280 lb.	$17.00	—$17.50
Rosin E-I	280 lb.	17.85	— 18.40
Rosin K-N	280 lb.	19.75	— 22.50
Rosin W. G.-W. W.	280 lb.	22.50	— 24.25
Wood rosin, bbl.	280 lb.	17.00	— 17.50
Spirits of turpentine	gal.	1.76	— 1.85
Wood turpentine, steam dist.	gal.	....	— 1.70
Wood turpentine, dest. dist.	gal.	1.64	— ....
Pine tar pitch, bbl.	200 lb.	8.25	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 14.75
Retort tar, bbl (500 lb.)	bbl.	15.00	— 15.25
Rosin oil, first run	gal.	....	— .91
Rosin oil, second run	gal.	.93	— .94
Rosin oil, third run	gal.	1.10	— 1.12
Rosin oil, fourth run	gal.	....	— 1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.48½	— $0.50
Upriver coarse	lb.	.35	— .37
Upriver caucho ball	lb.	.34½	— .36
Plantation—First latex crepe	lb.	.53½	— .54½
Ribbed smoked sheets	lb.	.53½	— ....
Brown crepe, thin, clean	lb.	.48	.48½
Amber crepe No. 1	lb.	.53	— ....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls.	lb.	$0.18	— $0.19
Castor oil, AA, in bbls.	lb.	.21	— .23
China wood oil, in bbls.	lb.	.23¾	— .24½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.19½	— .20
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½	— .23
Corn oil, crude, in bbls.	lb.	.19	— .22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19	— .20
Cottonseed oil, summer yellow	lb.	.22	— .27
Cottonseed oil, winter yellow	lb.	.24½	— .25½
Linseed oil, raw, car lots	gal.	1.77	— 1.87
Linseed oil, raw, tank cars	gal.	1.70	— 1.80
Linseed oil, boiled, car lots	gal.	1.75	— 1.80
Olive oil, commercial	gal.	2.50	— 2.60
Palm, Lagos	lb.	.16	— .17½
Palm, bright red	lb.	.16½	— .17½
Palm, Niger	lb.	.16	— .17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½	— .23½
Peanut oil, refined, in bbls.	lb.	.27	— .28
Rapeseed oil, refined in bbls.	gal.	1.45	— 1.65
Rapeseed oil, blown, in bbls.	gal.	1.60	— 1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19	— .20
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17¾	— .18

FISH

Winter pressed Menhaden	gal.	$1.20	— ....
Yellow bleached Menhaden	gal.	1.23	— ....
White bleached Menhaden	gal.	1.25	— ....
Blown Menhaden	gal.	1.26	— ....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—$40.00
Barytes, off color	ton	20.00	— 25.00
Blanc fixe, dry	lb.	.03½	— .04½
Blanc fixe, pulp	ton	30.00	— 50.00
Casein	lb.	.16	— .18
Chalk, English, extra light	lb.	.05	— .07
Chalk, English, light	lb.	$ .04½	— $ .06
Chalk, English, dense	lb.	.04	— .05
China clay (Kaolin), imported, lump	ton	25.00	— 35.00
China clay (Kaolin), imported, powdered	ton	30.00	— 60.00
China clay (Kaolin), domestic, lump	ton	10.00	— 20.00
China clay (Kaolin), domestic, powdered	ton	25.00	— 40.00
Feldspar	ton	13.50	— 18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00	— 35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	— 45.00
Fuller's earth, domestic, powdered	ton	25.00	— 30.00
Fuller's earth, imported, powdered	ton	35.00	— 40.00
Pumice stone, imported	lb.	.03	— .06
Pumice stone, domestic	lb.	.02½	— ....
Shellac, TN	lb.	1.10	— 1.15
Shellac, D. C.	lb.	....	— ....
Shellac, V. S. O.	lb.	....	— ....
Shellac, Diamond I.	lb.	....	— ....
Shellac, orange, fine	lb.	1.25	— ....
Shellac, orange, superfine	lb.	1.20	— 1.30
Shellac, A. C. garnet	lb.	1.10	— ....
Shellac, bleached, bone dry	lb.	1.35	— ....
Shellac, bleached, fresh ground	lb.	1.10	— 1.15
Soapstone	ton	15.00	— 25.00
Talc, domestic	ton	16.00	— 60.00
Talc, imported	ton	60.00	— 70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20	— .40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21	— .50
Ferro-manganese, 70-80% Mn	gross ton	140.00	— 150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00	— 50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00	— 3.50
Ferro-silicon, 50%	gross ton	85.00	— 95.00
Ferro-silicon, 75%	gross ton	150.00	— 175.00
Ferro-silicon, 10-15%	gross ton	45.00	— 60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25	— 1.40
Ferro-uranium, 35-50%, of U	lb.	7.00	— ....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50	— 7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, C_2, O_3	unit	$0.60	— $0.85
Chrome ore, 48% and over	unit	1.00	— 1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	— 7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00	— 6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	— 14.00
Fluorspar, gravel, f.o.b. mines	net ton	.....	— 25.00
Manganese ore, 45% Mn and over	unit	.50	— .75
Manganese ore, chemical (MnO_2)	gross ton	60.00	— 70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	— .85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00	— 15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50	— 10.00
Uranium oxide, 96%	lb.	2.75	— 3.00
Vanadium pentoxide, 99%	lb.	6.00	— .....
Pyrites, foreign, lump	unit	.17	— .....
Pyrites, foreign, fine	unit	.17	— .....
Pyrites, domestic, fine	unit	.16	— .17½
Ilmenite, 52% TiO_2	lb.	.02	— ....
Rutile, 95% TiO_2	lb.	.11	— ....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	— 3.00
Zircon, washed, iron free	lb.	.10	— ....
Monazite, per unit of ThO_2	unit	42.00	— .....

* Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq. ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.15½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil ,5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

EL MONTE — The city voted $55,000 bonds to construct a sewerage system and septic tank. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, engrs.

LOS ANGELES — The Mathews Paint Co., 219 South Los Angeles St., has awarded the contract for the construction of a 2-story, 99x99-ft. paint factory on San Fernando Rd., to J. V. McNiel, 736 H. W. Hellman Bldg. Estimated cost, $40,000.

MODESTO—The city voted $30,000 bonds to construct a sewage disposal plant. G. H. Freitas, city engr.

STOCKTON—The Natl. Paper Products Co. is preparing plans for a fireproof addition to its mill. Estimated cost, $1,000,000.

Illinois

CHICAGO—The Chicago Coated Board Co., 11 South La Salle St., plans to build a plant at Cottage Grove Ave. and 138th St. Estimated cost, $3,000,000.

CHICAGO—R. G. Pierce, archt, 10 South La Salle St., will soon receive bids for the construction of a 1-story, 75x80-ft. factory at East 94th St. and Commercial Ave., for the United States Graphite Co., 80 East Jackson Blvd. Estimated cost, $25,000. N. Ronneberg, 10 South La Salle St., engr.

Iowa

DANVILLE—The Sugar Creek Creamery Co. has awarded the contract for the construction of a 2-story addition to its plant, to the Clark Construction Co., Danville. Estimated cost, $50,000.

CORYDON—The city will soon award the contract for the construction of a filter and settling basin, also for furnishing filter house equipment, etc. A. T. Gallagher, city clk. M. G. Hall, civil and sanitary engineer, Centerville, engr.

Maryland

LAMCELLE (Cumberland P. O.)—The American Cellulose & Chemical Mfg. Co. plans to build a large addition to its plant. Guy Leonard, genl. mgr.

CURTIS BAY (Baltimore P. O.)—The Union Acid Wks. will be incorporated to construct a plant to cost $1,000,000; same to have daily capacity of 200 tons of sulphuric acid. A site of 7 acres has been purchased adjoining the plant of the Standard Acid Wks. Address George A. Whiting, Continental Bldg., Baltimore.

Michigan

DETROIT—The Detroit Graphite Co., 12th St., engaged E. R. Dunlap, archt., 209 Hammond Bldg., to prepare plans for the construction of a 2-story paint factory on Linsdale Ave. Estimated cost, $30,000.

Mississippi

BROOKHAVEN — The Mayor and the Board of Aldermen will receive bids until Jan. 20 for the construction of a sewerage system, including a disposal plant. Chester Byrne, city clk., M. L. Culley, Jackson, engr.

New York

BROOKLYN—Knoor Bros., 1116 Wyckoff Ave., will build a 1-story, 80x90-ft. brass foundry on Cooper Ave., near the tracks of the Long Island R.R. Estimated cost, $30,000. Work will be done by day labor.

COLLEGE POINT (Flushing P. O.)—J. B. Kleinert Rubber Co., 725 Broadway, New York City, will soon award the contract for the construction of a 4-story factory. Estimated cost, $150,000. R. G. Cory, 39 Cortlandt St., New York City, archt. and engr.

New Jersey

DOVER (Picatinny)—A. Niles, commanding officer, Dover Arsenal, will soon receive bids for remodeling and reconstructing certain buildings here for experimental plant for chemicals for Ordnance Bureau. Estimated cost, $4,000,000 and $5,000,000.

TRENTON—The Ajax Rubber Co., Breunig Ave., plans to construct a 3-story, 60x350-ft. rubber plant. Estimated cost, $39,000. H. M. Baer, 101 Park Ave., New York City, archt. and engr.

Ohio

CLEVELAND—The Acorn Refining Co., 8001 Franklin Ave., will soon award the contract for the construction of a 4-story, 40x105-ft. factory. Estimated cost, $60,000. E. M. Katz, pres.

CLEVELAND—The Paramount Brass Co., 1391 East 33rd St., has awarded the contract for the construction of a 1-story, 40x120-ft. brass factory at 1391 East 33rd St., to H. G. Slatmyer, 203 Lakeside Ave. Estimated cost, $10,000.

Oklahoma

LAWTON—The Lawton Star Refinery, recently organized, plans to build an oil refinery on a 15-acre tract just north of the Fair Grounds. Estimated cost, $100,000. F. A. Parkinson, pres., G. S. Hallman, mgr.

Pennsylvania

WILKES-BARRE — The Diamond Drug Co. is preparing plans for the construction of a 3-story, 22x180-ft. drug factory on Northhampton St. Estimated cost, $170,000.

Tennessee

MEMPHIS—The University of Tennessee, College of Medicine, 718 Union, plans to build a laboratory on Madison Ave., for the City Hospital, which it controls. Estimated cost, $100,000. H. A. Morgan, Nashville, pres.

Wisconsin

SHEBOYGAN—The Porcelain Enameling Association plans to remodel and rebuild part of the 4-story 60x150-ft. factory on Lake Shore Rd., recently destroyed by fire. Estimated cost, $20,000. Address W. J. Vollroth, 82 West 6th St.

Ontario

OWEN SOUND—The Bd. Educ. plans to construct a 13-story collegiate institute. Ratepayers voted on $180,000 bylaw to raise money for same. Chemical and physical laboratory equipment will be installed in same.

SARNIA—The Lake Huron Steel Corp. has purchased an 1,100-acre site along the St. Clair River and plans to construct a steel plant on same, to have a capacity of 100,000 tons of alloy steel annually. Estimated cost, $10,000,000. S. A. Howard, engr.

TORONTO—The Prest-O-Lite Co., Inc., 120 Elm St., has awarded the contract for the construction of a 3-story plant, on Hillcrest Race Course, to Wells & Gray, Confederation Life Bldg. Estimated cost, $400,000.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23-26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9, and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, New York Section, will hold a meeting, Jan. 23, on "Cheap Cyanide and Its Disposition."

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16-19.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

Industrial Notes

THE RICHARDSON-PHENIX CO., Milwaukee, Wis., has opened a Birmingham, Ala., office, in charge of James D. Scruggs.

THE BESSEMER LIMESTONE & CEMENT CO., Youngstown, Ohio, announces that it has taken over all the properties of the Bessemer Limestone Co. and is successor to it.

W. L. SAVELL and J. G. G. FROST, formerly general supt. and chemical supt., respectively, of Metals-Chemical, Welland, Ont., Canada, have opened a consulting office at 732 Frankfort Ave., Cleveland, Ohio, under the firm name of Savell & Frost.

ARTHUR D. LITTLE, INC., which designed, erected and put into operation the plant for the production of rosin, turpentine and pine oil from pine stumps for the National Reduction Corp. at Calvert, Ala., has turned it over to the owners as a going concern. It is of especial interest at this time in view of the demand for the reclamation for agricultural purposes of the cut-over lands of the South. Arthur D. Little, Inc., also announces that its experimental paper mill, which has been busy for some months on demonstrations of the paper-making quality of linters and cotton hull fiber which, during the war, were the chief sources of cellulose for the nitrocellulose used in smokeless powder, is now engaged on the commercial production of the acid-washed filter paper for quantitative chemical analysis formerly imported. Its capacity for this purpose is more than sufficient to meet the entire American demand and to insure the highest possible quality of product. The mill is operating on distilled water.

THE QUIGLEY FURNACE SPECIALTIES CO., New York City, announces that after several years experimenting with alloys and special steels for heat treating, it is putting on the market a complete line of carbonizing pots and annealing boxes for heat treating. These products are made of a special analysis known as Q-steel, designed for maximum resistance to oxidation, coupled with minimum cost per heat-hour of service. In addition to the low priced steel boxes and special castings, the company will market two high-grade alloys for similar work where the operating conditions will make this class of material more economical. The department of heat treatment will be under the management of H. H. Harris.

PERCY SCOTT LEGGATT, of Summerson & Co., Darlington, England, has been investigating the iron and steel possibilities on the coast at Vancouver, B. C., with the view to erecting an electric smelting plant there. Mr. Leggatt claims to have the capital behind him if he can obtain the necessary ore and power concessions. The furnaces would be made by his firm in England and sent to Vancouver knocked down.

A. P. Gillis, on behalf of the TIVANI ELECTRIC STEEL CO., of Belleville, Ont., claims that he has arranged the purchase of a $5,000,000 bond issue for the erection of an electric iron and steel plant of a capacity of 200 tons per day if the citizens of Vancouver will guarantee the interest on the bond issue for a number of years and will guarantee 50,000-hp. continuous service at $10 per hp.-yr.

THE VANCOUVER ENGINEERING WORKS, Vancouver, Canada, is installing an electric furnace for the production of special steels to be used in the construction of machinery that the company manufactures.

THE AMERICAN CONSTITUTIONAL LEAGUE has been organized by influential business men in Milwaukee, for the promotion of Americanization work. This will embrace all forms of education and publicity in favor of Americanism and in opposition to radicalism. Frank R. Bacon, president of the Cutler-Hammer Mfg. Co., Milwaukee, has been elected chairman of the new organization.

THE JARECKI CHEMICAL CO. of Cincinnati, Ohio, is rebuilding its plant, which was partially destroyed by fire last September. The Austin Co. has the contract for rebuilding this plant, the main portion of which is a special electric crane type fertilizer plant, 135 x 540 ft., to be used for acidulating, curing and storing chemical fertilizer and will run approximately $400,000 in cost. Gustav Jarecki is president.

THE INTERSTATE COMMERCE COMMISSION has declared unreasonable the rates on fertilizer from Mobile, Ala., to various stations on the Southern Pacific lines in Louisiana. These rates were attacked in a case brought by the Virginia-Carolina Chemical Co.

THE INTERNATIONAL OXYGEN CO., with main offices at Newark, N. J., is establishing a new branch plant at Toledo, Ohio, to furnish oxygen and hydrogen for all purposes to the numerous manufacturers and industries in that industrial section using either one or both of these gases in their processes. The capacity of the plant will be 3,000,000 cu.ft. of gas per month, the purity of which is said to be 99.5 per cent and higher.

FRANK H. NICKLE, manufacturer of agitator driving yokes, a standard power transmission device for driving agitator or stirrer shafts in open or closed chemical tanks, kettles and other containers, announces the organization of the Nickle Engineering Works, with office and factory at 729 North Niagara St., Saginaw, Mich. The company will install additional machine shop equipment and increase the scope of operations.

LAWRENCE M. BRILE, who has been connected for the last five years with the United Smelting & Aluminum Co., Inc., as vice president and sales manager, severed his connection with that company on Jan. 1, on which date he assumed the presidency of Brile & Ratner, Inc., a New York corporation, formed to engage in the metal and chemical brokerage business. Mr. Brile will take charge of the non-ferrous metal end of the business, while Mr. Ratner will take charge of the chemicals department. Temporarily, the office of Brile & Ratner, Inc., will be located at 115 Broadway, New York City.

THE JERRY JOHNSON 100-TON CYANIDE MILL at Cripple Creek is being dismantled by the Morse Bros. Machinery & Supply Co, of Denver. This mill, erected in 1914 and used but a few months, was completely equipped with Dorr thickeners, agitators and classifiers, Oliver filter, etc. The material is being shipped to Denver for resale.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, announces that the Atlas Machinery & Supply Co. is now handling the sale of the American steam ash conveyor in St. Louis territory. This company has offices at 1416 Syndicate Trust Bldg., St. Louis, Mo., and is a new sales organization in that vicinity headed by William H. Patton, who recently returned to the United States after two years service in the Army.

THE N. P. PRATT LABORATORY, one of the oldest chemical laboratories in the South, has sold its entire analytical department, together with its good will. Its successor will be known as Brogdon-Dumas Laboratories, Inc. The concern will do a general chemical engineering practice, including the making of all kinds of assays and analyses. J. S. Brogdon has conducted a commercial chemical laboratory in Atlanta for the past eleven years. W. C. Dumas, former state chemist of Georgia, more recently chief chemist of the N. P. Pratt Laboratory, has during the past thirteen years at various times been connected with the N. P. Pratt Laboratory. Additional space has been secured adjoining the old laboratory of J. S. Brogdon at 70½ Peachtree St., Atlanta, Ga. The union of these two laboratories makes a most complete chemical equipment.

New Publications

THE SCIENTIFIC AMERICAN PUBLISHING CO., 233 Broadway, New York City, announces that beginning with Jan. 1, 1920, the *Scientific American Supplement* will be changed in form and in period of issue. The new journal will be published on the first of each month, and will be known as the *Scientific American Monthly*.

THE BANKERS TRUST CO., of New York, has just published a brochure, "Financial Status of Belligerents," by Louis Ross Gottlieb, setting forth authoritatively and interestingly the debt, revenue and expenditure, and the note circulation of the principal belligerents in the World War.

THE GEOLOGICAL SURVEY OF GEORGIA has just issued a preliminary report on the oil prospect near Scotland, Telfair Co., Ga., by J. P. D. Hull and L. P. Teas.

THE PORTLAND CEMENT ASSN. is distributing a booklet entitled "Concrete Tanks for Industrial Purposes."

THE THIRD ANNUAL REPORT of the United States Council of National Defense for the fiscal year ended June 30, 1919, has just been issued.

A STUDY OF THE FORMS IN WHICH SULPHUR OCCURS IN COAL. By A. R. Powell and S. W. Parr. Bull. No. 111, Engineering Experiment Station, published by the University of Illinois, Urbana, Ill.

"SECURING BETTER COMBUSTION OF MID-WEST, WESTERN AND SOUTHWESTERN FUELS" is the title of a booklet issued by the Green Engineering Co., East Chicago, Ind., which contains eight articles taken from *Electrical World* and *Power*.

THE SALES MANAGER'S BUREAU of the St. Louis Chamber of Commerce has published a pocket-size trade directory comprising a classified list of manufacturers and jobbers in the district.

THE EXPERIMENT STATION of the Hawaiian Sugar Planters Assn. has issued a bulletin (No. 45), published at Honolulu on "The Paper Making Qualities of Hawaiian Bagasse," by Arthur D. Little, Inc., of Cambridge, Mass. It contains a general survey of the question, a discussion of previous attempts to use bagasse as paper-making material, description of the principal paper-making processes, discussion of the technique involved in handling Hawaiian bagasse with reference to the experimental results obtained, the commercial aspect of making paper in Hawaii from bagasse and the class of product which might be made, estimates of production and costs and tabulation of experimental data. The report followed the successful design and construction of a mill in Hawaii now in operation making a soft paper felt from bagasse which is used as a protection against weeds in the sugar cane fields under the Eckert patents. By this means about 50 to 70 per cent of the labor costs are avoided, and the yield is increased. The sharp, stiff cane sprouts break through the felt, while the soft-topped woods curl up and die.

THE THIRD ANNUAL REPORT of the United States Tariff Commission has just been issued.

"AMERICAN AND INTERNATIONAL LABOR CONDITIONS" is the title of a new booklet which gives a complete report of the proceedings of the Fall National Conference held under the auspices of the Society of Industrial Engineers, Cleveland, Ohio, Oct. 29 to 31, 1919.

ANNUAL REPORT OF THE DIRECTOR, BUREAU OF STANDARDS, to the Secretary of Commerce for the fiscal year ended June 30, 1919, has just been published by the Department of Commerce, Washington, D. C., and is known as Miscellaneous Publication No. 40.

SMELTER TREATMENT RATES. Bull. No. 30, published by the Canada Department of Mines, Ottawa, which is the report of the Committee of Investigation in the matter of tolls charged by the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, B. C., June, 1919.

Compressed Air Magazine appears in new form and style with the issue for January, 1920. Announcement is made in that issue of the fact that the magazine is entering upon its twenty-fifth year. W. L. Saunders has been editor in chief from the beginning, but now retires to be succeeded by Francis Judson Tietsort as editor and general manager. Other members of the staff are Eugene P. McCrorken, managing editor, formerly assistant editor of *Engineering and Mining Journal*, and Frank Richards as technical editor.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION has issued its third annual report.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS I: 5 "Silver, Copper, Lead and Zinc in the Central States in 1918," Mines report, by J. P. Dunlop and B. S. Butler (Mineral Resources of the U. S., 1918, Part I), published Oct. 31, 1919; I: 7, "Quicksilver in 1918," by F. L. Ransome, with a supplementary bibliography by Isabel P. Evans (Mineral Resources of the U. S., 1918, Part I), published Oct. 31, 1919; I: 8, "Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1918," Mines report, by Charles W. Henderson (Mineral Resources of the U. S., 1918, Part I), published Nov. 6, 1919; I: 9, "Arsenic, Bismuth, Selenium, and Tellurium in 1918," by James M. Hill (Mineral Resources of the U. S., 1918, Part I), published Nov. 19, 1919; I: 19, "Platinum and Allied Metals in 1918," by James M. Hill (Mineral Resources of the U. S., 1918, Part I), published Dec. 8, 1919; II: 14, "Fluorspar and Cryolite in 1918," by Ernest F. Burchard (Mineral Resources of the U. S., 1918, Part II), published Dec. 9, 1919; II: 17, "Silica in 1918," by Frank J. Katz (Mineral Resources of the U. S., 1918, Part II), published Dec. 4, 1919; I: 23, "Manganese and Manganiferous Ores in 1917," by D. F. Hewett (Mineral Resources of the U. S., 1919, Part I), published Oct. 31, 1919: I: 24, "Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1917," Mines report, by Charles W. Henderson (Mineral Resources of the U. S., 1917, Part I), published Nov. 8, 1919; II: 12, "Gypsum in 1918," by Ralph W. Stone (Mineral Resources of the U. S., 1918, Part II), published Nov. 6, 1919; II: 13, "Sand and Gravel in 1918," by R. W. Stone (Mineral Resources of the U. S., 1918, Part II), published Oct. 31, 1919; II: 15, "Peat in 1918," by C. C. Osbon (Mineral Resources of the U. S., 1918, Part II), published Nov. 24, 1919; II: 35, "Coal in 1917. Part B.: Distribution and Consumption," by C. E. Lesher (Mineral Resources of the U. S., 1917, Part II), published Nov. 18, 1919; Bull. 700, "The Analysis of Silicate and Carbonate Rocks" (A revised and enlarged edition of Bull. 422), by W. F. Hillebrand.

NEW BUREAU OF STANDARDS PUBLICATIONS: Scientific Paper 346, "Oxygen Content by the Ledebur Method of Acid Bessemer Steels Deoxidized in Various Ways," by J. R. Cain and Earl Pettijohn, issued Nov. 11, 1919; Sci. Paper 347, "Heat Treatment of Duralumin," by P. D. Merica, R. G. Waltenberg and H. Scott, issued Nov. 15, 1919; Sci. Paper 350, "Equilibrium Conditions in the System Carbon, Iron Oxide and Hydrogen in Relation to the Ledebur Method for Determining Oxygen in Steel," by J. R. Cain and Leon Adler, issued Nov. 10, 1919; Tech. Paper 137, "Coking of Illinois Coal in Koppers Type Oven," by R. S. McBride and W. A. Selvig, issued Nov. 17, 1919; Tech. Paper 141, "Electrolytic Resistance Method for Determining Carbon in Steel," by J. R. Cain and L. C. Maxwell, issued Dec. 6, 1919; Tech. Paper 146, "Cadmium Electrode for Storage Battery Testing," by H. D. Holler and J. M. Braham, issued Dec. 12, 1919; Ninth annual report by the director of the Bureau of Mines to the Secretary of the Interior, for the fiscal year ended June 30, 1919.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 162, "Removal of the Lighter Hydrocarbons From Petroleum by Continuous Distillation," by J. M. Wadsworth; Bull. 181, "Abstracts of Current Decisions on Mines and Mining, Reported From January to May, 1919," by J. W. Thompson; Tech. Paper 211, "Approximate Quantitative Microscopy of Pulverized Ores, Including the Use of the Camera Lucida," by Will H. Coghill and J. P. Bonardi; Tech. Paper 234, "Sensitiveness of Explosives to Frictional Impact," by S. P. Howell.

Manufacturers' Catalogs

THE LAW METALLIC PACKING CO., INC., New York City, has issued a pamphlet on "Law Metallic Packing."

WILLIAM R. PERRIN & CO., Chicago, Ill., calls attention to a booklet illustrating and describing filter presses for beet or cane sugar refineries.

THE FRANKLIN MANUFACTURING CO., Franklin, Pa., is distributing Catalog FC 7-19, on heat insulations, covering 78 pages. Less than one-half of this pamphlet deals with the Franklin Mfg. Co. products specifically; the rest constitutes a complete and useful handbook on the subject of heat insulation. Complete tables, diagrams, instructions and illustrative examples are given so that the proper kind and correct thickness of pipe covering can be determined for any set of conditions.

THE SCHUTTE & KOERTING CO. has issued a pamphlet recently entitled "Our Part in the War." Copies will gladly be sent to those applying.

THE UNITED STATES CONDITIONING AND TESTING CO., New York, has issued a pamphlet entitled "Tests and Analyses," which includes a price list of tests and analyses on dyestuffs, oils, soaps, rubber goods, paper, silk, cotton, wool, and fibers. The company maintains a chemical department which is prepared to analyze soaps, oils, raw materials, dyestuffs, chemicals, etc.

THE ELECTRIC FURNACE ASSN., Niagara Falls, N. Y., has issued a booklet on "Steel."

THE BACHARACH INDUSTRIAL INSTRUMENT CO., Pittsburgh, Pa., has recently issued two pamphlets. Pamphlet P summarizes the extended experience in the field of Pitot tubes and orifices; pamphlet F describes a new pressure-volume indicator, suitable for permanent installations or testing purposes.

THE DENVER FIRE CLAY CO., Denver, Col., calls attention to its attractive catalog on Melting Furnaces, known as Bull. 450, which illustrates and describes tilting furnaces, gas-fired furnaces, a motor blower, a combination burner, an oil furnace, etc.

GUYTON & CUMFER MFG. CO., of 4451 Fillmore St., Chicago, has issued Bulletin No. 101 covering steam-jacketed pumps and steam-jacketed pipe-fittings. This bulletin contains various illustrations of the pumps and accessories and tables with the necessary dimensions for design and erection.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

ALAN G. WIKOFF
Assistant Editor
L. W. CHAPMAN
Western Editor
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 22 — New York, January 21, 1920 — *Number* 3

Senate Passes The Water-Power Bill

BY A vote of substantially three to one the Senate passed on January 9 a bill for the development of water power in the United States. While the bill is not identical with that passed by the House last summer, there is agreement on essential points and there should be little difficulty in settling the difference in conference. The Senate bill provides for a Federal water-power commission consisting of the Secretaries of War, Agriculture and the Interior, which is authorized to license the development and operation of projects for a period of fifty years. At the expiration of licenses the Government has the right to take over the plant, issue a new license or permit continued operation under the old license. Licensees are to be required to pay an annual charge not exceeding twenty-five cents per developed horsepower, to reimburse the Government for the cost of administration and use and occupation of public lands necessary for the development of the project covered by the license.

One hesitates to grow too optimistic over this prospect of early enactment of water-power legislation. The subject has been debated for so many years that one emergency after another has found the country impotent to realize on its sources. Responsibility for the delay is being realized in the Senate, where Senator Williams declared recently during debate on the water-power bill that "the people of this country are gradually rising to the point where they demand abolition of the Senate for failing to function." But the Senate has now acted and it seems unlikely that much more delay will ensue, at least not more than is inherent in reaching agreement in conference. The national importance of the measure should spur the conference committee to early action.

More Power To the Chemist

ONE cannot read the remarks of OTTO EISENSCHIML before the Chicago Section of the American Chemical Society at the December 19 meeting under the subject "The Business Side of Chemistry," published in our last issue, without feeling that he has struck the keynote of greater success to the chemist and engineer in their dealings with the business world. The conditions under which business is done make every man engaged therein a salesman whether he desires it or not. Every word he utters in business connections, every move he makes, affects the sale of his personality with other people, whether it be conscious or unconscious. As the very foundation of business is the production of values, a man cannot be successful therein unless he is cognizant of the quantities and prices involved.

The chemical profession divides itself roughly into three classes: namely, the research chemist, who has to do with the production of values through new processes; the chemical engineer, who is interested in the installation of the plant for the successful production of the chemical, and the operator of chemical works, who has to do with the production and sale of chemicals when the plant is installed.

The research chemist may better his lot by demonstrating to his principals the value on a commercial basis of his discoveries. The chemical engineer, being by nature a business man, will collect deserved remuneration for the successful completion of the new plant. The operating chemist should be compensated for economies of operation effected or sales contracts consummated.

As Mr. EISENSCHIML stated, it is only a matter of business, which, in turn, is "common sense."

Wood Alcohol As a Beverage

THE recent fatalities in New England and New York resulting from the sale and consumption of certain intoxicating liquors containing wood alcohol should stimulate every chemist to use his individual influence in spreading information regarding the poisonous nature of this compound. To the chemist "alcohol" is a generic term and, since he is familiar with a large number of compounds belonging to this same class, the term is not necessarily associated in his mind with ethyl alcohol for beverage use.

Unfortunately, the public seems to be able to distinguish only two kinds of alcohol: denatured alcohol containing some evil smelling or ill tasting compound which obviously renders it unfit for human consumption, and alcohol which can be used in beverages. Wood alcohol, not being specifically designated as denatured (although, of course, it is used as a denaturing agent in many cases), is undoubtedly considered by many as belonging to the second class. The fact that containers of wood alcohol bear a label "poison" has even been explained by certain unscrupulous dealers as a ruse to prevent the Government from placing an internal revenue tax upon the contents. In order to prevent this confusion, manufacturing chemists have suggested to the Commissioner of Internal Revenue that the word alcohol be eliminated and that wood alcohol be known in future as "woodine." While this name may not meet with approval, viewed in the light of standard organic terminology, this action is a step toward the elimination of distinctions confusing to the non-technical mind.

Dr. REID HUNT, in a recent bulletin on wood alcohol, prepared at the request of the American Chemical Society, calls attention to the fact that the senses of

taste and smell cannot be relied upon to indicate the presence of wood alcohol and that poisonousness is an inherent quality of the substance, since it is oxidized in the human system to formic acid (and perhaps formaldehyde), while ethyl alcohol is converted into water and carbon dioxide, both harmless and easily eliminated.

In view of the serious consequences which may result from ignorance in this connection, every chemist should devote his energy to the enlightenment of the public regarding the dangers of wood alcohol.

It must be remembered, however, that wood alcohol or methyl alcohol has extensive legitimate uses in the field of chemical industry, and legislators and others should not lose sight of this fact in placing restrictions upon the sale and use of this commodity. The public must be protected, but the accomplishment of this aim must not result in the destruction of a legitimate industry.

Chemicals in A Smelter Flue

A PROMINENT metallurgist recently expressed the hope that the court order dissolving the packing trust might not react unfavorably in the smelting world to the extent of actually impeding recovery of byproducts, a work which he characterized as the most important now before technicians in this industry. His fears, however, appear somewhat magnified. Few Americans object to the slogan "Save all but the squeal," nor its actual realization, since conservation is fundamentally important. Rather, what they do object to is a manipulation of accounts so that economies in general operation are not reflected in the ultimate selling price of individual products to a method whereby the price of meat is all cost and the price of leather or blood all profit, and to a so-called publicity campaign showing that philanthropic butchers of great wealth make the merest trifle on their business. No one can reasonably object because a lead smelter saves, refines and markets its cadmium, and there is small danger of such a plant reaching out into various ramifications of the white-metal founding business because of this minor production. Then they should get into trouble, as have the packers when they market poultry because they have refrigerator cars and cold storage to handle them and strive to control the egg market because eggs are a poultry product. From this it is not a long step to the pillow business to get rid of feathers, and to the manufacture of beds and mattresses, in order to preserve a well-rounded market for the pillows. Thus it is that poultry is dear in order that an independent builder of brass beds in some corner of the country might be squeezed out of business!

Recover cadmium, a lead or zinc smelter must. Time was, and not so many years ago, that the cream of an ore was skimmed, and everything else slagged off, and what wouldn't slag went up in smoke and came down again to the detriment of the surrounding country. Nowadays, what with bag-house, dust chamber and Cottrell plant, very little of even the finest fume gets by, and it is only a question of time when smelter systems will build up to saturation with a dozen little-known and little-wanted elements and their compounds of low vapor tension.

Consider arsenic, as an instance. Any Montana smelter making a consistent effort to abate the dust nuisance rapidly overflowed with arsenic. Anaconda built a little plant fifteen years ago to re-treat some of the richest dust, but the ores even then produced more poison than the whole country could absorb, and a short run demoralized the arsenic market and left the company bare of outlet. As a matter of fact these Western stores of dirty arsenic were handy during the war, and even yet the price remains mysteriously high, but it is only a question of time before large producers of arsenic will actually be compelled to produce other compounds than the oxide. Ridding themselves of this substance will require the popularizing of new insecticides by exploiting their uniformity and low cost, easily possible in large-scale operation on less than valueless raw material.

Cadmium is another instance. Large quantities are available from zinc and lead plants, but no one knows what to do with it. During the war, a considerable amount was used in solders and white alloys in place of more expensive and scarcer metals, but with a relaxation of necessity, its consumption vanished. Again, who knows what tellurium is good for? Smelters have much more of it on hand than they want, but how can it be used?

These are but typical instances of some others which will arrive later. Truly, the utilization of byproducts is the most important now before technicians. But in many of these cases the problem will be broader than merely their isolation in comparative purity; it will comprise intensive research into the properties of the elements, their alloys and chemical compounds. When this is actually done, conservative chemical companies which are not now much interested in buying impure speiss offered by smelters need not expect too much sympathy from the public, which in the long run pays for the acid, the fertilizer, insecticide, alloys and chemical compounds now reposing in a smelter flue system.

Industrial Patriotism And Professional Folks

IN RECENT speeches and press articles, the duty of us folks who are Americans has been definitely pointed out by loyal and able men. The slogan "Industrial Patriotism" was sounded by Mr. JOHN W. O'LEARY in a talk to the chemists at the Chicago National Exposition of Chemical Industries. It doesn't really matter just what we call it or in what manner of words these thoughts of the quiet majority, that is, the middle classes, are expressed, but they are living up to the idea as called by Mr. O'LEARY.

And this appellation "middle classes" is only a name and no longer has any reference to the financial standing of its individuals. We refer mainly to the salaried people who make up this host, to the clerk, the office man, the stenographer, the engineer, the chemist, the professional man and others whose income depends on mind work in contradistinction to the laborer and the capitalist. Apparently the laborer refuses to think and the capitalist is becoming accustomed to paying someone to think for him.

Through all this turmoil and noise industrial, this "word-talk" of individuals with perverted ambitions, we have heard very little complaint from the middle-folks. Their average income is far below that of the hand-worker, who, by the way, has profiteered on the public funds quite as much as the capitalist. And why are these people silent? Not because they are

contented, not because their income is sufficient, nor yet because they do not desire the luxuries of life and a competency for declining years, do they labor patiently at the day's work.

It is because they are well-balanced folks, taught in many a school to think, so that from the examples of the past they can glimpse over the horizon of the future. They know that the reward surely comes in proportion to the effort exerted, that individual progress is in direct ratio to the application and that the progress of society must be evolutionary, never revolutionary. They ask no wage they do not earn, they scorn paternalism. They are busy working at research and study. It was GLADSTONE who said that if hard work was not genius it was a mighty good substitute for it.

Once we knew a humble shipping clerk, hight TOMMY JONES, pointing to no one in particular, who when asked what he did for recreation said, "Work, different kind of work." And he meant it. You can guess where TOMMY is today. What's the matter with the laboring man doing the same thing by adding head-work to his activities? We'll admit his job may be hard and the work sordid. He has only to start thinking to better himself. Self-education is easy in this age. If he hasn't the mental "pep" to "get on," the capitalist can't hand him an "automobile" salary for throwing a lever or swinging a pick. The capitalist, on the other hand, must use the power that is his with honesty and fairness. If he does not he will be elminated by the very laws upon which our business existence is founded.

Both sides of these controversies may well look toward the middle-folks then, as living exponents of real "industrial patriotism." Let them meet at the middle point of view, so to express it, with the soldiers on the job, who have "eyes front" toward the future achievements, and what's more, there is no stirring tune to carry them onward, except, mayhap, the music of the inspired soul.

Steel Supplies
Recent and Prospective

EVEN to those who have followed more or less closely the course of iron and steel production in the past year it must come as a shock to observe that only about 30,000,000 tons can be counted up as the year's pig iron production, while the production of steel ingots and castings can be set at only about 33,000,000 tons. The output of ingots alone in the first half of the year was about 17,500,000 tons.

These figures for pig iron and steel are barely more than three-fourths those of 1916, and since then the productive capacity has been materially increased, so that the outputs are only two-thirds the present capacity, estimated upon a conservative rather than an optimistic basis. In 1917 and 1918 full outputs, in relation to capacity, were not realized on account of various difficulties incident to the times. In 1919 the United States had no foreign war on hand, but it did not have peace at home.

These figures, showing such a wide gap between production and capacity, certainly have a bearing upon the iron and steel market. In many quarters it is being argued that the iron and steel industry is marked for much higher prices. Pig iron has, in fact, advanced fully $8 a ton since July 1, and some observers insist that if steel prices have not advanced, that is only because the United States Steel Corporation has been holding them down. The corporation is very strongly of the opinion that steel prices should not go above the March 21 schedule, arrived at by an agreement between Secretary Redfield's Industrial Board and representatives of the industry, and that if possible steel prices should even be reduced. The Steel Corporation backed up its theory by selling nearly 1,500,000 tons of its products in November, none of the sales being at above March 21 prices.

If an argument that iron and steel prices should be higher in future is based upon a claim that capacity production cannot be realized, on account of various drawbacks, the alleged drawbacks should be plainly stated in order that investigation may be made to determine whether or not the same influences may apply to operations by the consumers of steel. On the whole, it is probable that more work is done on steel to fit it for use than is done in producing it. In other words, the total value of all steel at the moment it is put into employment is probably much more than double its value at the time it leaves the steel mill. If there is going to be a shortage of labor at blast furnaces and steel mills, will there not also be a shortage of labor for making extensions to railroads, for building skyscrapers and for making and using all manner of tools in all manner of industries?

All along the line costs are very high, but the steel industry has also a very heavy overhead. This matter of overhead impels the steel producer to seek large tonnage outputs, but many classes of steel consumers are not similarly influenced. A railroad does not make improvements for the sake of reducing overhead, nor does the factor apply in the case of new building construction.

It seems clear that the fact that production of iron and steel in 1919 has been only two-thirds of the capacity is not an argument that market prices should advance. It is true that steel is very scarce at the moment, but that condition is due to two temporary influences, namely, the iron and steel strike and the coal strike.

Whatever the bearing of production upon the market, however, it behooves all iron and steel producers to seek the greatest tonnages in relation to plant facilities. There has been enough of inefficiency and slackening. As regards its equipment the iron and steel industry is well aligned for full production. There are no weak links in the chain from the raw materials in the ground clear to the finishing departments, though there may be some finishing departments that should have larger capacity, both in relation to demand and in relation to the capacity to produce crude steel. The Lake Superior iron ore mines are capable of producing all the ore needed by the tributary furnaces, the lake fleet is of sufficient capacity, and in the matter of coke many by-product ovens have been built in the past few years and very few beehive ovens have been abandoned. Pig iron capacity is at least 40 per cent greater than before the war, and more than 10 per cent greater than the maximum output yet recorded for a year, while it is quite possible that under favorable conditions the furnaces may exceed ratings based on past performances. Steel producing capacity is at least 40 per cent, perhaps 45 per cent, greater than it was in 1914. Efficient management and efficient labor are the two remaining desiderata for a remarkably heavy production by the industry.

Readers' Views and Comments

Atomic Structure of Metals in Solid Solution

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with much interest the paper in your Oct. 29-Nov. 5 issue on page 566, on the "Atomic Structure of Metals in Solid Solution," by A. E. Feild. While I feel that Mr. Feild's paper will stimulate thought along the lines of interpretation of the properties of solid solution alloys, I cannot agree with some of his general conclusions which would indicate that solid solution alloys consist largely of the amorphous phases of the components. The illustrative example given in his Fig. 2 shows the electrical resistivity of the solid amorphous metal and the solid crystalline metal diverging with decreasing temperature. This is admittedly an illustrative example. In his Fig. 3, however, where the actual examples of gold and silver are cited, the electrical resistivity of the solid amorphous phase and the solid crystalline phase converge with decreasing temperature. As pointed out in one of my papers[1] the convergance of several properties is the rule immediately below the freezing point of the metal, and I am wondering whether any actual examples exist in conformance with the illustrative example shown in Fig. 2.

On page 569, Mr. Feild writes: "A solid solution may then be regarded as entirely analogous to a super-cooled liquid preserving in the solid state all of the electrical properties such as specific resistance and temperature coefficient of resistance of the molten mixture of the components." Farther on he states: "According to our theory hardness in such an alloy is due to the existence of the metal in the amorphous solid state, thus confirming essentially Beilby's theory of the formation of an amorphous phase during cold working of a metal.

"In accordance with this view gamma iron is simply amorphous solid iron which is in solid solution with carbon."

Mr. Feild seems to have entirely ignored the directional and deformational properties of solid solution alloys, their appearance under the microscope, the heat of crystallization on solidification and the heat of fusion on melting, the grain growth phenomena after deformation, the usual crystallization shrinkage on solidification, etc. It might also be expected that an alloy of equal atomic proportions of silver and gold, for example, would show a sharp break in electrical resistivity at the melting range and that Mr. Feild's calculations based on the extrapolation of the electrical resistivity of the amorphous phase from the melting point down to room temperature would not hold at a temperature immediately below that of freezing. Mr. Feild's general conclusions, therefore, are untenable in the face of the existing evidence of the crystalline nature of solid solution alloys.

I do not maintain, however, that the existence of amorphous films between the grains of solid solution metal does not play an important role in the observed properties of solid solution alloys, nor that the atoms in the solid solution crystal are arranged in the same manner as the atoms in the crystals of the pure components. It is highly probable that the electrical and other properties of metallic solid solutions will be explained on the basis of an atomic arrangement and an electron distribution consistent with the present observations on the crystalline nature of solid solution alloys.[2,3,4]

Cleveland, Ohio. ZAY JEFFRIES.

[1] "Effect of Temperature, Deformation and Grain-Size on the Mechanical Properties of Metals," *Trans.*, A. I. M. E., vol. 60, 1919, pp. 474-576.

[2] See P. Ludwig, *Z. Ver. deut. Ing.*, vol. 63, pp. 142-144, Feb. 15, 1919.

[3] C. Viola, *Atte. Accad. Lincei.*, vol. 261, pp. 195-207 (1917).

[4] H. C. Burger, *Physik. Z.*, vol. 20, pp. 73-75, Feb. 15, 1919.

Sulphuric Acid Nomenclature

To the Editor of Chemical & Metallurgical Engineering

Sir:—I have read with much interest the views of Thomas J. Sullivan on "Sulphuric Acid Nomenclature" which I heartily indorse. There is no doubt that there is great confusion in the terms of the various strengths of this important acid, but practically all of this could be avoided by referring to all strengths up to fuming as per cent H_2SO_4 and above this as equivalent H_2SO_4.

Newark, N. J. R. ZELLER.

A New Compensated Heatmeter

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the Oct. 1 issue of CHEMICAL & METALLURGICAL ENGINEERING, a letter to the editor appeared, in which its author, Mr. T. S. Taylor, severely criticises our use of "Heatmeter" as a name for a new instrument of our manufacture. He claims that it is a misnomer, and misleading because heat is not measured quantitatively by means of the apparatus.

Kindly allow us space to explain that in utilizing "Heatmeter" as a trade name, this company merely availed itself of well-established precedents, and adopted a term quite as accurate and descriptive as many others of common usage in pyrometry; such as, for instance, "Multi-Pyrograph," "Hot-Spot-Potentiometer" and "Pyro-volter."

If it were expedient to quibble about the etymology of terms for designating special apparatus in any art, we could appropriately begin with the word "pyrometry," which literally means fire measurement, but I note that Mr. Taylor does not take exception to or comment on its ambiguity.

There are many other technical terms which should be banned, if Mr. Taylor's complaint were valid. For example, a "storage battery" does not store electricity; a "dry cell" is not dry; a "phonograph" does not write sound; a "potentiometer" does not serve to measure, but to balance, potentials; an "electrometer" is not a meter, but a means for comparing the intensity of static charges; and finally, the good old word "thermometer" must be deplorably misleading, because its derivation, from the Greek θέρμη" and the French "métre" makes it identical in its definition with "Heatmeter," and yet nobody is likely to imagine that either of these instruments may be used for the direct determination of thermal units. Hence our reputation is probably not at stake.

High school boys, Mr. Taylor admonishes us, are taught to appreciate the nice distinctions of nomencla-

ture in physics classes. This may be the case; but it may be interesting to learn that it was one of our most distinguished professors of rhetoric and philology at Harvard, who, in lecturing on colloquialisms and slang, told us that expressions such as "open circuit," "lost motion," "booster," "split phase," a "baking frost" and a "frozen bearing" were entirely permissible, and declared in substance that philologists admit that utility, rather than derivation or euphony, determines the adoption of new words or phrases which will constitute a succinct addition to our vocabulary.

Mr. Taylor also asserts I stated that an ammeter takes the place of a pyrometer in the "Heatmeter." If he reads my article carefully, he will note that I used an ammeter merely to demonstrate the fundamental principles of the Harrison-Foote invention in an elementary manner, and that the text describes the instrument as a modified form of precision millivoltmeter or pyrometer.

CHARLES P. FREY,
Chief Engineer,
The Brown Instrument Co.
Philadelphia, Pa.

Controversy Over Dye Licensing System

From the extensive hearings which were recently concluded before a sub-committee of the Senate Committee on Finance, it is very clear that both political parties are perfectly willing to safeguard the domestic dye industry, but that the question of method is very certain to bring on a determined fight when the bill comes before the Senate. The licensing system which it is proposed to apply to the dyestuffs industry will be the chief obstacle to the bill's speedy consideration. Unquestionably more than a majority of the Senate is opposed to licensing, but that they are willing to make concessions in certain cases has been shown by the attitude of many Senators, opposed to the principle of licensing, in the matter of continuing the licensing plan of handling of sugar. Many recognize the dye situation as presenting an exception, and it is not improbable that the Senate may adopt the general plan as set forth in the Longworth bill, which already has passed the House.

Joseph H. Choate, Jr., counsel for the American Dyes Institute, pointed out to the committee the success which has attended the administration of the licensing system in England and France.

General Sibert, in an argument for the stimulation of the dyestuff industry, declared that every chemical plant is a potential arsenal. Admiral Earle testified that the average time to convert a dye-making plant to war uses is three weeks. In a letter to the committee, the Secretary of the Interior urged early legislation. Van H. Manning, the director of the Bureau of Mines, appeared before the committee and pointed out the imperative need for legislation which would stabilize and stimulate the dyestuff industry.

Colonel Fries of the Chemical Warfare Service declared that the effectiveness of the United States in the war was lowered by lack of chemists. Even at the end of the war, he asserted, there had not been enough chemists developed to more than begin to handle the work. Colonel J. H. Burns of the Ordnance Department told the committee that the United States has been behind first-class powers in chemical knowledge.

Dr. M. T. Bogert, professor of organic chemistry at Columbia University, expressed the opinion that the coal-tar industry would have to have protection for ten years largely because of the time required to develop skilled men. He also pointed out that among the 15,000 trained chemists in the United States, not over 10 per cent are trained organic chemists. Dr. Julius Stieglitz of the University of Chicago, testifying in regard to synthetic drugs, declared that many lives and much suffering could have been prevented had we developed our chemical industry in the past. Henry Howard, representing the Manufacturing Chemists' Association, told how the Germans, prior to the war, used our patent laws to maintain a monopoly for their own country on dyestuffs. Henry Wigglesworth, also of the Manufacturing Chemists' Association, believes the licensing can be better administered by a board such as was provided in the original Longworth bill rather than placing the administration of the act in the hands of the Tariff Commission.

The main points made by those opposing the licensing system were that it is in reality an embargo under a different name; that no commission, no matter how composed, could administer a licensing system for dyes without doing great injury to the industry. Not only would the system be cumbersome in operation, it was declared, but it would place an army of $1,500 clerks in control of an important portion of America's business. The effect of the legislation would be very harmful to export trade, it also was stated.

Meeting of A. I. M. E., New York Section

The New York Section of the American Institute of Mining and Metallurgical Engineers held its regular monthly meeting at the Machinery Club, Jan. 7, 1920. Walter C. Perkins spoke on the co-operative system in Russia and gave a very interesting account of the method of organizing co-operative associations in commerce, industry, banking, etc. This method of conducting business has proved highly efficient even among the illiterate peasants of Russia. It has not been popular with the Soviet government, which has made every effort to destroy it. Mr. Perkins was of the opinion that the co-operative system is the best hope for the regulation of the cost of living, eliminating the usurer and the middleman.

Percy H. Thomas described the power development at the Chuquicamata and Braden copper properties in Chile. Natural conditions at the two properties are quite different and call for different types of plant. At Chuquicamata the absence of rivers and the desert nature of the country dictate the construction of a steam-power plant at tidewater, with oil for fuel, and a transmission line to the mines. At Braden, on the other hand, with a plentiful supply of water, a hydroelectric plant was called for. Mr. Thomas illustrated his talk with several reels of film.

Regulation of Engineering Practice by License Issued Under State Laws

In compliance with the instructions of Engineering Council, a committee to frame a uniform bill on the licensing of professional engineers met recently in Chicago. There have been a number of bills introduced in the several state assemblies and about eleven of these have become laws, several of which have been so drafted as to work unnecessary hardship. It has therefore been considered advisable to draft a model bill for introduction by those interested in the various states, in order to supplant or forestall enactments of indifferent origin or harmful results.

Theory and Practice of Catalysis

THE meeting on Jan. 9 of the New York Section of the American Chemical Society was well attended, Rumford Hall being filled to its capacity. Dr. Ralph H. McKee, chairman, opened the meeting. Secretary Herbert G. Sidebottom read the minutes and treasurer's report. He announced that the membership of the section was 1,990, but ten short of giving to the section a twenty-first representative to the Council.

The evening was devoted to papers on Catalysis, the theoretical physicochemical backgrounds being concisely presented by M. Harvey, a preliminary report on the catalytical oxidation of benzene at the Research Laboratories of The Barrett Co. by John M. Weiss and Charles R. Downs, and the action of driers in paints and varnishes by F. P. Ingalls.

Mr. Harvey opened his paper with a discussion of the mass action (1) of the Deacon chlorine process[1]:

$$4HCl + O_2 \leftrightharpoons 2H_2O + 2Cl_2$$

$$\frac{dx}{dt} = k(a - x)(b - x) \qquad (1)$$

where a and b are the initial, x the reacted quantities and $\frac{dx}{dt}$ the velocity. He then stated the gas equation derivative (2) and the fundamental physical law (3) showing the relation between velocity, force and resistance.

$$0.058 \log \frac{P_{O_2} P_{HCl}^4}{P_{H_2O}^2 P_{Cl_2}^2} = 2.3 \log T - \frac{27300}{T} + \text{const.} \qquad (2)$$

$$\textit{Reaction Velocity} = \frac{\textit{Chemical Force}}{\textit{Chemical Resistance}} \qquad (3)$$

From these three equations it can be seen that reaction can be increased in three ways, by increasing the concentration in (1), the temperature in (2) or decreasing the resistance in (3). The action of the Haber ammonia process was explained.

$$N_2 + 3H_2 \leftrightharpoons 2NH_3 + 24{,}400 \text{ Cal.}$$

The reaction is one of chemical compression; 4 mols. of nitrogen and hydrogen being changed to 2 of ammonia with an accompanying heat discharge. Table I is a record of percentage yields of ammonia with changes in temperature and pressure. It will be noted

TABLE I. HABER PROCESS YIELDS

Pressure	550° C.	650° C.	750° C.	850° C.
1 atm	0.07	0.03	0.01	0.009
100 atm	6.7	3.02	1.54	0.87
200 atm	11.9	5.71	2.99	1.68

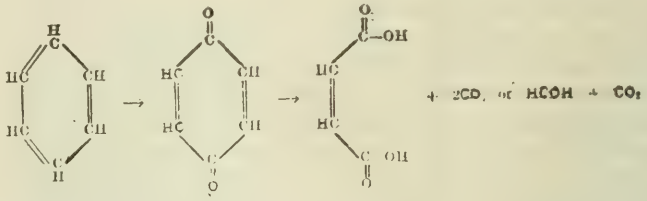
that lower yields are obtained at higher temperatures due to the heat of the reaction not being absorbed as the cooling head is diminished.

The hydrolysis of ethyl acetate in the presence of HCl was discussed from the oxonium and ion-hydrate theories of Falk and Nelson,[2] and H. Goldschmidt.[3]

Photochemical reactions were briefly touched upon from the quantum theory viewpoint. The formula[4] derived by Planck for radiation density was the basis of the discussion.

Mr. Weiss reviewed the literature relative to the previous work done on partial oxidation of hydrocarbons as a means of forming hydroxyls, ketones and new products. No practical results were obtained until 1907, when Orloff in Russia succeeded in producing products from cyclic ring petroleum. The year following the Bayer company took out patents showing that their research laboratory was investigating the field.

It was decided to concentrate on benzene during this investigation because it offered the simpler reactions. The scheme of these is shown graphically in the accompanying drawing. More details than can be given here will be found in the patents recently issued to the authors.[5] The catalyst used consisted of vanadium oxide on pumice. The reaction temperature was between 300



and 500 deg. C. Quinone and maleic acid are produced and seem to have an equilibrium ratio, though higher temperatures and increased amounts of oxygen tend to increase the yield of products of decomposition. The chief difficulty found in controlling these partial reactions is in absorbing the heat generated so as to keep within the temperature limits. In the formation of quinone from benzene 3,000 calories are liberated, and 10,560 in that of maleic acid, while 18,000 are given off in the total combustion to carbon dioxide and water. Very small yields of formaldehyde were obtained, due no doubt to its great reactivity with oxygen at the temperatures used.

The quinone is reduced to hydroquinone, which has a ready market as a photographic developer. The maleic acid is an intermediate for synthetic tartaric and citric acids. The Barrett Co. does not plan to manufacture these derivatives, but will be glad to supply any manufacturer with either the quinone or maleic acid.

The oxidizing action of steam at high temperatures and pressure on benzene was also studied.[6] At 60-lb. pressure and 690 deg. C., 23 parts of C_6H_6 vapor and 27 parts of H_2O gave a fair yield of diphenyl. No phenol was produced. This process furnished an interesting basic study for accounting for the large amounts of tar acid in Scottish tar.

F. P. Ingalls was highly entertaining as well as instructive in his paper on oil driers. He gave the action of lead, manganese and cobalt linoleates as well as the several other so-called oxidizers that have been tried out but not found to be oxygen carriers when in oil. Vanadium and cerium proved to be of no value. Lead ethylate also gave no results. The resinates of lead, manganese and cobalt were valuable, but unfortunately are quite susceptible to adulteration. The older method of boiling the oil with the drier metal oxides has largely been superseded by saponifying the oil and precipitating the linoleates by adding salts of the metals. These are dissolved in turpentine and mixed with the paint or varnish in such proportions as the drying time calls for. Linseed oil containing 0.075 per cent cobalt will dry in 2½ hr., so it will be seen that cobalt is a drying accelerator. Lead is the slower drier, but is preferred because of its smooth film. Paint that hardens too quickly tends to crimp. This is very noticeable with chinawood oil, which when applied to glass gives a somewhat frosted appearance.

[1] *J. Am. Chem. Soc.*, vol. 28, p. 380; 1906. *Zeit. Phys. Chem.*, vol. 59, p. 313; 1907.
[2] *J. Am. Chem. Soc.*, vol. 37, p. 1732; 1915.
[3] *Zeit. physik. Chem.*, vol. 60, p. 728; 1907.
[4] System of Physical Chemistry, Lewis, III, 1, 39.
[5] Weiss and Downs, U. S. Pat. 1,318,631-33
[6] U. S. Pat. 1,322,983.

Dr. Charles F. Chandler Receives the Perkin Medal

After introductory remarks by Charles E. Sholes, chairman of the New York section, at the fourteenth annual Perkin Medal presentation meeting of the Society of Chemical Industry, Friday night, Jan. 16, and some humorous reminiscences by Dr. M. C. Whitaker, who has been intimately associated with Prof. Chandler for the past twenty years, the Perkin Medal was graciously presented to Dr. Chandler by Prof. Marston T. Bogert of Columbia University.

Dr. Whitaker brought back to mind many incidents illustrating Prof. Chandler's fine personality, generosity, tact and greatness. Prof. Bogert gave a beautiful biographical sketch, reviewing back from 1637, when Dr. Chandler's forefathers came to New England, his early education and schooling at the New Bedford schools, the Lawrence Scientific School, Berlin, Göttingen and lastly his fifty-odd years as a university professor, and dean as well as world-wide chemical councilor.

Dr. Chandler gave an excellent example by presenting his acceptance address extemporaneously. He modestly stated that he had never considered himself as a candidate for the great honor that had just been conferred upon him. He then reviewed incidents taken at random from his life work which he humorously stated might excuse the medal committee. The outstanding features of Prof. Chandler's educational work along with his service as private and civic consultant are no less than monumental and are known to all American chemists about as well as the deeds of Washington. The flash point of lamp oils, ton assay weights, 66 deg. sulphuric acid, Baumé scale standardization, city plumbing regulations, sanitation, plant nuisances, and hundreds of other subjects were initiated by his genius. His titles, "Father of the American Chemical Society," "Dean of American Chemists," are tokens of esteem which can never be represented by even the most precious of metals cast in medals. For a fuller account and the addresses of the meeting, the reader is referred to our next issue.

National Academy of Sciences Establishes a Section of Engineering

The National Academy of Sciences has established a section of engineering. Despite all the comedy definitions from which the engineering professions suffer—a famous toastmaster was described in pre-prohibition days as "Digestion's Engineer"—the fact remains that engineering must be included under the general title of science. If this proposal had been made in the National Academy ten years ago there would probably have been recorded a number of fainting fits among its members. The committee consists of Messrs. H. L. Abbott, J. J. Carty, W. F. Durand, J. R. Freeman, H. M. Howe, F. B. Jewett, G. O. Squier and D. W. Taylor.

New Classification for Chemical, Physicochemical and Physical Phenomena

In the *Journal* of the Washington Academy of Science P. V. Well proposes a new classification for chemical, physicochemical, and physical phenomena, on the ground that recent advances have made the distinction between physics and chemistry both difficult and artificial. He proposes that all forces be classified as respectively, 1, molar; 2, molecular; 3, atomic; and 4, electronic. The corresponding sciences would then be molics, moleculics, atomics, and electronics.

Congress Investigates Expenditures For Nitrate Plants

A SUB-COMMITTEE of the House Committee on Expenditures in the War Department met at the Custom House, New York, Jan. 9-10 for the purpose of investigating the expenditure of $84,000,000 for the two nitrate plants at Muscle Shoals, Ala.

Frank S. Washburn, president of the American Cyanamid Co., testified that his company had offered to build Plant No. 2 with no thought of making a profit, during war time. Government officials decided, however, that the company was entitled to some recompense. As a result, the American Cyanamid Co. received a fee of $1,500,000, of which, Mr. Washburn said, about 85 per cent was deducted in taxes of various sorts and extra expenses cut into the remainder, so that the company made practically nothing. In addition, a contract was drawn up whereby the plants might be operated on a royalty basis by a subsidizing company acting as agent for the Government, for the production of nitrogenous fertilizer materials. The royalty to be paid to the American Cyanamid Co. until its patents expire is ¾c. per lb. of contained nitrogen.

When questioned as to the choice of Muscle Shoals for the location of Plant No. 2, Mr. Washburn pointed out that the simultaneous occurrence of abundant water power and deposits of high-grade limestone and coking coal within sixty miles made the situation unique from the point of view of raw material supply. Labor was also plentiful at the time the project was under consideration.

Possibility of Government Operation

The Government is interested in the manufacture of nitrogenous fertilizer materials under the contract already referred to. As a result of a study made by his company, Mr. Washburn was able to place before the committee statistics from which he had drawn the conclusion that the American Cyanamid Co. can purchase ammonia in the open market for a term of years cheaper than it can produce this compound from cyanamide. Hence, even under Government operation, the plant could not compete with the byproduct coke plants in the production of ammonium sulphate. In Mr. Washburn's opinion, Government manufacture of cyanamide would probably ruin the American Cyanamid Co., since the sale of cyanamide as such is limited (it being used exclusively in mixtures with acid phosphate) and the market is at present nearly saturated, 60,000 tons a year being produced by this company.

Bernard M. Baruch, chairman of the War Industries Board, discussed the nitrate problem during the war period briefly as follows:

Nitrate Program of War Industries Board

Sodium nitrate was admittedly the most important raw material which had to be obtained outside the boundaries of the United States. It soon became evident that Chile could not be depended upon, and a study of synthetic processes was undertaken. It was felt that, even though no plants were built, the knowledge of this possibility would prevent the Chilean producers from increasing their prices for fear of loss of trade in post-war times. With the enormously increased demand for propellants in the spring of 1918, Mr. Baruch saw that there was no possibility of even

the total production of Chile meeting the demand, and asked for four to six ammonium nitrate plants, each to have a capacity equivalent to 225,000 tons of sodium nitrate per year. These recommendations were made solely for the purpose of providing an adequate supply of nitrates for military purposes, and no thought as to the possibility of the cessation of hostilities was allowed to influence the decision. The matter of salvage was also considered of secondary importance.

Joint Committee on Ceramic Research

The National Research Council and the American Ceramic Society have established a joint committee for promoting the investigation of scientific problems underlying the ceramic industry, especially by founding a series of research fellowships whose holders shall devote their attention exclusively to these problems. The members of this committee are: A. V. Bleininger, chairman, ex-officio; Arthur L. Day, Homer F. Stanley, R. B. Sosman, E. W. Washburn, secretary, University of Illinois, Urbana, Ill.

The ceramic industries, including brick and tile making, and general crockery and glass manufacture as well as ornamental potteries, although among the earliest developed by man, have been the last of our great manufacturing industries to reach the status of applied sciences. They have been based for centuries on rule-of-thumb methods, trade secrets, and individual artistry. As far as their artistic features go, science can do little or nothing for them, but in all other ways it can be of great advantage to them.

In sharp contrast to the painfully slow development of these ancient industries is the extraordinarily swift development of such exclusively modern industries as those of synthetic dyes and others entirely based on the discoveries of modern science. The startling success and speed of growth of these are almost entirely the fruit of highly organized scientific research, with methods of scientific control at a young stage of the operations. A famous English scientist is authority for the statement that the capital, large as it has been, which the German dye firms have invested in scientific research has been the best paying investment which the world has ever seen. It is certain that an organized effort to develop the fundamental science of ceramics can have a great influence in advancing the industry.

Coming Meeting of the American Ceramic Society at Philadelphia

Headquarters for the American Ceramic Society meeting, Feb. 23-26, 1920, will be the Bellevue-Stratford Hotel, where rooms are available for general and special meetings, and where social functions will be held. Members of the society are asked to make reservations early, as all hotels in Philadelphia are crowded during the winter months.

Frederick Stanger, manager of the Enterprise White Clay Co., is general chairman of the local committee. Sub-committees have been appointed to assist him. William E. Saunders, of the United Gas Improvement Co., is chairman of the committee on the banquet. W. H. Fulweiler, of the same company, has charge of arrangements for a smoker, or "Section Q." C. H. Applegate, Jr., of the Philadelphia Textile Machinery Co., is chairman of the committee on hotel reservations. C. A. Hall, of the Pennsylvania Salt Manufacturing Co., is making arrangements for the meetings, equipment, etc. George Pettinos, of Pettinos Bros., has charge of the information bureau, and John T. Goheen, of the Brown Instrument Co., is arranging for trips of interest to be taken after the close of the meeting.

A. I. M. E. Annual Meeting

The annual convention and business meeting of the American Institute of Mining and Metallurgical Engineers will be held at the Engineering Societies Building in New York, Feb. 16-19.

Industrial excursions will be made on Thursday, Feb. 19, probably to iron and zinc mines and zinc and steel plants in the vicinity of New York, although it has been impossible to decide definitely this far in advance. In connection with the very important oil sessions, a trip is projected to one or more of the refineries in the metropolitan district.

The tentative program for the technical sessions includes the following papers:

A Foreign Oil Supply for the United States, by George Otis Smith.

Petroleum in the Philippines, by W. D. Smith.

International Aspects of the Petroleum Industry, by Van H. Manning.

Composition of Petroleum and Its Relation to Industrial Use, by C. F. Mabery.

Geologic Distillation of Petroleum, by Baily Willis.

Low-Temperature Carbonization of Coal, by S. W. Parr and T. E. Layng.

Examination of Ores and Metals in Polarized Light, by F. E. Wright.

Reverberatory Furnace for Treating Converter Slag at Anaconda, by Frederick Laist and H. J. Maguire.

Coal-pulverizing Plant, Nevada Consolidated Copper Smelter, by R. E. H. Pomeroy.

Milling Plant of the Alaska Castineau Mining Co., by E. V. Daveler.

Intercrystalline Brittleness of Lead, by H. S. Rawdon.

A Peculiar Type of Intercrystalline Brittleness of Copper, by Henry S. Rawdon and S. C. Langdon.

Relationship of Physical and Chemical Properties in Copper, by Frank L. Antisell.

Blast-furnace Flue Dust, by R. W. H. Atcherson.

Manufacture of Semi-steel for Shells, by Frank E. Hall.

An Experiment in One-piece Gun Construction, by P. W. Bridgman.

Tensile Properties of Boiler Plate at Elevated Temperatures, by H. J. French.

Microstructure of Iron and Mild Steel at High Temperatures, by H. S. Rawdon and Howard Scott.

Physical Changes in Iron and Steel Below the Thermal Critical Range, by Zay Jeffries.

Graphitization of White Cast Iron, by R. S. Archer.

Use of Microscope in Malleable Iron Industry, by Enrique Touceda.

The Coefficient of Expansion of Alloy Steels, by John A. Mathews.

Critical Ranges of Some Commercial Nickel Steels, by Howard Scott.

Forgeability of Iron-Nickel Alloys, by T. D. Yensen.

An invitation has been extended to the members of the Canadian Mining Institute to attend this meeting. A joint meeting with the Electrical Engineers for one day of the session is also being arranged.

Some Chemical Data on Coal Pyrite

A Study of the Use of Coal Pyrite for the Manufacture of Sulphuric Acid—Analyses of Coal Pyrite Samples for Sulphur, Carbon, Arsenic, Phosphorus—Summary and Conclusions

BY H. F. YANCEY*
Assistant Chemist, Bureau of Mines

IN 1917 one-third of the sulphuric acid produced in the United States was made from native sulphur.[1] This represents an abnormal condition in the sulphuric acid industry, because under normal conditions in the past very little native sulphur was used in the manufacture of acid. In 1918, however, owing to the heavy war demands the quantity of native sulphur so used increased greatly over the 1917 consumption. Conditions which necessitated curtailment of the importation of Spanish pyrite ore, and the increased demand, imposed rather critical difficulties on the acid industry. Many manufacturers began burning sulphur instead of pyrite. Under normal conditions such a procedure appears to be bad economic practice and a wasteful use of natural resources. The shortage of pyrite ore gave impetus to various Federal and State governmental agencies to locate adequate sources and deposits of this ore, and to stimulate development of known existing domestic sources.

In April, 1918, a conference of representatives of State Geologists and of the U. S. Bureau of Mines was held at Urbana, Illinois, for the purpose of investigating the possibility of the recovery of pyrite resulting from coal mining operations. The following States were represented: Iowa, Missouri, Illinois, Michigan, Indiana, Kentucky, Tennessee, Ohio, and Pennsylvania. H. A. Buehler and E. A. Holbrook represented the U. S. Bureau of Mines.

The plan adopted at this conference was to make a pyrite survey in each State. Representatives of the respective State Geological Surveys visited coal mines and estimated the possible pyrite production. In many of the mines representative samples of the pyrite or marcasite were taken, and sent to the Middle West Station of the Bureau of Mines at Urbana, Illinois, for determination of their sulphur content. As very little pyrite containing less than 35 per cent sulphur is used in acid manufacture, the determination of sulphur was considered an important adjunct of the survey work. There has not been at any previous time such a systematic investigation of production, and of sulphur content of coal-pyrite ore in the main coal-producing States. The survey indicated that about 1,500,000 short tons of pyrite concentrates could be recovered from coal-mining operations in the Eastern and Central coal fields of the United States.

SULPHUR MINERALS IN COAL MEASURES

The chief sulphur mineral occurring in coal measures is known as iron pyrites, pyrite, or ferric sulphide (FeS_2). Another mineral, known as marcasite, occurs in the coal along with pyrite. As marcasite does not differ in chemical composition from pyrite, it will be included under the general term pyrite in this report. Pyrite from coal mines is sometimes commercially termed "coal brasses" and is called "sulphur" by the miners; other local names sometimes used for coal pyrite are "sulphur balls," "kidney sulphur," "cat faces," and "niggerheads." A "niggerhead" may or may not be pyrite. Some of them consist almost entirely of calcium carbonate, while others are completely pyritized. The mineral pyrite occurs as bands, lenses, nodules, and in very thin leaves in the coal seam. The thin leaves occurring in the cleavage planes are not recoverable, and are therefore not within the scope of this discussion.

Fig. 1 shows a typical pyrite lens with adhering coal. The lens represents a fair grade of pyrite, though streaks of foreign carbonaceous material may be noted in it. Fig. 2 is a view of a typical band of high-grade pyrite adhering to the coal. This particular band was almost continuous and occurred near the top of the coal seam. The lenticular and band pyrite are very rarely so interbedded or intergrown with coal or slate as to be of low grade when freed of outside adhering coal. The figures give an idea of the approximate size of both the lens and band pyrite. These two forms of pyrite are the most important from the standpoint of sulphur recovery in most of the mines. Fig. 3 shows two views of a pyrite nodule, boulder or "niggerhead." The adhering coal has been mostly removed. The upper picture shows a top view of the elipsoid-shaped nodule. The lower picture represents the cross-section, the nodule having been broken with the hammer. The nodule has been completely pyritized. Some of these nodules occurring with the coal have not been completely pyritized, and have only a thin outer layer of pyrite surrounding the limestone center. This form of pyrite is therefore not so important as band and lenticular pyrite.

EXPERIMENTAL WORK ON COAL PYRITES

In this paper the results of sulphur determinations on about 120 samples of pyrite from nine States are recorded. Most of the samples were from Ohio and Missouri. Other samples were from Indiana, Tennessee, Kansas, Kentucky, Illinois, Pennsylvania, and Michigan. About 250 samples of milling products resulting from the concentration of picking belt refuse, washery refuse, and handpicked coal-pyrite ore were analyzed for sulphur. Specific gravity determinations on coal-pyrite containing varying amounts of sulphur are given. The relation of color and sulphur content is discussed. Brief reference is made to impurities occurring with some pyrite ore which rendered difficult ore-dressing operations designed to produce a

*By permission of the Director, U. S. Bureau of Mines.
[1]U. S. Geol. Survey, Mineral Resources, part 2, p. 61; 1917.

high-grade commercial pyrite concentrate. The carbon and arsenic content of pyrite concentrates is recorded because of its bearing on the manufacture of sulphuric acid from such concentrates. The percentage of phosphorus in pyrite from coal mines is given, for a few samples, because of the importance of investigating possible sources of low-phosphorus iron ore.

The results of numerous ore-dressing tests on coal-pyrite ore will be given in a separate Bureau of Mines publication.

Preparation of Samples for Analysis

The samples received from the field were first cleaned to remove adhering slate and coal particles from the pyrite. This was done because the information desired was the sulphur content of the mineral itself, and not of the mineral and its adhering impurities. It is obvious that a milling operation designed to produce pyrite concentrates would involve

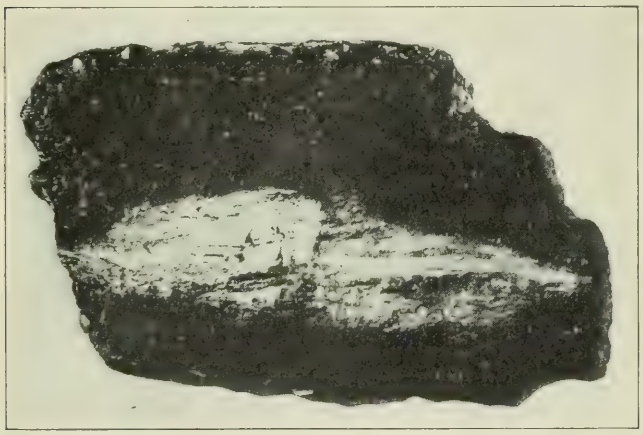


FIG. 1. LENS OF PYRITE (ABOUT ONE-THIRD ACTUAL SIZE)

crushing and washing of the ore so as to remove adhering slate and coal. After the samples were cleaned a brief description of the physical appearance was recorded, and an estimate of the sulphur content of the cleaned mineral was made.

Determination of Sulphur by the Parr Method

The sulphur was determined according to the method of S. W. Parr.[2] One-half gram of the sample, crushed to pass 80 mesh, was weighed into a Parr sulphur bomb and intimately mixed with about 7 to 10 grams of sodium peroxide. About one-half gram of potassium chlorate was then added, and an equal amount of powdered benzoic acid. The lid was then secured on the bomb, and the contents mixed by shaking vigorously. The bomb was next heated over the Meker burner for five minutes; the explosion generally occurred about one-half minute after the bomb was placed over the flame. The heating was continued because the explosion itself does not always give a perfect fusion resulting in the decomposition of all of the pyrite. At the end of five minutes the bomb was cooled under the water-tap, the lid removed, and the fusion crucible placed in a beaker containing about 100 cc. of water. When the reaction had subsided the crucible was washed out, the solution neutralized with hydrochloric acid, and 4 cc. added in excess. The solution was then filtered, diluted to about 300 cc., and the sulphate precipitated from the hot filtrate by the addition of an excess of 10 per cent of barium chloride solution according to the standard method. After standing, the precipitated barium sulphate was removed by filtration, and washed with dilute hydrochloride acid (5 cc. concentrated hydrochloric acid in one liter of hot water). This is followed by several washings with hot water. The precipitate was then ignited at a dull red heat, cooled and weighed.

Other Methods for the Determination of Sulphur

The method described is sufficiently accurate for this study, and more rapid than most of those involving wet oxidation of pyrite. Some investigators have pointed out that barium sulphate should be precipitated from cold[3] solutions containing ferrous,[4] rather than ferric, iron.

These refinements increase the time required for the determination, and were not used because a high degree of accuracy was not required. However, for extremely accurate work on high sulphur materials, such as pyrite, it is probable that the method of Allen and Bishop[4] would be more satisfactory for umpire and sulphuric acid company analyses.[5] They obtain slightly higher results in the absence of alkali chlorides. Allen and Bishop's method requires the reduction of the iron in the solution before the precipitation of barium sulphate; while Smoot[6] advises the removal of this iron, before precipitation of the sulphates, by electrolysis, using a mercury cathode. Allen and Johnston[7] have referred to the disturbing influence of alkali chlorides, and recommend the Carius method of oxidation by heating with fuming nitric acid in a sealed tube. Hulett and Dushak[8] have investigated this subject. The method of Lunge[9] is widely used both in this country and abroad.

Comparative Study of Sulphur Determination Methods

A comparative study of the different methods was made by the joint committee on standard methods for coal analysis, with a very satisfactory showing for the sodium peroxide fusion procedure.[10] References to some of the recent work on the determination of sulphur are given below.[11]

The Parr method was found to be quite satisfactory for all milling products resulting in the concentration of coal-pyrite ore. Some of these products carried considerable amounts of slate and clay, and therefore of silica. This silicic acid did not separate, at the dilution mentioned, when the sodium peroxide fusion was acidified with hydrochloric acid, and even when present in the sample to the extent of 65 per cent did

[2]Parr, S. W., "The Use of Sodium Peroxide in Certain Quantitative Processes," *J. Am. Chem. Soc.*, vol. 30, p. 764; 1918. "A Fusion Bomb for Sulphur Determination in Coal," *J. Ind. Eng. Chem.*, vol. 11, p. 230; 1919.

[3]Folin, Otto, *J. Biol. Chem.*, vol. 1, p. 131; 1905-06.

[4]Allen, W. S., and Bishop, H. B., Eighth International Cong. App. Chem., vol. 1, p. 33; 1912.

[5]Moore, H. C., *J. Ind. Eng. Chem.*, vol. 7, p. 634; 1915; *Ibid.*, vol. 8, p. 1167; 1916. *Ibid.*, vol. 11, p. 45; 1919.

[6]Smoot, A. M., *Eng. Mining J.*, vol. 94, p. 412.

[7]Allen, E. T., and Johnston, J., *J. Am. Chem. Soc.*, vol. 32, p. 588; 1910.

[8]Hulett, G. A., and Dushak, L. A., *Zeit. anorg. Chem.*, vol. 40, p. 196; 1904.

[9]Sulphuric Acid and Alkali, vol. 1, part 1, p. 95.

[10]*J. Ind. Eng. Chem.*, vol. 5, p. 525; 1913.

[11]Raeder, M., *Tid. Kemi Farm. Terapi*, vol. 14, p. 257; 1917. *Chem. Abs.*, vol. 12, p. 1160; 1918. Martin, E., *Mon. sci.*, vol. 8, p. 149; 1918. Karaoglanow, Z., *Zeit. anal. Chem.*, vol. 56, p. 561; 1917. *Ibid.*, vol. 57, p. 77; 1918.

not contaminate the barium sulphate precipitate.[12] This was determined by evaporating one sample containing 65 per cent silica to dryness, after the water leach of the sodium peroxide fusion had been acidified with hydrochloric acid. The resulting dehydrated silica was then filtered off, and the sulphates precipitated. Several determinations gave a value agreeing very closely with that obtained by precipitating the sulphates directly without previous removal of the silica. This particular sample contained 15 per cent sulphur.

Sulphur Content of Specimens

Ohio.—The State of Ohio was represented by 47 samples. Pyrite investigations were made in about 150 mines. Of the 47 samples examined only 24 per cent contained less than 40 per cent sulphur. Only 4 per cent of the samples contained less than 35 per cent sulphur. The best sample had a sulphur content of 51.2 per cent. The formula FeS_2 requires 53.42 per cent sulphur and 46.58 per cent iron. This sample had the highest percentage of sulphur of any examined during the entire investigation. Mr. W. M. Tucker conducted the investigation in Ohio.

Missouri.—Thirty-six samples of pyrite were collected in thirty-four Missouri coal mines by Mr. Russell Gibson of the Missouri Bureau of Mines and Geology. Twenty-two per cent of the samples examined contained less than 40 per cent sulphur, while only 5 per cent of the samples contained less than 35 per cent sulphur. The best sample showed 48.5 per cent sulphur.

Indiana.—Only one sample of pyrite from Indiana was examined. This contained 46 per cent sulphur. Four samples of concentrates obtained in washing Indiana coal-pyrite ore were found to contain from 44 to 46 per cent sulphur. A report on pyrite in Indiana coal has been prepared by Mr. L. P. Dove and will be published by the Indiana Geological Survey.

Tennessee.—Five samples came from coal mines in Tennessee. All of these samples contained more than 45 per cent sulphur. The specimen having the highest sulphur content analyzed 47.6 per cent. Three lots of hand-picked ore from this State gave high-grade sulphur concentrates with good recoveries of sulphur. In two of these lots the heads contained 40 per cent sulphur.

Kansas.—No samples were collected in Kansas, but one lot of hand-picked coal-pyrite ore was received and concentrated. The head sample of this lot showed 40.3 per cent sulphur. The concentrates obtained by crushing and washing contained 46.5 per cent sulphur.

Kentucky.—Three samples were collected in Kentucky. All three samples contained more than 43 per cent sulphur, 45.6 per cent being the highest. Two samples of washery refuse from a different part of the State were not amenable to concentration, because siderite with some calcium carbonate occurs as a stony impurity along with the pyrite. The siderite and pyrite are closely intermixed, as rather fine crushing, prior to washing, was necessary to give a satisfactory concentrate. The specific gravity of this siderite, being 3.2, rendered the washing and concentration of the ore difficult.

Illinois.—Seventeen pyrite samples were submitted by the Illinois Geological Survey. All but three of these samples contained more than 40 per cent sulphur. The best sample contained 48.9 per cent sulphur. Mr. G. H. Cady made the pyrite survey in Illinois, and the results of his investigation will appear as a bulletin of the Illinois Geological Survey Division. Among the States Illinois ranked third in the production of pyrite in 1917.[13] It is significant that all of this pyrite was recovered in coal-mining operations. Two important papers dealing with this subject have been published.[14]

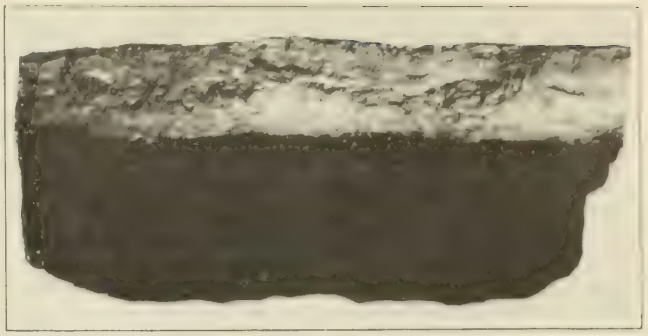


FIG. 2. BAND OF PYRITE (ABOUT ONE-THIRD ACTUAL SIZE)

Pennsylvania.—Two samples of pyrite were received from the Topographic and Geologic Survey Commission of Pennsylvania. They both contained about 44 per cent sulphur. Two samples of washery refuse were examined, both of which contained about 20 per cent sulphur, but which would produce a high-grade pyrite by concentration. Two lots of coal-pyrite ore gave high-grade concentrates with satisfactory recoveries of sulphur on washing.

Michigan.—The coal mines of Michigan were represented by three samples. A washery refuse concentrate contained 41 per cent sulphur. Two samples of pyrite showed 47.2 and 38.5 per cent sulphur. The high-grade sample was dark in color, but dense, heavy and amorphous, while the low-grade (38.5 per cent) sample was brass-yellow, crystalline and much lighter, indicating a lower specific gravity.

TABLE I. SULPHUR CONTENT OF COAL PYRITE

State	Number of Samples Examined	Per Cent of Samples Containing Over 40 Per Cent Sulphur
Ohio	47	75
Missouri	36	78
Indiana	5	100
Tennessee	5	100
Kentucky	3	100
Illinois	17	93
Pennsylvania	2	100
Michigan	3	66
Kansas	1	100

The summory of the sulphur content of specimens is given in Table I.

Relation of Appearance to Sulphur Content

The mineral pyrite generally occurs as brass-yellow cubic or other isometric crystals. Marcasite differs from pyrite in crystalline form only in that it is generally lighter in color, and has a slightly lower specific gravity.

As has been previously mentioned, a record was made of the physical appearance of the sample. By comparison of this record with the sulphur content

[12] Hillebrand, W. F., U. S. Geol. Sur., Bull. 422, pp. 196-198; 1910.

[13] U. S. Geol. Survey, Mineral Resources, part II, 26; 1917.

[14] Holbrook, E. A., "The Utilization of Pyrite Occurring in Illinois Bituminous Coal," Illinois Univer. Engineering Exper. Sta., Aug. 20, 1917. Pogue, J. E., "The Pyrite Situation With Special Reference to Coal Mining in Illinois," 4 pp., Illinois Geological Survey, October, 1917.

it was early found that the color of the specimen did not give an accurate indication of probable purity. In fact many of the coal-pyrite specimens containing more than 45 per cent sulphur were dirty-gray or brown in color, dull and non-crystalline even on fresh fracture. Samples of bright brass-yellow crystals of pyrite from Virginia and Georgia pyrite mines (not coal mines) were often found to contain less sulphur than dull, dirty-gray specimens of pyrite from coal. In several instances samples of pyrite from coal, having a brass-yellow, crystalline appearance, were found to be rather low in sulphur.

In a general way it was found that the estimation of the grade of a coal-pyrite specimen (sulphur content) should be based upon its apparent specific gravity when "weighed" in the hand, rather than upon its color or structure.

The specific gravity of pure pyrite is given by Dana[15] as 4.95 to 5.10, and by Moses and Parsons[16] 4.9 to 5.2. The same authorities give the specific gravity of marcasite as 4.85 to 4.90 and 4.6 to 4.9 respectively. The specific gravity of several samples of pyrite from coal mines is given in Table II. The corresponding sulphur determination was made on a portion of pyrite from the same piece as that used for the specific gravity determination, except in the case of the sample from Ohio, when both determinations were made upon the finely pulverized sample.

TABLE II. SPECIFIC GRAVITY OF COAL-PYRITE

Lab. No.	Per Cent Sulphur	Specific Gravity
Tenn. 11	15.1	2.70
Ill. 18	25.5	2.89
Ill. C-17-51	29.7	3.62
Ill. C-18-20	42.0	3.99
Ill. C-18-62	44.0	4.41
Ill. 22	46.7	4.09
Ill. C-18-68	48.9	4.32
Ohio 111A	51.2	4.76

It will be noted that sample 111A from an Ohio mine contained nearly the theoretical (53.42) per cent of sulphur, and showed the highest specific gravity. This is to be expected. Even this sample has a specific gravity too low to meet Dana's value for either pyrite or marcasite, but does come within the limits given for marcasite by Moses and Parsons. As shown in the table the specific gravity of pyrite does not increase directly with the sulphur content. It is apparent that variations in the specific gravity of the non-pyritic material would account for these variations.

Carbon in Coal-Pyrite Concentrates

It is generally assumed that carbon dioxide exercises an injurious action in the lead chambers, and for this reason "coal-brasses" have not been considered good raw material for the manufacture of sulphuric acid until quite recently. It now seems that this assumed injurious action was due to inaccurate information, or to difficulties encountered in making sulphuric acid from roughly hand-cleaned coal-pyrite ore containing from 10 to 25 per cent coal with its accompanying volatile matter. The maximum amount of carbon in pyrite concentrates allowed without penalty is generally 8 per cent. Lunge[17] states that a Bohemian works is making sulphuric acid from a material containing 10 per cent bituminous material without any special trouble. Pyrite concentrates from a pyrite washery contain much smaller amounts of carbon, and apparently do not cause trouble in the manufacture of acid. Some figures on the carbon content of pyrite concentrates are given in Table III.

TABLE III. CARBON CONTENT IN COAL-PYRITE CONCENTRATES

Product	Total Sulphur Per Cent	Total Carbon Per Cent	Organic Carbon Per Cent
First Bed Pyrite Concentrates	44.77	2.90	2.27
Pyrite Lump Concentrates	45.88	2.60	1.83
First Hatch Pyrite Concentrates	45.03	3.75	2.96
Recleaned Pyrite Middlings	43.88	6.76	6.61

Analyses made at the Pittsburgh Station, Bureau of Mines.

In this connection Parish[18] has called attention to some of the difficulties met in the manufacture of sulphuric acid from coal-pyrite. He states that coal-brasses should contain a minimum of 38 per cent available sulphur, and ferrous sulphate not to exceed

FIG. 3. BALL OF PYRITE (ABOUT ONE-THIRD ACTUAL SIZE)

6 per cent. He recommends the use of a nitric acid feed on the Glover tower, and points out that carbon dioxide occupies valuable chamber space in the system. Excessive amounts of iron sulphate would not

[15]Textbook of Mineralogy, 1913.

[16]Mineralogy, Crystallography and Blowpipe Analysis, 1900.

[17]Lunge, G., Sulphuric Acid and Alkali, vol. 1, pt. 2, p. 971; 1913.

[18]Parish, P., *Gas J.*, vol. 141, p. 246; 1918.

be present in a freshly prepared pyrite concentrate. Thereafter, the amount present would depend upon the conditions of and the length of time in storage, as well as upon the mineralogical and physical characteristics of the pyrite. Experience seems to indicate that under average conditions the formation of iron sulphate would not materially affect the value of coal-pyrite concentrates, but storage for more than a year might be inadvisable.

In connection with storage, the tendency of coal pyrite to fire spontaneously must be considered. It is well known that hand-picked pyrite, containing, as it does, generous amounts of coal, takes fire quite readily during storage. Information covering the storage of washed pyrite concentrates, which ordinarily contain less than 5 per cent of carbon, for long periods of time are not available. However, pyrite washeries in Illinois have never experienced appreciable heating or firing of washed concentrates during storage for several months.

Arsenic in Coal Pyrites

Arsenic is poisonous, and has an especially injurious effect on the production of sulphuric acid by the contact process. According to Hjelt[19] Spanish pyrite from the Rio Tinto district contains an average of 0.91 per cent arsenic. Pyrite recovered from coal-mining operations showed much less of arsenic in six samples examined. A sample from Pennsylvania supposed to be high in arsenic contained 0.056 per cent. A sample of concentrates from an Illinois pyrite washery having an output of 1700 tons of pyrite concentrates per month showed only 0.029 per cent of arsenic. Another Illinois pyrite washery concentrate contained only 0.005 per cent. The first hutch product obtained in jigging several hundred pounds of Ohio coal-pyrite ore contained 0.005 per cent arsenic. A similar product, but from Tennessee, had an arsenic content of 0.015 per cent. A jig concentrate on Pennsylvania ore contained 0.039 per cent arsenic. The results on these samples can be taken as fairly representative of coal-pyrite concentrates, and show that the arsenic content of this material is negligible.

Phosphorus in Coal Pyrite

The clinker or cinder remaining after burning off the sulphur from pyrite has been utilized as an iron ore. The material is generally so fine that it requires agglomeration or nodulizing, as well as roasting, to remove the remaining sulphur. Several other factors determine its suitability for use as an ore of iron, but because of the present low-phosphorus iron-ore situation, it was considered advisable to determine the amount of phosphorus present in coal-pyrite. Ten samples of pyrite concentrates were obtained at pyrite washeries and from milling tests on half-ton lots of coal-pyrite ore. The percentage of phosphorus found to be present in the pyrite varied from 0.003 to 0.083 in these concentrates. Seven of the samples contained less than 0.015 per cent phosphorus, while four showed less than 0.008 per cent phosphorus. It is apparent that a considerable portion of the burnt coal-pyrite cinder could be used for the production of low-phosphorus iron. In England the cinder is used in the manufacture of paint.[20]

[19]Hjelt, *Dingler's polytech. J.*, vol. 226, p. 174.
[20]Parish, P., *Gas J.*, vol. 141, p. 246; 1918.

Summary and Conclusions

Most of the pyrite occurring with coal contains economic and useful percentages of sulphur.

Color and physical appearance do not indicate probable sulphur content.

Properly prepared pyrite concentrates do not contain injurious amounts of carbon.

Pyrite from coal contains only very small amounts of arsenic.

Pyrite from coal is mostly low in phosphorus.

Acknowledgment

The work described in this paper was carried out under the direction of E. A. Holbrook, to whom acknowledgment is made.

This report was prepared under a co-operative agreement among the Illinois State Geological Survey Division, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines. The work was conducted in the Mining Laboratory of the University of Illinois.

U. S. Bureau of Mines,
Urbana, Illinois.

Furnace for Testing Firebrick Under Load at High Temperatures

By C. H. Lovejoy

THE proposed standard test for firebrick under load at high temperatures, outlined in the 1918 *Proceedings* of the American Society for Testing Materials, and more extensively described in this journal of date Jan. 1, 1918,[1] leads me to write this description of a furnace for similar purpose, which has been used by the Pittsburgh Testing Laboratory, Pittsburgh, Pa., for the past five years. The main differences between these furnaces lie in the manner of applying the load and the means of determining the load at any time during the progressive failure of the brick under test.

The apparatus consists essentially of a firebrick chamber in which the test brick is heated while a pressure is applied at the ends. We use a pressure of 50 lb. per sq.in. (double that recommended), which will produce ultimate failure in all but the best brick when the temperatures mentioned in the proposed test are attained. By applying the load with a spring instead of levers, we are able to carry practically all our tests to ultimate failure, determine the variation in load sustained by the brick at the higher temperatures, and obtain an idea of the rate of failure. The spring we use is easily removed and frequently checked up in our testing machine. This is mostly a matter of form, for when in use it is never stressed to capacity, and we have found no appreciable differences in it during the five years it has been in service. When compiling our results we plot a load-temperature curve as well as a time-temperature curve. As a rule we try to have our time-temperature curves alike and draw our conclusions from the load-temperature curve.

The apparatus is best described by outlining the procedure followed in making a test. The brick to be tested, *T*, is placed in the center of the furnace (Fig. 1); the upper end blocked to the roof with half of a refractory brick, the lower end blocked to the moving piston, *P*,

[1]"A Furnace for Testing Refractory Materials Under Load at High Temperatures," Robert J. Montgomery. Met. & Chem. Eng., vol. 18, No. 1, p. 18, Jan. 1, 1918.

with another refractory brick. To guard against eccentricity in loading, a very thin piece of sheet asbestos is placed between the blocks. The opening in the bottom of the furnace is closed by a piece of heavy asbestos board fitted around the lower blocking brick.

The piston *P* is raised by turning nut *N* until the brick to be tested and the blocking are in firm contact with each other. The length of the uncompressed spring is now measured accurately. Further turning of nut *N* will produce compression in the spring and bring pressure to bear on the end of our test brick. For each inch of compression in the spring we use, we obtain 400 lb. load. Suppose the end area of our brick to be $2\frac{1}{4}$ in. x $4\frac{1}{4}$ in. = 9.56 sq.in. at 50 lb. per sq.in. = 478 lb. total load to be applied. This will be obtained by continuing to turn nut *N* until the spring is compressed 478 ÷ 400 = 1.19 in.

The two gas burners at *B* and *B* (Fig. 2) are lighted, at first without any air blast. These burners are staggered so that no flame shall impinge upon the test specimen. When the furnace has reached 500 deg. C. the door *D* is blocked, the blast turned on, and regulated so as to reach 1350 deg. C. in five hours, and maintained at this temperature for one hour. Furnace temperatures are read every 20 minutes by an electric pyrometer inserted through *H*, opposite the brick. The amount of compression in the loading spring is measured at the same time. Very poor brick will start to fail and bulge in the middle as low as 950 deg. C. or 1000 deg. C., the load falling off in proportion as this deformation reduces the amount of compression in the spring. Such brick will show complete failure below 1200 deg. C., the spring having returned to its original length, the load reduced to zero. This class of brick is not useful in arch construction or other work where it is necessary that the brick stand a load. Fair brick will start about 1100 deg. C. and still have about 25 lb. per sq.in. left on them at 1350 deg. C. First-class brick will generally show no signs of failure before 1200 deg. C. and many will stand 1300 deg. C. before starting to fail. We have found only two brick that would show no signs of failure at 1350 deg. C. If desired the temperatures may be carried above 1350 deg. C. to whatever point is necessary to produce complete failure; always at temperatures below 1500 deg. C.

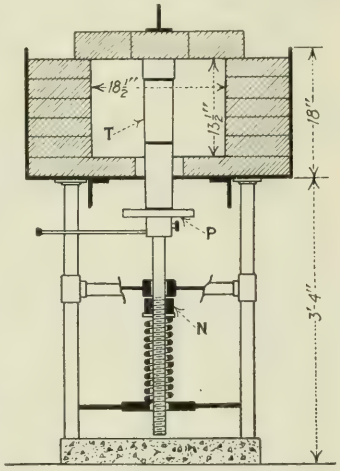


FIG. 1. SECTION THROUGH FURNACE

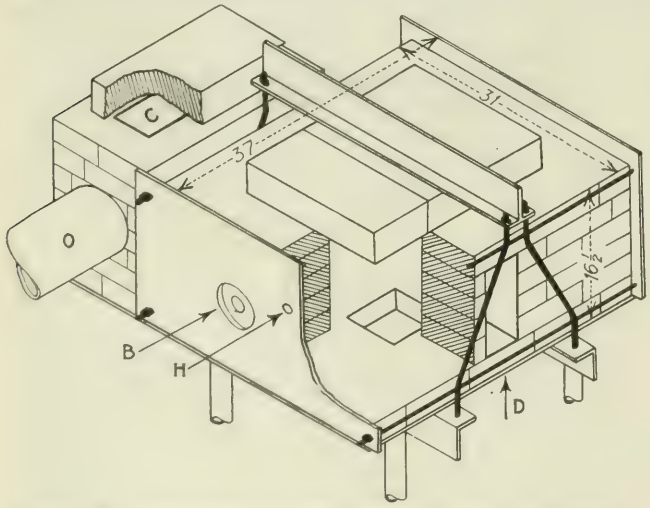


FIG. 2. ISOMETRIC VIEW OF HEATING CHAMBER

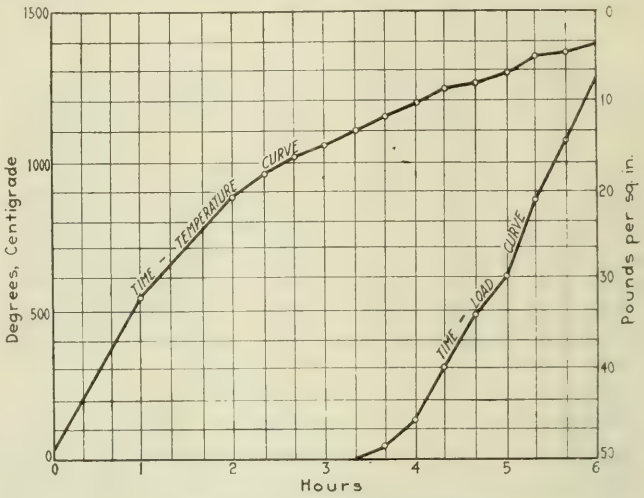


FIG. 3. TEST OF FAIR QUALITY FIREBRICK

Considerable difficulty was experienced with the original furnace through the frequent melting off of the outlet pipe carrying away the gases, until the extra chamber *C* was built on the rear of the furnace.

In the proposed standard test using the lever furnace, the load remains constant, and different rates of heating are recommended for different qualities of brick, always stopping short of ultimate failure. In our work we receive samples from many sources in which the main question is not what this specimen will stand without failing but what this brick is good for and where it will fail. Our furnace enables us to arrive more quickly at the answer to this question.

For general testing and variety of service we have found this furnace very satisfactory. The metal work is simple and easy to assemble; the spring insures straight line application of the load; the brick work is made without special shapes and is easily laid up; and the whole furnace is compact and was moved twice in the last year with a minimum of effort.

The credit for the general design of this furnace belongs to J. B. Shaw, who built the original furnace. Several attachments have been added by other members of our staff for the purpose of making it automatic and self-recording, but it is not essential to describe them here.

Pittsburgh Testing Laboratory,
Pittsburgh, Pa.

Extension of General Import License

The general import license has been extended to cover salvarsan, neo salvarsan, arsphenamine, and all substitutes and equivalents therefor, and narcotics. The effective date was Jan. 10. Individual import licenses therefore will not be required for these commodities except when shipments originate in that part of Russia under control of the bolshevik authorities.

Reminiscences of Early Years at the Great Falls Smelter

Brief Notes of the Early Development of this Once Great Copper Concentrator and Smelter, Particularly as Affected by the March of Events in the Metal and Share Market Ore Supply and Metallurgical Science

By CHARLES H. REPATH

Consulting Engineer,
Sometime Chief Engineer, Boston & Montana C. C. & S. M. Co.

AFTER operating for more than 20 years, the concentrator at Great Falls, Montana, was closed down somewhat before the outbreak of the war. It was maintained in operating order, however, for many months, but finally the machinery was removed, scrapped or disposed of as opportunity offered.

The definite passing of this mill—perhaps the oldest in the Rocky Mountain copper regions—where were solved many of the problems underlying the mammoth operations of today, warrants more than perfunctory mention. In fact, during the '90s the plant was known as the "last word" in copper, its pre-eminence falling only with the completion of the large Washoe works in Anaconda. Even thereafter, the staff was continually working on the betterment of the milling and smelting practice, and was able to make refinements in principle and method which have been of wide application elsewhere. Possibly, then, these reminiscences of early years at this plant may be of more than casual interest.

The Boston & Montana Consolidated Copper & Silver Mining Co.—or more briefly, as it is still known, the "B. & M."—was organized with a moderate capitalization late in the '80s, and owned some Butte mining properties on the northeasterly end of the then productive copper zone. It also owned two small plants near by in Meaderville—the upper works, and the Colusa, or lower works, one of which embodied, by the way, the first copper concentrator started in Butte, a 25-ton mill erected in 1881 by A. Wartenweiler for the Montana Copper Co. to produce jig concentrates of copper glance from Colusa ore. The early B. & M. operations were quite profitable, and in 1889, when it was decided to increase the smelting capacity, the first steps were taken by the management in the issuance of a $500,000 bond issue to cover construction. At that time the output was a high-grade matte which was shipped to England for refining—the monthly production contained about 2,000,000 lb. of copper and 14,000 oz. of silver.

A New Smelter Authorized

It was not easy to determine the correct location for what was then thought to be a large smelter. Available sites in Butte were cramped, water was scarce, coal and coke expensive, and the existing sulphur smoke unendurable. A much more favorable area was purchased in Cascade county, on the north bank of the Missouri River, just below Black Eagle, the first of a series of wonderful waterfalls which have but recently been utilized. Here was available power to drive machinery and pumps, ample water for concentration, and a big river into which tailings and slag could be sluiced. At Belt or Sand Coulee, within a few miles, was located extensive deposits of bituminous coal, already developed and supplying locomotive fuel at about $1.75 per ton. Unfortunately, however, the site was 175 miles from the mines across the continental divide, and the question whether ore should be hauled to the coal or coal to the ore was argued at length. A favorable freight rate (65c. per ton) was negotiated, however, and tentative plans were adopted for a 2-section 500-ton concentrator, Brückner roasters, producers for gasifying the bituminous coal and tilting open-hearth smelting furnaces.

Mr. Charles O. Parsons, the general manager at that time, employed Mr. Frank Rossberg, a concentrator man from Anaconda, to design the mill. The first question was the method of crushing to be employed—whether to use the steam stamps so successful in the Michigan copper country or the jaw crushers and rolls thought to be more applicable in Butte. Montana milling practice had been strongly influenced by Michigan ideas at a somewhat earlier date, when Marcus Daly went to the Calumet & Hecla to get a man to design a new mill at Anaconda, fortunately securing the services of Otto Stahlman, then working as draftsman under John Ellenbecker. Daly was much impressed with the magnitude of the operations in Michigan, and while the old mills at Anaconda had already demonstrated the efficiency of crushers and rolls, they were rather small installations and Daly threw aside all their accumulated experience for the "bigness" of a stamp mill. Rossberg, although originally a Michigan steam-stamp proponent, had a very open mind and knew that the stamp was far from perfect, and while the cost of stamping was much less it produced many fines, causing a tremendous loss in values. Great Falls construction was therefore delayed for months through 1890 on account of this controversy between what might be differentiated as the Anaconda system and the B. & M. system of concentration. The former, as noted, exemplified Michigan practice using steam stamps, hydraulic separators, Collom jigs, and revolving slime tables. The B. & M. Colusa mill attempted to reduce sliming by crushing in Blakes and Cornish rolls, and to cut down the water consumption by screening in trommels, then concentrating on Hartz jigs and vanners. Evidently a proper choice required the decision of fundamental questions.

Character of Site at Great Falls

Tentative ground plans and cross-sections were adopted, however, sufficient to allow excavation and foundation work to proceed. The site chosen was against a steep river bank, close to the falls, where power could be transmitted from the wheels by rope drives, and where the huge quantities of water required

could be readily available. How big an item the latter was can be appreciated when it is known that the 500-ton mill required 240,000 gal. of water per hr.—many times what would be used today. The excavation was enormous—a series of benches were dug into the hillside, mostly in a water-bearing shale, exceedingly tough when fresh, but rapidly disintegrating into a slippery clayey mass on exposure. Immense rock retaining walls were therefore necessary, not only to hold up the benches, but also to withstand the impact of the steam stamps, should they later be installed.

The delays due to indecision as to plans and to extra heavy work, the overrunning of estimates, and the expanding construction program caused much dissatisfaction with the Great Falls management, and called for a second bond issue of $600,000 to complete the smelter. In order to find out the exact status of affairs, the Eastern management in the spring of 1891 asked Captain Daniell and Frank Klepetko of the Tamarack Mining Co. to inspect construction operations, in company with

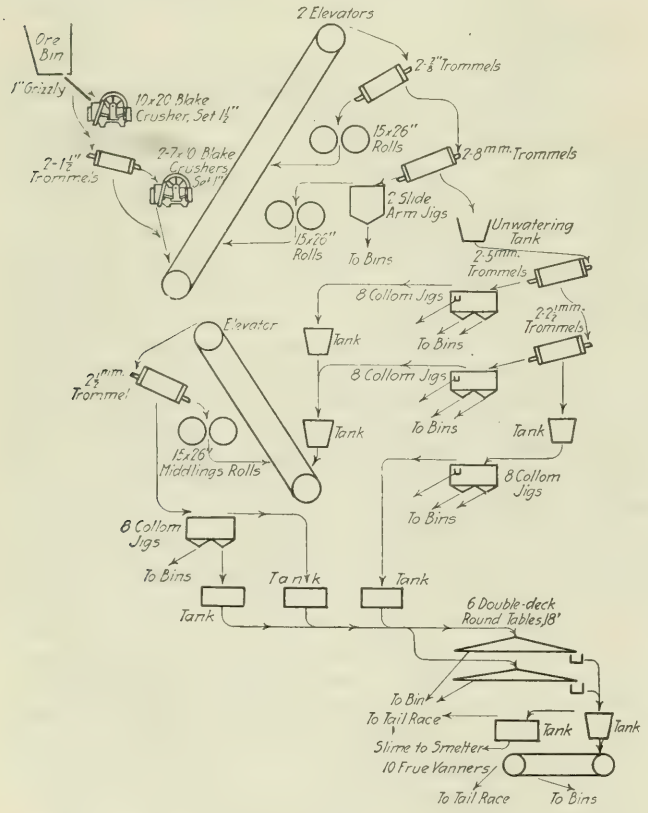


FIG. 1. ORIGINAL FLOW SHEET OF CONCENTRATOR, 1892.

Thomas Couch, Butte manager of the B. & M., and C. H. Palmer of the Butte & Boston. Their report quieted much of the official apprehension, and Mr. Klepetko was soon after retained as manager, being given instructions to push the work to completion with all possible speed. After investigating the concentrator problem, he decided against steam stamps and ordered the installation of the Butte system. This was accordingly done, and the mill started in March, 1892.

Original Mill

A brief description of the original mill follows: Concentrating machinery occupied two-thirds of a wooden building, 136 ft. by 262 ft. in dimensions. Ore was delivered to wooden storage bins of 3600 tons capacity, crushed in 10 by 20 and 7 by 10 Blake crushers and 15 by 26-in. rolls, and concentrated in slide arm jigs, Collom jigs, and double deck round tables whose tailings were finally treated on Frue vanners, all as shawn on the flow sheet (Fig. 1). This machinery was driven by two 44-in. water wheels, from which a 400-hp. manilla rope transmission went to the mill, together with a 250-hp. transmission to the smelter. A 40-in. wheel was also used in the power house to drive two rotary pumps, furnishing 3500 gal. per min. through a 24-in. riveted pipe, about 1000 ft. long. The remainder of the mill was occupied by a 22 by 48-in. Corliss engine for reserve power, and a 15 by 30-in. Ball steam stamp for reserve crushing.

Early operations in the mill were fairly satisfactory from the viewpoint of recoveries. Many troubles appeared due to disproportionate spouting and splitting of feeds, but such difficulties were encountered ten years later when the Washoe mill started. Shortly after concentration commenced, Mr. Klepetko brought Mr. W. A. Estabrook over from the B. & M. plant in Butte to be superintendent of the concentrator, Mr. Rossberg leaving to work up a centrifugal milling machine for some Helena people. Estabrook made a number of changes which, while not affecting the general flow sheet greatly, practically rebuilt the entire plant and brought the mill up to its rated capacity of from 500 to 600 tons per day. Rolls, elevator boots and heads, trommels and launders were raised or lowered for more adequate service. During all this time there was a continual struggle with poor machine design—constant and vexatious delays due to breakages in crushing, jig or table division resulted in new designs and local construction for nearly every piece of machinery in the concentrator.

Smelting Practice

Meantime the smelting departments were not having an easy time of it. These were arranged as shown in Fig. 2, housed in a light steel building 230 by 455 ft. in dimensions, built by the Berlin Iron Bridge Co. (at a cost of about $60,000, by the way!) Roasting was done in 24 Brückners, then the perfection of roasting practice, with a rated capacity of 16 tons per day; actually about 250 tons of concentrates were calcined. In the design of the metallurgical machinery, Julian Kennedy of Pittsburgh was retained as consulting engineer, and the plant showed many points of similarity to steel-works practice. Twenty-four Wellman gas producers supplied gas to eight matte furnaces (Fig. 3)—small tilting open-hearths operated with hydraulic cylinders and with regenerative checkerwork. Six of these were gas-fired, while two, owing to lack of capacity in the producers, were operated experimentally by direct coal-firing. Slag was granulated and sluiced to the Missouri River below—a most economical disposal which continued until three or four years ago. A high-grade matte was produced, crushed, sacked and shipped to New York. Later it was handled in pots by one 20-ton overhead crane to two converter stands, each designed for 5 tons of matte. (Seventeen-pound air was furnished through 1600 ft. of 30-in. riveted pipe from a blowing engine near the water wheels.) The detailed construction of these stands was very similar to those at bessemer steel plants, with sectional shells, and hydraulic operation centrally controlled from a pulpit. It was originally thought that only the

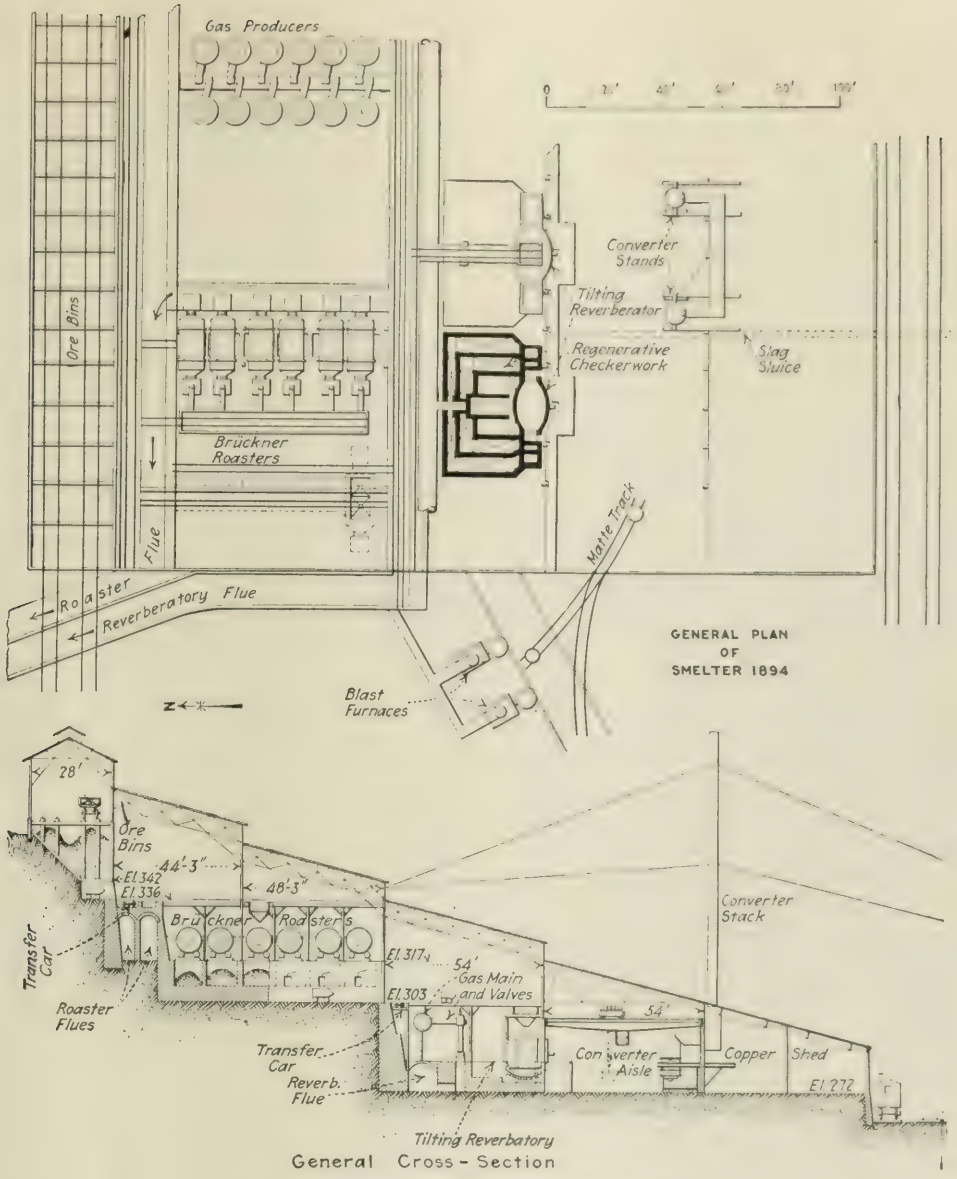


FIG. 2. GENERAL DRAWING OF SMELTER, 1894

bottom and tuyere section of the converter would need relining at intervals, but operation quickly demonstrated that corrosion went higher, and the lining had to be rebuilt after about five blows. For this reason one stall was out of commission constantly, and two more stands were immediately constructed in order to treat all the matte. An interesting forecast of the well-known propensity of Great Falls engineers toward large converters is that as early as the middle of 1892 Manager Klepetko reported that serious consideration was being given to the question whether larger converting shells would not be advisable. The steady growth of these embryonic ideas has been interestingly set forth recently, however, by Messrs. Wheeler and Krejci in the Montana volume of the Transactions of the American Institute of Mining Engineers, and therefore need not be repeated here.

Troubles in Gasifying Low-Grade Coal

Most of the grief in the smelter could be traced back to the gas-producers, however. With from six to eight reverberatories in operation, 350 tons of calcine could be easily handled, even if one of the furnaces was used as a matte well. This was the equivalent of 1000 tons of concentrating ore such as was being delivered to Great Falls (7 to 9 per cent copper!) or even less of the even richer "second class" ore then being treated at Butte. The Great Falls concentrator's product analyzed about as follows:

Copper, per cent	14 to 18
Sulphur, per cent	39
Silica, per cent	13
Iron, per cent	28

All of this had to be smelted in the reverberatories, so no coarse concentrates were made. Indeed, in order to supply the deficiency in calcine considerable first class ore (40 to 50 per cent copper) was fine-crushed in the smelter and sent to the Brückners! The reverberatories seemed to work fairly well when supplied with good gas and hot calcine (sulphur 8 per cent) producing a matte with 50 to 60 per cent copper and containing 19 to 20 oz. of silver per ton of blister. A satisfactory slag ran about 30 per cent silica, 60 per cent iron oxide, 8 per cent alumina, 0.6 per cent sulphur, and 0.7 per cent copper. Converter slag was handled as follows: After a reverberatory had been tilted and skimmed, a ladle of

hot converter slag was run into the matte-furnace, when the intimate contact between slag and "copper bottom" reduced the copper content to approximately that of a normal reverberatory slag. After a sufficient time had elapsed with the furnace under gas, it was again skimmed and was ready for another charge of calcine.

By the spring of 1893, however, it was demonstrated that the method of heating was defective. With the dusty, low-volatile, high-ash fuel available, it seemed impossible to make rich gas continually. In order to smelt at all, then, very hot calcines were essential, which the Brückners would only produce from a fine, dusty charge. To complicate matters, the producers were placed on a bench some 45 ft. vertically above the regenerator ports (see general cross-section in Fig. 2), and it was therefore necessary to run them under high pressure in order to force the hot gas down into the checkerwork. This in turn necessitated high blast-pressure on the producers, with an attending high content of CO_2. Troubles were multiplied in winter, when the occasional stretches of severe weather separating the ever-blowing chinooks would freeze up everything—even a water pipe with a fire under it would not remain open through a week of 30 below!

It was many months, even years, before all these troubles were straightened out. Taylor producers were immediately bought and tried with somewhat more success. Finally a tight, warm, stone building was erected at a low elevation across the end of the converter aisle, and producers, largely of local design, installed. As shown in Fig. 4, these were cylindrical shells, with a rotating grating ring. Ashes were periodically raked out from the pit into sluices. Steam jets injected combustion air into the charge, and gas was drawn off below a revolving top, from which projected four water-cooled stirring arms. The coal itself had to be crushed to hazelnut size and all fines carefully screened out—a mechanical feeder periodically dropped a quantity of this clean nut into the shaft. Slack from the coal crushing and screening plant was trammed to a boiler house and used to make stean for the blast; any excess was sluiced to the river. The gas itself was very sooty and dusty even when made of this clean nut, and the gas mains were consequently enlarged to ample capacity, and provided with the necessary drains and manholes so that the accumulation of fluffy carbonaceous material could be hosed out at relatively short intervals. As an illustration of the material these producers gasified and their product, the following 1910 analyses may be interesting:

Coal:—Total H_2O, 7.7 per cent; combined H_2O, 1.3 per cent; volatile matter, 27.0 per cent; fixed carbon, 48.8 per cent; ash, 22.8 per cent; B.t.u. 10,173.

Gas:—CO_2, 9.2 per cent, CO, 13.9 per cent; CH_4, 2.1 per cent; H_2, 15.4 per cent; N_2, 59.4 per cent.

Reflex Upon Finances

All these troubles could not help but be reflected in the cost sheets, and the Great Falls project was an easy butt of all kinds of criticism. Previous to its inception the newly formed B. & M. company was able to show a very good balance sheet and paid regular dividends—its Butte plants were smelting nearly 400 tons of ore per day, at a cost of about 9¾c. per lb. of copper in matte f.o.b. New York City. These profitable operations still continued, and the new plant at Great Falls was not at first able to equal their performance. About $900,000 had been expended for new construction, the smelter had been put into operation months later than promised, and was possibly absorbing all the money Butte operations were able to clear, since no dividends were being paid, even at an average price of 10¾c. for copper. "B. & M." was regarded as a highly speculative issue on the Boston mining exchange, and was steadily declining from about 35, when the new smelter started, to 16 in the middle of 1893. Of course, the general panicky conditions of this year were reflected in this price, but the quotation was only 26 when dividends were finally resumed in 1894. As a matter of fact, the B. & M. weathered the free-silver storm more fortunately than other Butte companies—it was the only concern which operated continuously throughout, producing about 3,000,000 lb. of copper monthly. (In the fall of 1893 not more than 500 men were at work in the Butte mines as compared to the payroll of 9000 six months before.) According to the annual report the company apparently was insolvent with a balance of $450,000 in liabilities on July 1, 1893, but this was changed in three months to an asset balance of $205,000. Compare quotations of 16 to 26 with the price of around 475 just before the stock was withdrawn from listing after the company's absorption by Amalgamated!

Changes and Additions in 1893

In the face of such conditions it required no little courage to recommend further expansion at the new

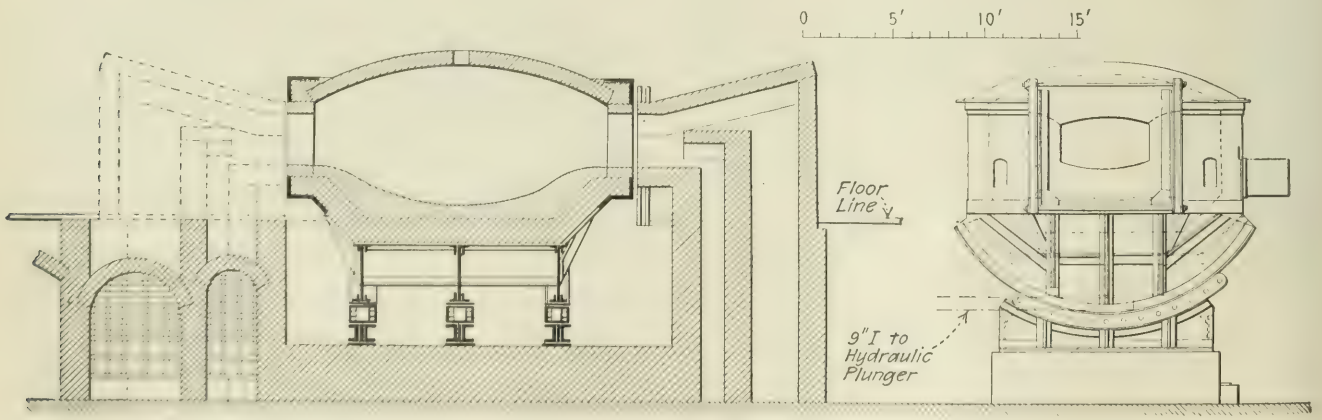


FIG. 3. OPEN-HEARTH FURNACE FOR COPPER MATTE, 1894

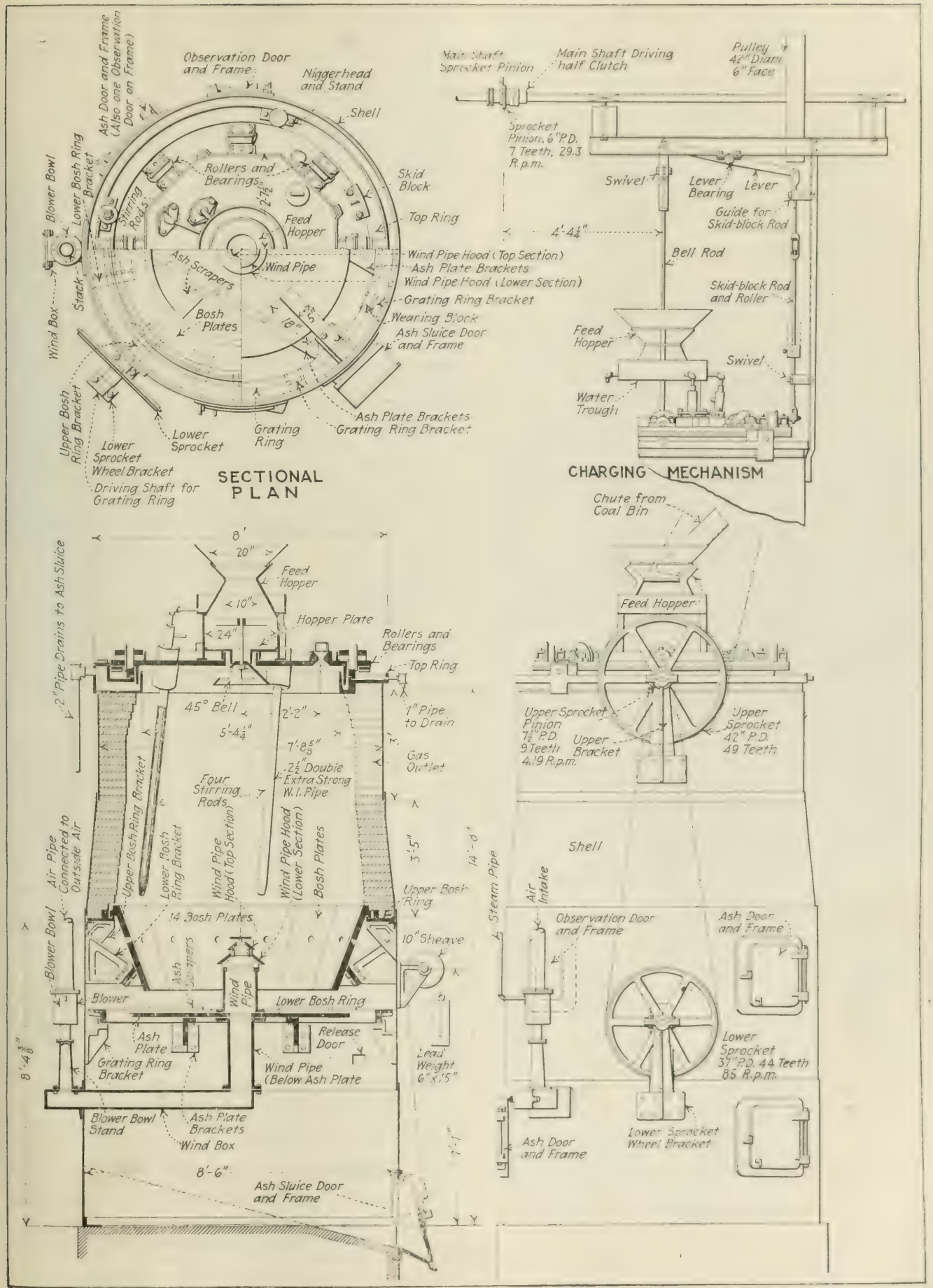


FIG. 4. AUTOMATIC GAS PRODUCER—GENERAL DRAWING

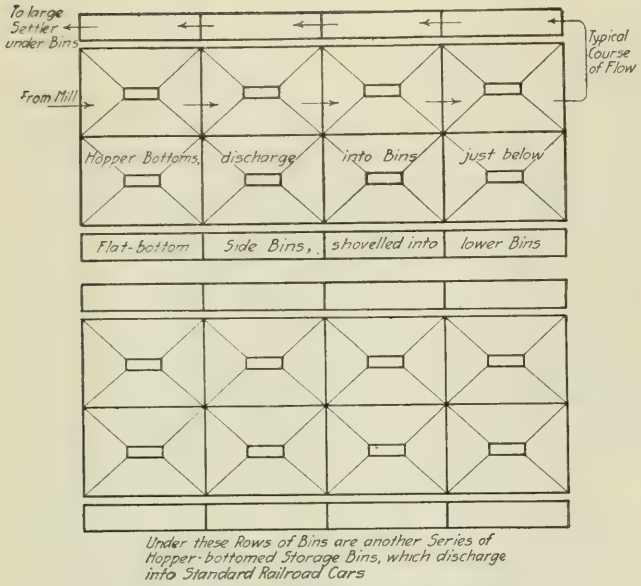

To large Settler under Bins
From Mill
Typical Course of Flow
Hopper Bottoms, discharge into Bins just below
Flat-bottom Side Bins, shovelled into lower Bins
Under these Rows of Bins are another Series of Hopper-bottomed Storage Bins, which discharge into Standard Railroad Cars

FIG. 5. ONE SECTION OF CONCENTRATE BINS

plant. Yet it appeared logical and was done. The undoubted economies of the new plant were abundant water power, cheap coal, and greatly reduced freight on copper over the 55 per cent matte previously shipped. The installation of a converter department had effected great economies, since large sales of Montana matte in Liverpool were made at 10c. per lb. of copper when Lake was commanding 15, the seller losing all silver under 30 oz. per ton. In order to save the silver lost in Eastern refining, the construction of a 1,000,000-lb. electrolytic refinery costing about $250,000 was rushed to completion after the smelter commenced operation. This consisted primarily of a low brick building 110 by 174 ft. in dimensions, containing 228 tanks. Low voltage electric current was generated by three 180-kw. multipolar Thompson-Houston machines driven by a pair of 39-in. wheels, and transmitted over 22½-in. copper wires. Later, when the capacity of the refinery was increased to 3,000,000 lb., power was generated by a pair of 66-in. wheels direct-connected to two 4500-kw. 220-volt direct current generators, and the power delivered some 2000 ft. over a pair of heavy copper barlines, supported on a low wooden trestle. A furnace-refinery building

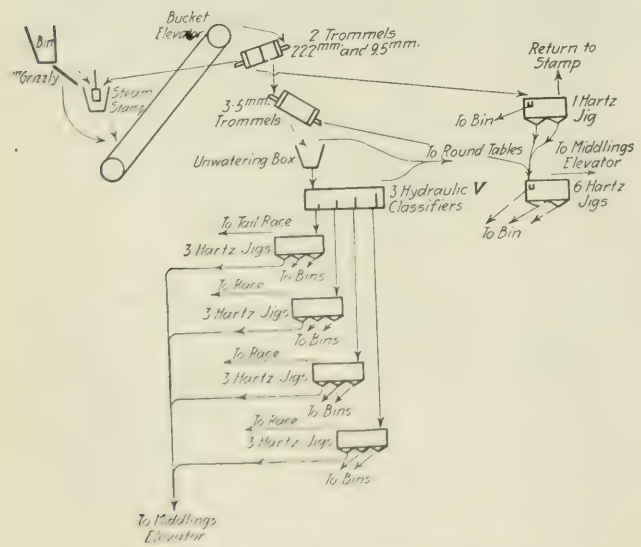


FIG. 6. STEAM STAMP SECTION, 1894

of iron with two small coal-fired reverberatories for refining cathodes, and a number of small auxiliaries completed the installation. This refinery operated quite successfully from the start, handling 50 per cent more metal than the original plans.

Extra converters and a Tod blowing engine were installed to handle Butte & Boston matte in the middle of 1893. The concentrator flow sheet was also altered somewhat in the fall of 1893, when the hutch concentrates from the finishing jigs and also from the tables and vanners were settled in small tanks in the lowest part of the mill, as sketched in Fig. 5. The overflow was elevated to a bin in the upper part of the mill holding coarser concentrates in the hope that the slimes might be filtered out. The cups from the third row or 2.5-mm. jigs were regarded as a middling, while the second hutch product was also sent to the elevator and recrushed; tailings from these jigs went directly to the river. High silica products were also recovered from corresponding portions of the last row of jigs, treating recrushed middlings, but this material was sent to concentrate bins because there was not fall enough to get them back into the elevator. A steam stamp section, with the flow sheet about as shown in Fig. 6, was also installed in the concentrator. This was seldom used, however, on account of the large amount of fine slime it produced, being regarded as a spare to operate only

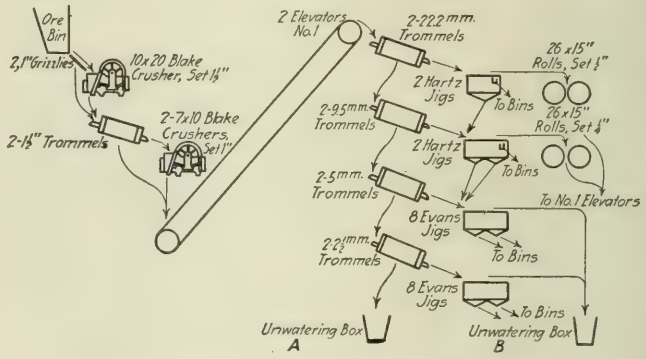


FIG. 7. COARSE CONCENTRATE DIVISION, 1897

during bad breakdowns in the roll sections. I believe it was in existance until 1897, however, when the third crusher and roll section used this part of the building, a new middlings section being installed in an annex. The steam stamp still exists and does yeoman duty, however, being converted into an air-operated hammer for the blacksmith shop.

A Blast-Furnace Found Essential

Smelter operations during 1893 quickly impressed Mr. Klepetko with the fact that blast-furnaces were urgently needed. Much ore was being delivered to the plant containing 40 to 50 per cent copper which could not be concentrated, and if sent to reverberatories, had to be finely crushed before it would satisfactorily roast and deliver a hot calcine. A mountain of converter slag had also accumulated with little promise of recovering the 2 to 5 per cent copper contained. In addition to all this, fine crushing second-class ore caused much sliming and high mill tailings. Coarse concentrates to be smelted in blast-furnaces would remedy these crushing troubles, and even if they were not of very high grade it would be best for the entire system to remove them early in the game. Consequently two small blast-furnaces were erected in a light building placed near where the present

blast-furnaces are, but in order to economize on excavation, set at an angle with the main smelter building as shown in Fig. 2. At first, matte from a small forehearth was cast from time to time in molds, broken and remelted in reverbertory furnaces. Soon larger settlers were built, and a matte ladle car hauled the liquid to a point under the converter craneway. These blast-furnaces were running early in 1894 and gave great satisfaction, bringing operations to a point where abandonment of concentrating and smelting in the Butte properties was justified. Mr. A. T. Elliott was engaged by Mr. Klepetko to take charge of the blast-furnace operations, coming with a crew of experienced furnace men from Argentine, Kansas—then a very important lead smelting center! Mr. Elliott was thereafter closely and honorably connected with the metallurgical operations for over twenty years, acting as general smelter foreman for a large part of that time.

Mr. W. J. Evans also arrived from Michigan at about the same time, to become mechanical superintendent. He, however, gave almost his whole attention to the mill, which now of course had to be remodelled to produce the necessary coarse concentrates for the blast-furnaces.

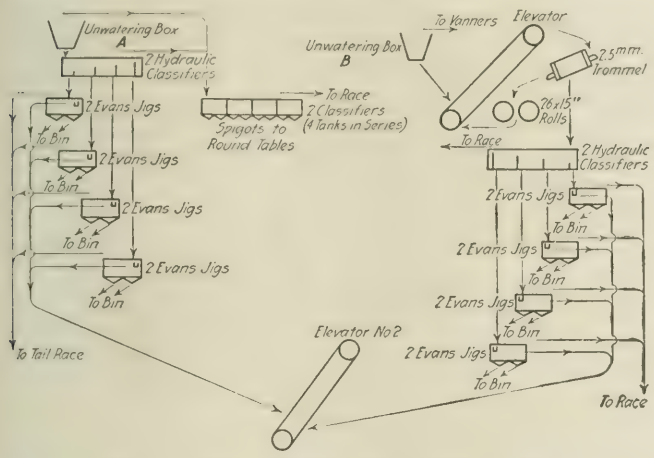


FIG. 8. FINE CONCENTRATE DIVISION, 1897

More attention was also given to the recovery of values from low grade middlings: the final result of a gradual change was the flow sheets given in Figs. 7 to 9 operating in the original wooden building. Briefly, the first coarse jigs were replaced by 2-compartment Hartz jigs and the crushing size increased from ½ to ¾ in. (later to 1¼ in. when two one-compartment bulljigs were installed for this coarsest material). Screen sizing was installed in place of hydraulic classification wherever possible in order to avoid the addition of such large quantities of water. Middlings were roll-crushed as before, but a "middlings-section" was later added owing to the fact that the tails from the middlings jigs were too rich to throw away. No tailings were allowed to go to waste coarser than 3 mm., but even then they would carry a considerable amount of metal—especially the jig tailings would run up to 1.5 per cent copper, while vanner tailings would run as high as 1 per cent. Jig tailings were therefore recrushed in Huntingtons, classified, and concentrated on fine jigs, round tables and Frue vanners (Fig. 9). During this time Mr. Evans also developed the so-called Evans jig, which was almost universally used on Butte ores for over ten years. This improvement was made by changing the rocker arm motion of the Collom jig to a rectilinear motion from an eccentric operating between two horizontal bars. This motion was put on the old Collom hutches, the plunger area being modified correspondingly.

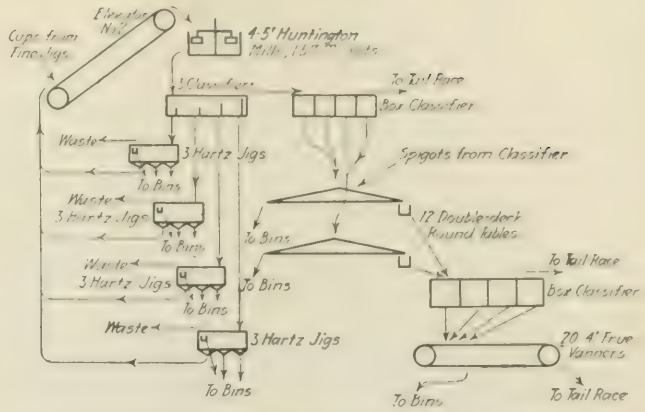


FIG. 9. MIDDLINGS DIVISION FOR THREE CONCENTRATOR SECTIONS, GREAT FALLS MILL, 1897

From my note book Table I on concentrator operation during 1894 may be interesting and worth recording. The ordinary operating labor (11 and 13-hr. shifts) per day was one foreman, two assistant foremen, two oilers, two rollmen, 16 jigmen, 2 tablemen, 2 vannermen, 2 cleaners, 2 carpenters, 2 firemen, 1 machinist, 2 machinist helpers, 1 pipe fitter, 2 tankmen, 1 slimer, 1 roustabout, 8 to 10 extras on a 10-hr. day shift for helpers, special changes, new construction and repairs.

Conclusion

By the beginning of 1894, therefore, the new plant was operating very nicely. The company's report showed that the Great Falls work had cost a total of about $2,100,000 and that the cost of copper had been reduced to about 8c. per lb. (a reduction of about 1c. over the previous year) with an average selling price of 9.2c. During that year some 4.7 per cent copper ore had been mined and sent to Great Falls—the lowest grade ore in Butte copper history! The average content was near 7.5 per cent—about 500 tons daily. Dividends were resumed a few months later, and the company entered on its phenomenal career as a money maker. During 1894 two more blast-furnaces were added, one of which was resmelting Butte & Boston matte. These first furnaces were replaced three years later by the present blast-furnace installation—which, by the way, has probably now smelted its last charge.

TABLE I. CONCENTRATOR DATA, 1894.

Capacity of concentrator, 2 sections at 250 tons per section.
Water used, 240,000 gal. per hr. for 500 tons.

Power:			
Rope transmission to drive machinery			500 hp.
Pumps			175 hp.
Electric lights			15 hp.
Total			690 hp.
Speed of machinery:			
Rolls	50 r.p.m.	Collam jigs;	
Crushers	300 r.p.m.	1st, 2nd, and 3rd row	125 r.p.m.
36 in. trommels	20 r.p.m.	4th row	130 r.p.m.
Hartz jigs	140 r.p.m.	Slime tables, 1 revolution in	1.5 min.
Slide-arm jigs	140 r.p.m.	Elevators, 300 to 400 ft.	per min.
Cost in 1894:			
Tons concentrated			170,000
Labor, (average crew 52½ men per day) or $3.10 per shift			$59,349
Supplies, (castings, shells, screens, belts, lumber, and hose)			34,336
Concentrate, handling and transfer			6,863
Boiler house expense (heat and reserve power)			5,120
Shops (machining and smithing)			1,911
Power house and transmission (maintenance of wheels, pumps, and generators) or $11 per hp. yr.			7,558
Miscellaneous operating account			4,297
Unloading ore, overhead, and other distributable expense			11,920
Total cost for 1894			$141,360
Less construction accounts			9,464
Net concentrating expense or about 72c. per ton			$121,896

Lowest monthly cost, 53c. in June.
Highest monthly cost, 94c. in January.

Legal Notes

By Wellington Gustin

Inspection of Potash Crystals Before Payment and Ex-Dock New York Construed

IN AN action to recover for damages claimed to have been sustained by reason of defendant's breach of a contract to deliver certain crystal chlorate of potash, the defendant set up a counterclaim for damage for the breach of a contract to deliver certain soda ash. Both the complaint and counterclaim were dismissed and both plaintiff and defendant appealed. (B. Brown & Bros. vs. Raritan Chemical Works, 177 N. Y. S., 309.)

The complaint claims an agreement was made between the parties by which the defendant was to sell and deliver to the plaintiff 300 kegs of crystal chlorate of potash at 60c. per lb., immediate delivery, net cash. This agreement defendant failed to keep, according to the complaint. This agreement was entered into on Nov. 29. The defendant replied by introducing the sales memorandum of brokers who handled the transaction. This memorandum sets out the terms as "net cash against the delivery order. Shipment spot." Replying further, the defendant on Dec. 1 presented plaintiff delivery order for the potash crystals and demanded payment therefor. Acceptance by plaintiff was refused without an inspection of the potash crystals, then in a warehouse at Jersey City. The defendant, at plaintiff's request, issued a permit allowing the inspection. This permit reached plaintiff's office at 3:30 p.m. In an accompanying letter plaintiff was told that the goods would be held until 5 p.m., at which time if payment was not received the contract would be regarded as broken by plaintiff's act.

Question Before the Court

So it appears from the facts that the potash crystals were neither inspected by the plaintiff nor delivered by defendant, and the question therefore presented was whether plaintiff had the right, under its contract, to an inspection of the goods before being required to pay for the same. If it had such a right, then the question of whether the opportunity offered by defendant was a reasonable one was a question of fact for the jury, said the court. But the terms of the sale were net cash against delivery order, and those terms conclusively negative any idea that an inspection was to be allowed them. On the contrary, the court said, by agreeing to pay cash on production of the delivery order, plaintiff effectually waived any right to examine the goods. The act of defendant in offering plaintiff a privilege of inspection was a purely voluntary one, without consideration, and no new contract was created thereby, nor was any so claimed. Hence the court affirmed a dismissal of plaintiff's claim against defendant for failure to deliver the potash crystals.

Taking up defendant's appeal on its counterclaim: This claim arises out of a written contract between the parties for the sale of 24 carloads of soda ash at 2⅛c. per lb. ex-dock New York, net cash against documents, to be bought by plaintiff for defendant. The provision as to deliveries was as follows:

"Deliveries: Shipping instructions to be given by the buyer not later than 20th of the month next preceding the month of shipment. Two cars monthly over year 1917. Shipments from works from January to December inclusive."

None of the soda ash was ever delivered under the contract, as no shipping instructions were ever given by the buyer (the defendant) as required by the contract. The general provision was that shipping instructions were to be given by the buyer not later than the 20th of the month next preceding the month of shipment. The special provision was for two cars to be shipped monthly from the works, from January to December; and these shipments were to be made to whatever points the buyer fixed. The court held that under these conditions the seller was not bound to tender the soda ash to defendant at any particular point, but that the seller had the right to await the shipping instructions, and if these were not received, then to treat the failure to give them by defendant as a breach of the contract.

Said the court: This was not a case where the goods were to be delivered "f.o.b." at the City of New York, or at any particular place. They were to be shipped from plaintiff's works to such place as named by defendant. The clause "ex-dock New York" merely fixed the price as being at that point, in order to determine the responsibility for freight charges. Holding that defendant thus breached the contract, for which it was itself asking damages for subsequent breach of plaintiff, the court upheld the lower court's dismissal of defendant's counterclaim.

Damage During Transit Follows Title to Consignee

That the buyer cannot reject a shipment of goods on its arrival because of damage during transit, the goods having been sold f.o.b. point of shipment, has been held by the Supreme Court of New York in an action by the seller for the purchase price of the goods. It was held that title passed to purchaser by the bill of lading and deterioration in transit was a loss following the title which became vested in the consignee. (Derma-Viva Co., Inc., vs. Kells Co., 176 N. Y. S., 776.)

From the facts it appears that several months before the shipment of goods sued for the plaintiff had written defendant that its terms of shipment were to be "f.o.b. Chicago," and that claims for damages must be made to carrier. This particular shipment was so made on Dec. 19, in boxes marked "Keep From Freezing, Ship in Refrigerator Car." The bill of lading, with invoice, was received by defendant and retained about two weeks without objection. The goods arrived Jan. 5, but were frozen, and these shipping documents were returned by mail to the plaintiff. There had been delay in filling the order. It had been originally mailed to plaintiff's New York agent on Nov. 21, but the court found such delay was not a proximate cause of the damage to the shipment. Title passed by the bill of lading, the goods being sold f.o.b. Chicago, said the court. Defendant's secretary and manager held the shipping documents to await the arrival of the goods, and admits he would have accepted them, had the articles not been frozen. Such loss resulting in transit follows the title to the consignee, so that such a consignee cannot rescind the shipment, where the documents had thus been retained without objection. Hence a judgment for the defendant in the lower court was reversed with directions to enter judgment for the plaintiff.

Production of Copper From Secondary Material

Methods of Sampling Miscellaneous Products Entering the Refinery, Their Treatment in Regular or Special Furnaces, With a Discussion of the Commercial Possibility of Recovering Some of the Impurities as Metallic By-Products

BY LAWRENCE ADDICKS*

IN ADDITION to the circulating products incident to normal copper refining, the plant is often called upon to treat a wide range of metallurgical by-products from outside sources as well as miscellaneous copper-bearing scrap material. Now that matte smelting plants exist on the Atlantic seaboard, there is little reason to consider anything in the nature of ore or matte, but the following list of materials is fairly representative of what offers:

A. Junk.
  a. Lamps, clocks, etc.
  b. Borings and chips.
  c. Wire.
  d. Sweepings.
  e. Coins and alloys.
B. Mill Products.
  a. Wire.
  b. Scale.
  c. Cement.
  d. Stampings.
C. Metallurgical Products.
  a. Cement.
  b. Amalgamation plates.
  c. Secondary pig.
  d. Nickeliferous pig, black copper, etc.
  e. Furnace bottoms.
D. Refinery By-Products.
  a. Silver refinery slags.
  b. Liberator tank cathode products.
  c. Flue products.

There is a suprisingly large tonnage of such miscellaneous material available, and of course a good deal of it is absorbed by relatively small sweep smelters, who generally feed it indiscriminately into a small blast-furnace, making a foul pig which is sometimes given an additional reverberatory treatment and sent back to the market as casting copper and sometimes is sold to an electrolytic refinery. Such work is a very disturbing element in a copper refinery unless the tonnage accepted is great enough to warrant the establishment of regular facilities for handling it. The general questions involved are, first, sampling; second, disposition; third, proper furnace construction; fourth, possible saving of impurities as by-products.

SAMPLING

The sampling of junk is an art in itself. The ordinary junkman, who travels around in a wagon buying what offers, learns in time to make very close estimates of the metal values of such material, but the refinery cannot afford to let its sampling department adopt such methods on general principles.

The first rule in sampling junk is to classify the material. The insulated wire is put in one lot, the bare wire in another, the alarm clocks and automobile lamps in a third, the sweepings in a fourth, the borings in a fifth, and so on. Clocks and lamps have been considered as a class because they are one of the staples of the junk business. Occasionally large lots of Oriental bronze coins come into the market. A noteworthy instance of this was when Japan took over the control of Korea and exported about 6,000,000 lb. of Korean "cash."

The second step in the sampling is to endeavor to get a representative part of each classified pile. Coins or sweepings can be quartered down like so much crushed ore. Wire can be clipped here and there. Borings can be reasonably sampled by selection. The remainder can be handled only by intelligently taking grab samples, and this requires experience and skill.

The third rule is always to take duplicate samples and to hold the lot intact until assays are out, giving an opportunity for resampling if the assays show sufficient lack of agreement to indicate poor sampling.

The next step varies according to the nature of the material. With dirty metallic material, such as wire or borings or sweepings, a burning loss should be obtained by soaking with gasoline where necessary and igniting, noting the weight before and after. With miscellaneous manufactured material, where different metals are used, as in a clock, or containing solder, as in a teapot, the only way is to make a crucible melt of a rather large sample, accounting for the bar, slag and crucible absorption. Often a material has to be sorted into metallics and dust, as in the case of some sweepings. In general, therefore, it will be seen that sampling junk is a tedious and expensive business. Most junk carries some gold and silver values arising from jewelers' sweeps, etc.

Mill products, such as scrap wire, punchings, etc., shipped directly from the wire mill or other factory to the refinery, are much easier to sample. Here the material is already classified and relatively clean. Care must be taken to see that no bimetallic wire has inadvertently found its way into straight copper wire bundles. It would be thought that bright copper wire from primary sources would need no sampling, but there is always more or less grease attached to it, and the true copper content is nearly always several tenths of 1 per cent below standard. Tinned wire will run 1 per cent or more low and bimetallic wire may run 40 per cent low. The refinery in turn makes a small profit in that the wire bars sent out and accepted by the trade as 100 per cent copper in reality run seven or eight hundredths of 1 per cent below this.

Among the metallurgical products two require special mention, amalgamation plates and furnace bottoms. Amalgamation plates are copper sheets which have been amalgamated on the surface and used to collect gold and silver values from finely crushed native ores. The amalgam has been thoroughly scraped off before the plate is scrapped on account of wear or other defect, but nevertheless sufficient gold is retained to make such material relatively valuable. In this case it is necessary to shear the plates up into equal squares of a few inches on a side; then take systematically say every tenth

*All book rights reserved by the author.

square, following such a system of reduction until the sample is small enough to permit of crucible reduction.

Furnace bottoms are very troublesome to handle. They are generally received in large masses which cannot be drilled or broken. They are usually placed in a furnace for treatment by an overhead crane at a time when the roof is out for rebuilding. They cannot be blasted or cut apart and the only way to reduce the size of a large piece is to build a small flue across the top and channel with a hot oil flame.

The only way to sample them is therefore to chip around the edges. Unfortunately they are often quite rich, as silver and gold tend to concentrate in furnace bottoms. The refiner has to make an allowance in the treatment terms to cover the sampling danger when handling such material.

Disposition

There are several places in the process where secondary material can be introduced. The first is the slag cupola, the function of which is primarily to treat the anode and wire bar furnace slags and which always has capacity to spare. Nearly anything in the scrap line can be introduced here, but it does little more than extract the metals contained and put them into compact shape. Their chemical treatment requires oxidation, which cannot be obtained in the strongly reducing atmosphere of a black copper cupola. Plants treating junk exclusively usually make a blast-furnace melting their first operation, using some briquetting or sintering apparatus to take care of the very fine material before charging.

The usual point of entry is the anode furnace. This insures saving the silver and gold contents and getting the copper in electrolytic form, neither of which is possible to the small junk smelter.

There are certain objections to introducing such material into an ordinary anode charge. In the first place, it is usually in such shape physically that it will take up a disproportionate amount of space in the cold charge. This can be met to a certain extent by charging it at the recharge period when there is plenty of room in the furnace. Then impure material delays the blowing and skimming, and it is important that the furnaces operate on schedule time. Finally, quicker work and better elimination of impurities as well as a better slag concentration for possible by-product recovery are made by treating impure material without dilution. This leads to setting an anode furnace apart for special work at least part of the time. This has another great advantage in that it allows direct costs of the work to be kept.

Then we have the refining or wire bar furnaces. Nothing should be added to a cathode charge regarding which there can be any question as to quality. It is customary to include as admissible, however, scrap wire baled in "cabbages" which originates at standard wire mills. In ingot charges, where conductivity requirements are not quite so strict, liberator cathodes from the first row of tanks in the purifying system may be added with discretion.

Finally, we have the possibility of using a special refining furnace for the production of casting copper. This is attractive in that it enables material which is practically free of silver and gold and high in copper—scrap brass for example—to be worked directly into a marketable product. The disadvantage is that casting copper has no stable market. It always sells at a discount and at times is nearly unsalable.

Until recent years the standard refining reverberatory has been constructed of silica throughout. In some special cases a silica brick bottom has been employed, but the usual construction was silica sand bottom with silica brick sides and roof. Such a furnace is built with a cooling vault, cast-iron bottom plates mounted on brick piers, and a false bottom of fire-clay brick. The vault should be arranged with consideration of a possible run-out of copper through the bottom. It is desirable to lead the molten copper away from the vault before it sets, so that it can be recovered without tearing down the entire furnace, but it is equally essential to see that it does not run into the casting wheel pit or ash pit, where it will probably come into contact with water and cause serious explosions. When a break-out occurs the only thing to do is to charge cold copper into the furnace to set the charge, which is not difficult on account of the high heat conductivity of copper; but if explosions are occurring it is not safe to approach the furnace.

A sand bottom must be carefully impregnated with copper, and an excellent way in which to accomplish this is to mix the sand with about 30 per cent of its weight of copper oxide scale. This is thoroughly turned over and shoveled into the previously dried furnace, where it is calcined at a moderate heat for about 12 hr. The fire is then dropped and the floor carefully leveled and tamped down. The furnace is then fired at maximum temperature—perhaps 2700 deg. F.—for 24 hr. and the furnace after cooling is ready for a small seasoning charge of scrap wire or similar light material. This charge, amounting to perhaps 10 per cent of the rated capacity of the furnace, is melted and ladled out, and after another brief cooling, one twice as large is put in. After this has been ladled the furnace should be ready for service, although it should not be crowded for a few charges, starting at 50 per cent capacity and working up.

This furnace, even when treating high-grade material, will be more or less fluxed by the cuprous oxide of the charge, the silica of the slag being taken chiefly from the bottom of the walls near the metal line. The old treatment for this was "fettling," or plastering corroded spots with fire clay, after each charge was cast.

Prolonged heating in the treatment of foul charges is apt to smelt some of the bottom of the furnace, and when pieces of the bottom begin to "float up" there is always danger of a run-out. Also if elements such as lead are present in appreciable quantity the litharge formed will hungrily attack the silica of the furnace. In fact, a good silica furnace can be easily ruined by a single charge of leady copper. More than 2 per cent lead is always cause for great anxiety.

After a while magnesite and chrome brick were tried as a lining material for the walls of the furnace near the metal line. Approved practice was the use of magnesite for the zone protected and the introduction of one course of chrome brick between the magnesite and silica of which the wall was continued up, the chrome acting as neutral material between the basic and acid bricks.

Magnesite brick spalls badly when exposed to sudden temperature changes. Chrome brick is not subject to this objection, but fails because of softening when exposed to heavy thrust when highly heated.

The next step was to use a chromite verb with great gain in heat control of the furnace, since small dimensional changes from the cutting away of the verb cause great differences in the characteristics of a furnace.

Then the complete basic furnace was developed with magnetic bottom and chrome walls and roof. (Addicks

and Brower, U. S. patents 1,083,719 and 1,148,814.) The sand bottom furnace is constructed with the bottom inside the walls; the basic brick furnace is built with the walls standing on the bottom in order to carry the thrust of the inverted arch directly through to skewbacks reacting against the brickstaves.

With complete basic furnaces it has been found possible to treat material high in lead, and which may require heavy firing for several days without damage to the furnace, so that clean anodes may be made from foul sources of supply.

By-Products

Tables I and II give an idea of the character of some of the low-grade material offering in quantity.

An examination of these analyses shows that aside from copper, the main value, there are often present considerable quantities of gold, silver, nickel, cobalt, lead, zinc and tin. Where gold and silver are present in sufficient quantity to pay the cost of electrolytic treatment, the furnace product should obviously be anodes. Where the silver and gold values are low, casting copper may be considered as a product, but the time required for refining, market deduction for casting copper, values and costs must be carefully balanced in making a decision.

TABLE I. ANALYSES OF CEMENT COPPER

Source	Oz. Gold	Oz. Silver	Per Cent Copper	Per Cent Iron	Per Cent Insoluble
United States	Trace	3.6	80.93	1.40	8.80
United States	0.01	5.3	71.53	1.30	17.06
United States	0.28	11.0	60.58	10.00	1.68
Australia	0.45	0.32	78.28	3.97	3.50
England	0.05	19.8	76.62	5.20	1.63
Belgium	Trace	0.40	69.51	8.50	2.24
Unknown	Trace	0.20	32.18	26.02	5.99

When any of the other impurities are present in quantity, we may consider the possibility of their recovery in slags, in flue products or through the electrolyte purifying plant. In the formation of slags the elements oxidize in the order of their basicity. Their relative affinities for oxygen may be judged by the heats of formation of their common oxides, as follows:[1]

Au_2O_3	−11,500	CoO	+ 64,100
Ag_2O	+ 7,000	FeO	+ 65,700
CuO	+37,700	ZnO	+ 84,800
PbO	+50,800	SnO_2	+141,300
NiO	+61,500		

From these figures we should expect to get first the tin, then the zinc, then the group of cobalt-nickel-iron, and finally the lead, leaving copper-silver-gold in the metal bath. In practice, however, we have to consider the fusibility of these oxides and the readiness with which they form silicates. The situation is quite different from ore smelting in that we are dealing with metallic alloys and always in the presence of a preponderating amount of copper.

The possibility of recovering tin from secondary copper such as given in Table II is indicated in Table III.

[1]Values from Richards' "Metallurgical Calculations."

TABLE III. TIN RECOVERY

Input

Material	Weight	Per Cent Sn	Contents
Fine bullion	53,567	3.19	1709
Fine bullion	50,874	3.30	1679
Fine bullion	61,125	2.07	1265
Fine bullion	51,918	2.23	1158
Fine bullion	54,027	2.10	1135
Fine bullion	54,440	3.02	1644
Furnace returns	6,000	0.27	16
Anode scrap	30,000	0.15	450
Total	361,951	....	9056

Output

Material	Weight	Per Cent Sn	Contents	Per Cent Sn Input
Anodes	178,801	0.61	1701	18.8
First slag	7,686	0.38	29	0.3
Second slag	17,796	0.78	139	1.5
Third slag	39,657	14.43	5722	63.2
Metallics	4,019	0.61	25	0.3
Unaccounted for	13,992	.....	1440	15.9
Total	361,951		9056	100.0

There has been collected in the third slag 63 per cent of the tin. If we take the copper in this slag at 25 per cent, we shall have upon reduction to metal a foul alloy running 30 to 35 per cent in tin, a reasonable first step toward the recovery of this metal.

Zinc is not a sufficiently valuable metal to warrant the cost of its extraction from impure or low-grade products. Inasmuch as a copper furnace is operated at a temperature above the boiling point of zinc, it would be possible to make a certain recovery as fume, but as this would be contaminated with other volatile impurities such as arsenic and antimony present in foul bullion, such an operation would have no commercial standing.

While iron, cobalt and nickel stand close together in the heat of oxidation scale they show a marked difference in slagability. In fact the ease of removal in a reverberatory furnace might be arbitrarily indicated as 1.00 for iron, 0.10 for cobalt, and 0.01 for nickel.

TABLE IV. RELATIVE SLAGABILITY OF IRON, COBALT AND NICKEL

	Original Bullion	After First Refining	After Second Refining
Copper, per cent	94.55	99.42	99.66
Iron, per cent	3.04	0.011	0.008
Cobalt, per cent	0.894	0.023	0.024
Nickel, per cent	0.408	0.110	0.109
Iron	1.000	0.004	0.003
Cobalt	1.000	0.026	0.021
Nickel	1.000	0.270	0.266

This is illustrated in a general way by some published[2] data of experiments conducted in a 2-ton furnace at the Wysk smelter in Russia, some of the results of which are shown in Table IV.

Iron is of course far too cheap a metal to be considered as a by-product except in very large-scale ore smelting operations. It can be easily removed from copper bullion by slagging, but not without the corresponding renewal of a small amount of the copper as cuprous oxide, which forms the scorifying agent.

Cobalt can be removed with reasonable facility in

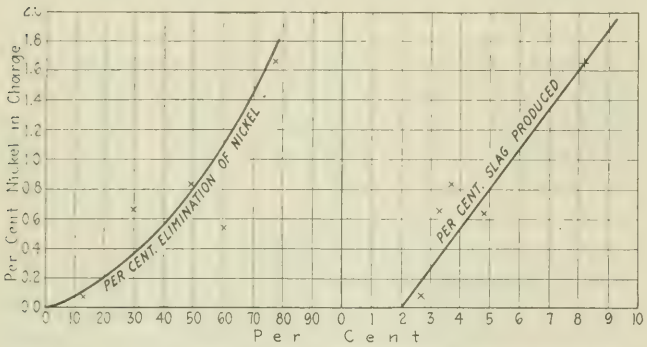
[2]Hofman's Metallurgy of Copper, p. 391.

TABLE II. ANALYSES OF FOUL COPPER BULLION

Material	Source	Oz. Au	Oz. Ag	Per Cent Cu	Per Cent Ni	Per Cent Co	Per Cent As	Per Cent Sb	Per Cent Bi	Per Cent S	Per Cent Fe	Per Cent Pb	Per Cent Se	Per Cent Te	Per Cent Zn	Per Cent Sn	Per Cent Insol
Black Cu	Australia	0.24	2.0	.....	0.89	.....	0.22	0.20	0.06	0.86	0.01	.....	0.01	0.01	.....		
Black Cu	Africa	0.003	0.15	90.25	Trace	5.59	0.10	.....	.....	1.32	2.05	None	.....	.....	.....	.....	.....
Secondary Cu	United States	0.12	7.8	84.77	0.24	.....	0.04	0.23	None	0.55	3.19	3.09	Trace	Trace	3.17	2.07	0.96
Blister	United States	0.40	9.0	97.80	1.28	.....	0.002	0.003	Trace	0.04	0.07	0.005	0.08	0.006	0.03		0.14
Black coins	Korea	0.08	6.2	67.48	....	....	2.15	0.06	0.01	.....	1.87	24.10	Trace	....	4.27		0.08
Yellow coins	Korea	0.12	5.9	56.73	....	....	0.47	1.15	0.03	.....	1.35	9.31	....	....	30.81	1.2	0.18
Secondary Cu	United States	0.09	6.2	85.01	0.35	..	0.03			0.94	0.92	5.49			1.60	4.21	0.11
Secondary Cu	Europe	....	....	75.66	0.40	..		0.15			0.89	2.37			19.12	1.38	

like manner and collected in a slag running perhaps 20 per cent cobalt and 20 per cent copper, but really cobalt-free copper could not be produced without slagging a large amount of the copper in repeated scorifications.

Nickel is much more difficult to deal with, and is generally recovered by separation as a soluble sulphate in electrolytic refining. Considerable data are available on its behavior in the anode furnace. An example of



BEHAVIOR OF NICKEL IN THE COPPER REVERBERATORY

some large-scale experiments is given in diagrammatic form in the illustration, and these curves are analyzed in Table V.

TABLE V. BEHAVIOR OF NICKEL IN THE COPPER REVERBERATORY

	Per Cent				
Nickel in charge	0.0	0.5	1.0	1.5	2.0
Elimination	...	37	57	72	81
Nickel in product	0.0	0.32	0.44	0.45	0.40
Slag	2.0	3.8	5.7	7.6	9.4
Nickel in slag	0.0	4.9	10.0	13.8	17.1

It is evident that more prolonged working of the charges richer in nickel would result in a somewhat lower nickel in the product and a larger quantity of slag lower in grade as to nickel, but it is quite out of the question to reduce the nickel tenor of a large charge to the degree shown by the small Wysk furnace. The slag, if treated in a matting furnace for the recovery of copper, will lose a large part of its nickel to the new slag; if treated in a black copper cupola, the nickel will be nearly all reduced with the copper.

Lead is readily separated from molten copper as litharge. As this active base rapidly attacks siliceous material, quite small quantities of lead demand a basic furnace for safe handling. Lead is practically insoluble in pure copper, but in the presence of sulphur or various impurities it is absorbed, and considerable quantities are found in secondary copper and occasionally in blister where leady copper ores have been treated. Certain bearing metals are made of a mixture chiefly of copper and lead, and the black Korean coins listed in Table II showed high percentages of lead. When melting down large quantities of these in a furnace with a basic brick bottom placed over a cooling vault, it was noticed that practically pure lead sweated through the bricks underneath, indicating liquation and a possible means of separating lead from copper. A copper-lead slag which can be profitably smelted for both metals is readily made from such material.

In general, electrolytic refineries recover a large part of any nickel or lead entering their plants in sufficient quantities, and steps would be taken to recover cobalt and tin did the crude copper carry sufficient of these metals, but the disturbance of the process due to interference of these impurities in the main business of copper refining overshadows the possibility of placing impurities on a revenue-producing basis except where large regular quantities have to be dealt with. Where casting copper is made, a portion of these alloy impurities remains and actually improves the copper for certain purposes by increasing its fluidity or altering its color.

The Absorption of Gases in Spray Systems and Towers

By Edwin M. Baker

IN PROBLEMS involving the absorption of a gas by a liquid it is generally desired to absorb or dissolve some one constituent of a gas mixture by the liquid. It will be found convenient to call the gas to be absorbed or dissolved simply the "gas," and the gas mixture containing this gas and other diluting gases the "gas mixture." The absorption of gases in liquids may be divided into three subdivisions of a general class, in which most absorption problems will fall. First, the case where the nature of the gas and liquid is such that a chemical reaction takes place so that the gas will not exert any appreciable vapor pressure after absorption. The absorption of ammonia gas in an excess of sulphuric acid would be an example. Second, the case where the nature of the gas and liquid is such that a chemical reaction takes place, but the compound formed is sufficiently unstable so that the dissolved gas exerts an appreciable vapor pressure. The absorption of ammonia gas in water would be an example. Third, the case where no chemical reaction takes place between the gas and liquid, and where the liquid exerts a vapor pressure directly dependent on the amount of absorbed gas. An example of this is the absorption of the so-called gasoline content of natural gas in heavy mineral oil. Different combinations of gases and liquids may be found which will give a series of conditions gradually shading from the first to the third subdivision. In this general class, then, are included the cases where simple or no chemical reactions take place. It does not include complicated reactions such as take place on the introduction of oxides of nitrogen with excess oxygen in the form of air into absorption towers; where water is used as the absorbing agent to form nitric acid; and where the oxidizing of the lower oxides of nitrogen must be taken into account.

In the general class considered, if the gas mixture and liquid were put in a closed container and left a sufficiently long time, the liquid would absorb the gas until the vapor pressure of the dissolved gas just equalled the partial pressure of the gas in the gas mixture. In case 1 this would be 100 per cent absorption, because the dissolved gas would exert a zero vapor pressure. Hence the partial pressure of the gas in the gas mixture would be zero, and the per cent gas would be 0 per cent. Since the volume of gas divided by the volume of gas mixture equals the partial pressure of the gas divided by the total pressure, then the per cent of gas in the gas mixture equals

$$\frac{\text{partial pressure of the gas}}{\text{absolute pressure of the gas mixture}}$$

In cases 2 and 3 the per cent absorption would be something less than 100 per cent, depending on the nature of the gas and liquid. Suppose we express the nature of the gas and liquid by calling the theoretical percentage absorption, when the liquid and gas are in intimate contact for a sufficient time, at some imaginary standard con-

ition, K. The theoretical absorption under some other ondition may be called K'. Then K' may be increased (if t is not already 100 per cent) by increasing the total ressure on the gas mixture, since this increases the par- ial pressure of the gas, and hence the vapor pressure of he dissolved gas necessary to re-establish equilibrium. And the latter means increased concentration of the issolved gas. Lowering the temperature of the system ill in general increase K', since lowering of the tem- erature gives a lowering of the vapor pressure of the issolved gas. Increasing the concentration of the gas n the gas mixture will in general increase the amount of as absorbed, since the partial pressure of the gas in- reases in proportion to the per cent composition. Lower- ng the concentration of the dissolved gas in the liquid ill decrease the vapor pressure of the gas, and so ncrease the amount of gas that will dissolve. The value f K' can be found in the literature for most gases and quids. Or, at least, information may be found from hich a working value of K' may be obtained. Fig. 1 ives various values of K' at 60 deg. F. and 30 in. arometer, for certain concentrations of ammonia in the as mixture and liquid. A family of such curves would e required to express K' for all conditions.

Rate of Absorption

This, however, does not tell us anything about the ate of absorption under any given conditions. In eneral, it may be said that the force which causes a as to be absorbed by a liquid is the difference between he partial pressure of the gas in the gas mixture and he vapor pressure exerted by the gas dissolved in the quid. With no difference the rate would be zero, nd in order to get a rapid absorption of a gas in a quid it must be understood that theoretically perfect bsorption cannot be expected, that is, some difference n partial and vapor pressure must be allowed for.

The rate of absorption also depends on the intimacy f contact between the liquid and gas mixture, and this epends on the design and operation of the particular bsorption tower or spray system.

The per cent of the theoretical absorption realized epends on the rate of absorption and the duration of ontact of the liquid and gas mixture, the latter also epends on the design and operation of the apparatus.

To sum up, the rate of absorption, R, for a given gas nd liquid will be proportional to the product of the ifference in partial and vapor pressures, D, times a actor expressing the intimacy of contact, I, or $R = DI$. The per cent of theoretical absorption, A, will e proportional to the rate of absorption times the time f contact T, or $A = C_1DIT$, and the actual absorption or any gas and liquid will be proportional to K' times , or actual absorption, $P = C_2K'DIT$.

This formula is not capable of any direct mathe- natical application, but may be useful in comparing arious systems working on different gases and liquids, r for analyzing certain absorption problems. C_2 is the roportionality constant, depending on the units in hich the other factors are expressed, etc. K' is the heoretical absorption under the particular temperature, ressure and concentration of entering and exit gas ixture and liquid employed. K' will generally be fixed y plant operating conditions, and may be varied only y changing these. D, the difference in partial and apor pressures, depends on these plant conditions; and lso on the design of apparatus, in that for a given concentration of gas in the exit gas mixture and liquid, and for a given concentration of the entering gas mix- ture, D will have the effect of being larger with the counter-current flow principle than with parallel-current flow. The effective value of D with counter-current flow will depend on the number of spray systems or towers in series and on the number of effective zones in each unit. I and T will depend on the design and operation of the system as a whole. Increasing the liquid flow or circulation rates will in general increase I, the intimacy of contact, while increasing the volumes of gas mixture handled will decrease both I and T. This formula may be especially useful if a particular system is being used under known conditions and it is desired to know what it, or a duplicate system, will do under different conditions, say using a different gas and liquid. If the same conditions of flow rates of gas and liquid are to be maintained, the formula reduces to (1) per cent of absorption, $P_a = C_3K'_a$, and likewise (2) $P_b = C_3K'_b$, where the subscripts refer to operation under known or desired conditions. Substituting in (1) the

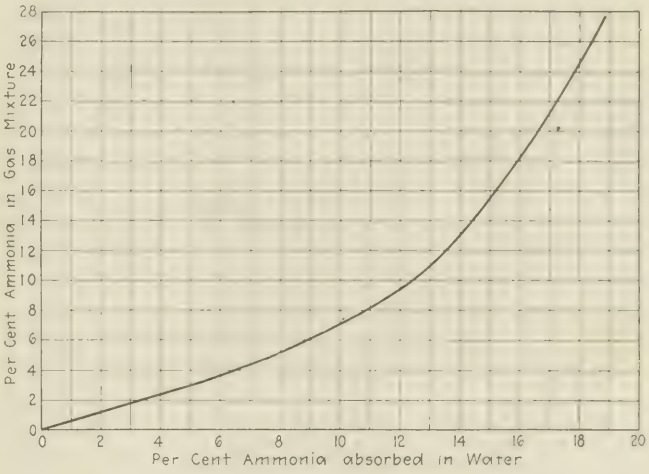


FIG. 1. CONCENTRATION OF AMMONIA IN GAS NECESSARY TO GIVE SOLUTION OF STRENGTH SHOWN. THEORETICALLY PERFECT ABSORPTION

known values will give a value for C_3. K'_b may be found from plant or published data. Then the product of C_3 times K'_b will be the per cent absorption under the new conditions. Now suppose it is desired to use some other conditions of flow rates of gas and liquid. If the effect on the per cent absorption of varying these two factors is known for any fixed K', when this is less than 100 per cent, then the K'_b we have obtained may be corrected to correspond. The results so obtained should be sufficiently accurate to act as a real guide in making new installations or to show plainly if some of the towers or systems in use are not giving the proper absorption, due to faulty construction or operation, or to offer a comparison of the capacity and efficiency of widely different systems.

The writer recently made some absorption tests using the spray system for liquid cooling.

Ammonia gas, from cylinders of liquid ammonia, mixed with air, was used as the gas mixture, and city water was used as the absorbing liquid. The per cent of ammonia in the exit liquid and in the entering and exit gas mixture was determined, and the temperatures of the entering and exit water and gas were taken, as well as data to compute the rate of flow of water. The rate of flow water and all temperatures were held

practically constant, while the volume and percentage composition of gas mixture were varied. The composition of the exit gas mixture and water varied as a result of this. Fig. 2 shows the per cent ammonia in the exit gas mixture plotted against the per cent ammonia in the exit water from the spray system, as compared with the amount that would be found for theoretically perfect absorption. At first sight the relative value appears very large, but it should be remembered that the amounts involved are very small. The data shown here are important only in that they show that the per cent ammonia in the exit gas is largely determined by the per cent ammonia in the exit liquor. The curve for theoretical absorption is nothing more than values of K', and since the absorption obtained is proportional to this, it follows that the absorption is taking place according to definite laws, and is not haphazard. If such a relation is found not to exist in any absorption tower or other system, it would be advisable to investigate the tower filling or distribution of absorbing liquid for effective channels where gas is getting by without being acted on. Fig. 3 shows the total percentage of ammonia recovered by absorption plotted against the volume of gas mixture handled. In this spray system, and presumably in others, this was found to be one of the most important variables in operation. Increasing the volume of gas decreases the intimacy and time of contact, and so, other things being equal, naturally decreases the total absorption.

The increasing of the percentage of ammonia in the entering gas increased the percentage of total absorption in terms of the theoretical. The effect was small enough, however, to be nearly hidden by other variations in the test conditions.

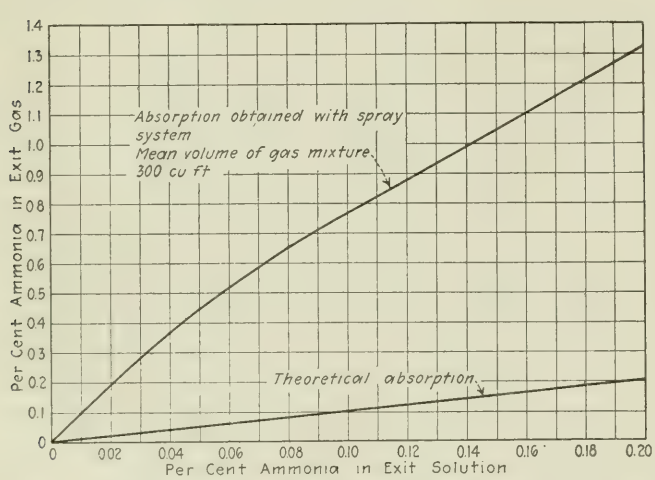


FIG. 2. PER CENT OF AMMONIA IN THE EXIT GAS AND SOLUTION FOR ABSORPTION OBTAINED WITH SPRAY, AND THEORETICALLY PERFECT ABSORPTION IN WATER

The flow of water used was such as to give nearly maximum absorption, and the rate of flow was not varied. The curves given are of general importance only in that they may be duplicated for existing installations, and comparisons drawn. In this case the curve in Fig. 3 shows practically the per cent absorption in general operation for this particular system, with flow rates of liquid of about 30 gal. per min. It is practically a series of values for $C_2K'DIT$, and since, according to the composition of the exit water reached, the theoretical absorption should be 99.8 per cent $= K'$, the curve practically gives values of C_2DIT. In other words, if a given volume of any gas is to be absorbed in any liquid, from the curve in Fig. 3 can be obtained the absorption that may be expected for the volume of gas handled; i.e., for 300 cu. ft. per min., this machine would give 75 per cent of the theoretical absorption. This is the value of C_2DIT. Now, if the temperature and concentration of the exit liquid and entering gas are to be such that only 80 per cent of the gas may be theoretically absorbed, the value of K' will be 80 per cent. The actual absorption that will be realized will then be 75 per cent of 80 per cent = 60 per cent of the gas in the gas mixture. Suppose the gas mixture originally contained 50 per cent of the gas to be absorbed, or 150 cu.ft. Of this 60 per cent, or 90 cu.ft., will be absorbed and 60 cu.ft. will pass through. The exit gas mixture then has a volume of 6 + 150 = 210 cu.ft., and contains 60 ÷ 210 = 28.6 per cent gas.

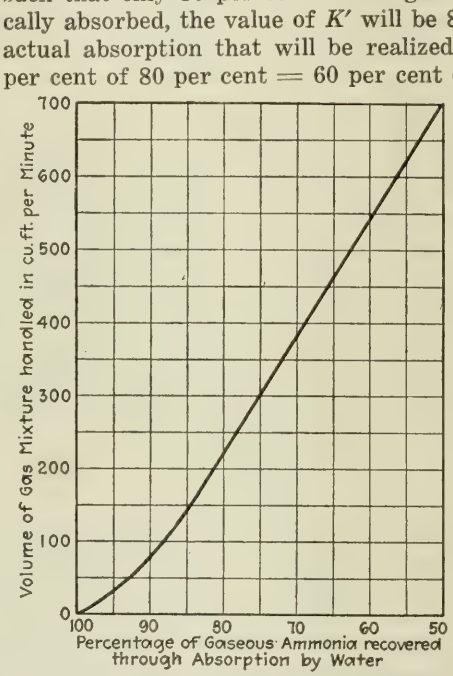


FIG. 3. RELATION BETWEEN VOLUME OF GAS MIXTURE HANDLED AND PERCENTAGE RECOVERY OF AMMONIA

Suppose this exit gas is passed through a second spray system, counter-current flow of liquid and gas mixture being used. Also, to simplify the problem, assume K' to remain unchanged, though in general it would increase in the successive spray systems. For 210 cu.ft. per min. the absorption would be 80.5 per cent of the theoretical, or the total absorption would be 80.5 per cent of 80 per cent = 64.4 per cent. The absorption in the second spray system is then 64.6 per cent of 60 cu.ft. = 38.6 cu.ft. The total absorption in two sprays is then 38.6 + 90 = 128.6 cu.ft. or 128 ÷ 150 = 85.7 per cent of the gas.

The exit gas from the second spray contains 150 cu.ft. of diluting gases and 60 — 38.6 = 21.4 cu.ft. of gas. This gives 150 + 21.4 = 171.4 cu.ft. of gas mixture, containing 21.4 ÷ 171.4 = 12.4 per cent of gas. Suppose this gas to be passed through a third spray system, counter-current principle. The absorption for 171.4 cu.ft. is 83 per cent of the theoretical, or the actual absorption is 83 per cent of 80 per cent = 66.4 per cent. The absorption in the third system is then 66.4 per cent of 21.4 cu.ft. = 14.2 cu.ft., making the total absorption in the three systems 14.2 + 38.6 + 90 = 142.8 cu.ft. and the recovery 142.8 ÷ 150 = 95.2 per cent. The results obtained are low, for a large volume of gas mixture was assumed, and in general the value of K' (which has been considered constant) will increase quite rapidly in the spray systems or towers having the more dilute exit liquid.

The last portion of this paper is subject to considerable elaboration, but this article has aimed rather at giving merely fundamental principles.

Chemical Engineering Laboratories,
University of Michigan.

The Catalyst for the Oxidation of Ammonia*

escription of General Types of Equipment Employed for the Production of Nitric Acid by the Catalytic Oxidation of Ammonia—Platinum as Catalyst—Influence of Space-Time-Temperature Conditions—Conclusions

By G. A. PERLEY

THE methods involved in the production of nitric acid by the catalytic oxidation of ammonia have been described in a great variety of places. It eems strange to observe the tremendous variations in ie general types of apparatus employed in this work hen the basic feature must be the same for all uipments where platinum is used as a catalyst.

Some combinations used in commercial practice are:

Ostwald Catalyst

The use of a preheated mixture of air and ammonia rough a heat exchanger in accordance with Ostald's plans. Platinum sponge or nets were used as ie catalyst. A modification of this type has consted of a nickel tube, 8 ft. long by 2 in. diameter, in ie end of which was rolled a piece of platinum foil eighing about 1.6 oz. An enamel-surfaced iron tube rrounds this nickel tube and serves as the inlet for ie ammonia-air mixture. The hot gases passing wn the inside of the nickel tube transfer a portion their heat content to the cold ammonia-air mixre flowing up between the nickel tube and the amel-surfaced iron tube. It is reported that a temrature on the catalyst of from 600 to 800 deg. C. is tained with a 9 per cent (vol.) NH_3. Such a system quires the use of expensive enamelled iron and ckel, while the production per unit is necessarily nall. Again there is no temperature control on such system, and in actual practice there is a certain mount of pre-decomposition. A production of 164 . of nitric acid per day, or the equivalent of the idation of 45 lb. of NH_3 per unit, is the reported eld. This gives a capacity of only 28 lb. of NH_3 per . of platinum per day. It seems as if this capacity reported is somewhat low, yet it shows the ineffiency of the use of a solid sheet of platinum.

Kaiser Catalyst

A modification by Kaiser of Spandau has been deribed where heat control was obtained through the parate preheating of the air in a coke furnace to 00 deg. C., and then admixture of this with the amonia. Dr. Kaiser has claimed a preactivation of the itrogen of the air by this preheating. His claims of ecuring 200 per cent oxidation efficiency by this solled "autoxidation" have been proved most ridicous. While the catalyst of the Ostwald modification was usually some sort of thin foil, the Kaiser atalyst consisted of four platinum gauzes placed in ose contact with one another.

The gauzes were made of 0.0024-in. diameter wire nd 80 meshes per linear inch. A catalyst of 0.02 in. tal thickness resulted. Kaiser used a gas velocity hich he claimed gave a catalyst contact of 0.0006 ec. A square foot of the Kaiser four-layer catalyst probably weighed approximately 6.6 oz., and he has stated a maximum output of about 3750 lb. of HNO_3 per sq.ft. of catalyst per day. The actual plant yields are said to be more nearly 1056 lb. of HNO_3 per sq.ft. per day. On this last basis a capacity of 43 lb. NH_3 per oz. of Pt per day is the result. In view of the recent studies it seems probable that Kaiser could have obtained nearly the 3750 lb. of HNO_3 per sq.ft. of catalyst per day, but the secret was not due to autoxidation.

Frank & Caro Catalyst

The Frank & Caro type of catalyst consisted of a single platinum gauze made up of 0.0026-in. diam. wire and 80 meshes per linear inch. The gauze was welded to silver terminals and heated by electrical energy to about 650 to 700 deg. C. The type of apparatus used by the followers of this equipment usually consisted of an aluminum frame and a rectangular catalyst $15\frac{3}{4}$ x $23\frac{1}{2}$ in., with the flow of the air-ammonia mixture going up through the electrically heated gauze. Here precooling of the intake mixture contrasts to the preheating of the Ostwald type. The Bamag Co. has claimed that this platinum gauze, per converter, weighs about 2.89 oz. and that such an equipment oxidizes 176 lb. of NH_3 per day at 90 to 92 per cent efficiency. This is 60 lb. NH_3 per oz. of Pt per day, and is considerably higher capacity than that secured by the Ostwald type (28 lb.). The yields as reported are probably very near correct.

American Cyanamid Catalyst

The patents of the American Cyanamid Co., as taken out by Dr. Landis, cover essentially the same equipment as those of the Frank & Caro type, except that a chemically pure platinum gauze is employed, and the size is perhaps a few square inches smaller; also, the flow of the ammonia-air gas mixture is downward rather than upward as in the Frank & Caro type. Even the precooling is protected in the Landis patents. It is interesting to know that in the operation of the Landis converters no precooling device was adopted and a 0.003-in. diam. wire at 80 mesh gauze was used. A capacity of about 50 lb. of NH_3 per oz. of Pt per day could be obtained with 90 to 92 per cent oxidation efficiency.

Partington Catalyst

A composite of the Frank & Caro with the multilayer gauze has been used in England and described by Partington.[1] Here an aluminum frame holds two layers of a platinum gauze and the gas flow is up through the first layer, which is electrically heated, and then through a second gauze, which is electrically insulated from the first by small silica rods. In this apparatus it is necessary to use less than 50 per

*A paper read at the Philadelphia meeting, September, 1919, nd published by permission of the American Chemical Society.

[1] *J. Soc. Chem. Ind.*, vol. 37, p. 337r; 1918.

cent of the electrical energy consumed by the Frank & Caro type of apparatus. Precooling was avoided by Partington, and although preheating was not employed, it was recommended as desirable, provided the pre-decomposition of the ammonia could be economically prevented. The commercial units employed were small and utilized two layers of a 4 x 6 in. platinum gauze of 0.0025-in. diam. wire and 80 meshes to the inch. Both layers were of the same type of gauze. The gauze weighed 1.6 oz. per sq.ft. An output of 1026 lb. of HNO_3 per 24 hr. is claimed by Partington, and with 95 per cent conversion, and with a gauze temperature of 650 to 700 deg. C. This is equivalent to a capacity of 291 lb. of NH_3 per day per oz. of platinum. This method had been duplicated in the United States and it was never possible under any conditions to obtain these capacities with the published high oxidation efficiencies. The method of determining oxidation efficiencies for a given catalyst unquestionably governs the expression of the gauze rating. Partington recommends in another place a unit with a sectional area of 1 sq.ft. and the two layers of gauze with the electrical heat only upon the gauze which the gas stream meets first. He states that such a catalyst should produce 1 to 1.7 tons of HNO_3 per 24 hr., but the oxidation efficiency may be about 90 per cent.

Bureau of Mines Catalyst

Parsons & Jones have made patent applications for the use of a type of converter developed in some cooperative experimental work by the Bureau of Mines. Here a four-layer platinum gauze is used. The layers are in close contact, and the gauze is made of 0.0026-in. diam. wire and 80 mesh. The platinum gauze alone resembles the Kaiser type. The chief feature in this type of converter lies in the fact that no electrical heat is utilized, nor is there any preheating of either the air or air-ammonia mixtures. By the use of a non-conducting (heat-insulated) converter frame and a cylindrical form of gauze, the temperature of the catalyst is maintained sufficiently high to give oxidation conversions of from 90 to 91 per cent. A capacity of 70 lb. of NH_3 per oz. of platinum per day can be obtained on pure grades of NH_3.

Recent Developments

The nitrate division of the Ordnance Department has found that a decided increase in oxidation efficiency with an added capacity can be obtained, even with impure ammonia mixtures, by the use of a heat exchanger for the air and a subsequent mixing of the heated air with the cold NH_3 just prior to the gauze entrance. A four-layer, close-contact, cylindrical form of gauze of 0.0026-in. diam. wire and 80 meshes per in. was used in the work. The maximum intake temperature which could be secured by the exchanger was utilized. A capacity of 100 lb. of NH_3 per day per oz. of platinum at 95 per cent conversion has been obtained with a 0.0026-in. diam. wire and 80-mesh gauze. This type of converter was developed after operating experience with all other types. It differs from the Kaiser type chiefly by the utilization of the waste heat of the reaction through a properly designed heat exchanger for the intake air of the ammonia-air mixture. The function of the heating of the air is not one of activation or autoxidation, but rather a case of increasing the ammonia-air gas mixture to a temperature above 600 deg. C., without any predecomposition, in order to secure a high reaction velocity when the gas mixture comes in contact with the catalyst for but a short period.

The work of the writer has led him to utilize a heat exchanger for the ingoing air and a subsequent small mixing chamber of an iron pipe with a thin walled silica lining. A three-layer gauze mantle, with the layers separated by means of a $\frac{1}{16}$-in. diam. wire coarse mesh platinum gauze, is also recommended. The catalyst gauze should be of 0.0035-in. diam. wire and 120 mesh in order to secure greatest economy of platinum. The ideal three-layer gauze should utilize a different size mesh and wire diameter in each layer.

An examination of the above brief résumé of the various types of platinum catalysts indicates that a serious state of affairs exists. Everything from preheating to precooling and from one gauze layer to several gauze layers is employed in the commercial projects. Close-contact layers and separated layers have been recommended.

The methods of measuring temperatures, the various types of gas flow meters, and the distinctly great variation in the methods of determining the oxidation efficiencies have made an accurate scientific comparison of the above diverse data a physical impossibility. The writer is making arrangements to compare all of the above types with one standardized set of temperature, gas flow and analytical methods of estimation.

Prior to this exhaustive study it has seemed advisable to discuss some possibilities involved in this oxidation reaction. The choice, design and control of a given form of platinum catalyst must certainly be dependent upon each reaction which must be carried out, and hence a careful study of the theoretical possibilities is distinctly worth while.

Theories of Reactions

The average investigator has accepted the reaction $4NH_3 + 5O_2 = 4NO + 6H_2O$ as the primary step in the oxidation reaction. This attitude has come forth from the fact that as the temperature of the catalyst is above 620 deg. C. the only nitrogen oxide capable of existence at that temperature was NO.

Accordingly, this reaction becomes most interesting when we consider Ostwald's Law of Successive Reactions. It is recognized that whenever a chemical reaction occurs with the possible formation of intermediate compounds, the one involving the smallest loss of free energy will be formed first. Whether the formation of such can be established depends on the stability of the intermediate compound in question.

Kuhlmann originally considered that the basic reaction at the platinum catalyst was essentially

$$2NH_2 + 7O = 2NO_2 + 3H_2O$$

Mendeléeff[2] illustrates a method of producing nitric acid by passing a mixture of ammonia and air over heated spongy platinum. No reactions are written. However, he suggests that ammonia and nitric acid are the extreme compounds of nitrogen with hydrogen and oxygen, and that all the other compounds of these elements may be regarded as intermediate compounds. Mendeléeff[3] considers the following as pos-

[2]Principles of Chemistry, p. 283.
[3]*Ibid.*, page 278.

ibilities when starting with ammonium hydroxide nd substituting a hydroxyl:

(1) NH_4OH and abstracting water we get NH_3.

(2) $NH_2(OH)_2$ and abstracting water we get NH_2OH, hydroxylamine.

(3) $NH_2(OH)_3$ and abstracting water we get $NH(OH)_2$, dihydroxylamine.

(4) $NH(OH)_4$ and abstracting water we get $N(OH)_3$, orthonitrous acid.

This is particularly interesting when we note the iews which F. Raschig[4] has taken on this matter. Ie considers that $NO + H_2O$ are not the initial prodcts of the ammonia oxidation reaction, at least in n insufficient supply of oxygen. The reaction is suposed to proceed in a limited supply of oxygen to

$$4NH_3 + 3O_2 = 2N_2 + 6H_2O.$$

However, Müller[5] assumed that NH_3 dissociated into ts constituent elements, since he found the gas to conist of 59 per cent N_2 and 41 per cent H_2 at the high emperatures. Raschig considers that di-imide is essenially the first product that is formed in the oxidation eaction. He points out that hydrazine can also form. Iendeléeff pointed out that the formation of hydroxylaine in the previous mentioned work indicated the xistence of di-imide and hydrazine. Raschig has conidered the reaction in a limited oxygen supply as:

$$2NH_3 + O_2 = N_2H_2 + 2H_2O \quad \text{(chiefly)}$$

nd

$$4NH_3 + O_2 = 2N_2H_4 + 2H_2O \quad \text{(in part)}$$

nd that it is the di-imide which immediately decomoses into nitrogen and hydrogen and makes it appear hat we have

$$4NH_3 + 3O_2 = 2N_2 + 6H_2O.$$

Oesterheld[6] has studied the intermediate stages in he electrolytic oxidation of ammonia, and it was not ossible to isolate hydroxylamine. It is interesting o note that the determination of the oxidation potenials confirmed the series of ammonia to hydroxylaine to hyponitrous acid to nitrous acid.

The work on ammonia oxidation involving the use f a multilayer platinum gauze catalyst certainly inlicates that the ammonia oxidation reaction is really nore intricate than it first appears.

It would appear that the matter of decreased exosed gauze surface might not be the only limitation o a close contact of the layers if we carefully conider all of the possibilities of intermediate comounds. If the initial reaction is not a case of direct ormation of nitric oxide, but of some one of the ther possible intermediate compounds between NH_3 nd HNO_3, then the oxygen requirements at the catayst surface become quite different. The basic reaction eretofore considered has been

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

nd indicates a very high reaction order. The existnce of a reaction of the 9th order is quite unlikely, or usually the apparently high order reactions have een reduced to a series of reactions which involve imple interactions. This is unquestionably true in the ase at point, but the present uncertainty comes in the hoice of these consecutive series of reactions which esult in the production of NO from NH_3.

While it is the desire to isolate the exact series of reactions occurring at the surface of the platinum catalyst, it must be realized that the task involves many experimental data. Already there is quite an accumulation of such, yet the facts are inconclusive. A continued study of the absorption spectra may clear up the uncertainties.

The combustion of carbon has created much discussion, and even today the ultimate decision is uncertain. While Dixon, Strange and Graham[7] consider the formation of CO as the initial product, yet we find Haber[8] concludes that the initial reaction is the direct formation of CO_2. Rhead and Wheeler[9] have concluded that there is a simultaneous formation of CO and CO_2. The theoretical equilibrium indicates that carbon monoxide must be the chief constituent above 800 deg. C., and yet the evidence points to at least some dioxide. The initial formation of nitrogen peroxide rather than nitric oxide in the ammonia oxidation reaction would certainly be an important factor in the catalyst spacing relations. While the analogy to the ammonia oxidation reaction may not be completely well founded, yet it serves to show that it will be easy to develop a variety of opinions relative to this.

At one period of the past investigations, the qualitative indications were exceedingly strongly in favor of an opinion that the initial step of the oxidation reaction demanded a much larger oxygen concentration than that corresponding to the formation of nitric oxide. If such ultimately proves to be the case, the spacings between the gauze layers will demand a careful adjustment of the space-time-temperature-oxygen interdependencies.

Spacing of Gauzes

If the initial step of the oxidation reaction involves excessive amounts of oxygen, then the relationship of gas space between the catalyst layers becomes one of the greatest importance. However, this feature is important even without this oxygen factor directly entering the consideration.

The use of a single layer of platinum gauze with 0.0025 to 0.003 in. diameter wire and 80 mesh as a catalyst appears to be rather popular in the various above-mentioned systems. Since the reaction is essentially a contact process, it seems absurd that the use of much smaller free spaces between the wires of the gauze have not been adopted. From the standpoint of economy of platinum a single gauze of 0.0025 in. diameter wire and from 120 to 150 mesh is more desirable.

The function of a second or third gauze layer can be attributed to the blocking of the gas spaces of the first layer. However, if the only service which a second layer of a platinum gauze catalyst performs is one of "cleaning up" the spare ammonia molecules which pass through the interstices of the first layer, then the use of more than a two-layer gauze catalyst is probably distinctly uneconomical from the standpoint of platinum consumption.

The Bureau of Mines work involved the use of a four-layer catalyst for the purposes of heat conservation. An eight-layer catalyst has been recommended. The heat conservation argument cannot be real unless the four-layer catalyst will oxidize essentially four

[4] *Z. Phys. Chem.*, p. 138, 1918.
[5] *Z. Phys. Chem.*, p. 169, 1913.
[6] *Z. Anorg. Chem.*, vol. 86, p. 105; 1914.
[7] *J. Chem Soc.*, vol. 59, p. 759; 1896.
[8] Thermo. of Tech. Gas Reaction, p. 255.
[9] *J. Chem. Soc.*, vol. 101, p. 846; 1912.

times the quantity of ammonia per unit time and unit inner layer exposed surface of a single-layer catalyst. Even then, the heat conservation will only be that equivalent to the small conduction and radiation losses. If a suitable heat exchanger is employed, this heat conservation argument becomes negligible and the economical use of the platinum becomes the real issue. In other words, are more than two layers of a platinum gauze catalyst justified? The answer is certainly dependent upon the function of the catalyst, and the function of the catalyst governs in part the spacing arrangement of these two layers. Of course it is impossible to make absolute contact of one layer to the other, and it is also impractical to block up an excessively large amount of the upper surface of the second layer by the protecting under surface of the first gauze layer.

Effect of Voids Between Separated Catalyst Layers

The effect of a void heated space between the possible separated layers must be considered, even if the initial oxidation reaction goes to NO. It is quite clear that the thickness of this space must essentially be dependent upon the velocity and temperature of the gas mixture. While Landis[10] has considered that the oncoming ammonia-air mixture would be decomposed by the radiated heat from a hot gauze, such a state of affairs seems impossible. The gas cannot be heated in this manner, although convection currents may play some part. We do know that if the gas becomes heated through conduction, or by contact with the first layer of the catalyst, or through a properly designed heat exchanger, after a sufficient time the reaction $4NH_3 + 3O_2 = 2N_2 + 6H_2O$ will occur. The burning of ammonia in air is an old time experiment and involves no catalyst whatsoever.

The work of Jellinek[11] upon the nitric oxide equilibrium has shown that nitric oxide can be catalytically decomposed to nitrogen and oxygen, yet this is a matter of temperature-time-catalyst. It is also true that the velocity of dissociation of nitric acid, in the absence of a catalyst, is dependent upon the temperature. The reaction $2NO \rightarrow N_2 + O_2$ in the absence of a catalyst may account for the slow decomposition of some of the combined nitrogen only when a temperature of 827 deg. C. is attained. While NO is unstable below 1227 deg. C., yet the velocity of the decomposition reaction is distinctly slow. The partial pressure of the NO is small and the time short. Hence, it will be difficult to realize that much trouble should be encountered by this reaction in the space between the two gauze layers at the gas velocities generally employed.

Interaction of Ammonia With Nitric Oxide

Another possible source of trouble might involve the interaction of ammonia with nitric oxide. The reaction $4NH_3 + 6NO = 5N_2 + 6H_2O$ has been considered by Reinders and Cats[12]. This reaction has also been studied by Baxter and Hickey[13] in reference to a possible method for the production of pure nitrogen. Reinders and Cats state that the double decomposition reaction of NH_3 and NO can take place without a catalyzer. Experiments were conducted by them with 5 per cent NH_3 mixtures in air and with a 10 : 1 ratio of NO : NH_3. The studies were only qualitative, yet it was observed that the reaction without catalyzer, or in porcelain, proceeded slowly, while with platinum the reaction was greatly increased. However, it was noted that the relative influence of platinum upon the reactions involving the oxidation of ammonia to nitric oxide and that involving the double decomposition were quite different. The influence of the platinum catalyst upon the reaction velocity of the nitric oxide formation was much greater than on the double decomposition reaction. This relative influence of the catalyst is probably a very important factor in these reactions. Recent qualitative work has indicated that, in the absence of a catalyst, this reaction depends much upon the time-temperature factors and that it can be made small compared to the nitric oxide formation reaction at the catalyst surface. However, a certain amount of care must be exercised to prevent this reaction from assuming an important position.

Influence of Space-Time-Temperature Conditions

All of the above-mentioned decomposition reactions are dependent upon the gas velocity, or the space-time relationships. It would seem as if the spacing between the layers should then depend quite entirely upon the space-time-temperature conditions. It is surely advisable to determine these relationships for any specific commercial type of apparatus that is being utilized, and then adjust the spacings between the gauze layers in accordance with the requirements.

The writer is convinced that the close contact of gauze layers involves an unnecessary amount of protected platinum surface and is to be avoided.

The importance of the spacings between the gauze layers was clearly demonstrated in some preliminary work which was under the direction of the writer for the nitrate division of the Ordnance Department. Lieut. George Cawley originally began the study of this separated gauze layer problem because of observations made upon layers which were not in close contact with each other. It was noted that the points of the second layer, where there was contact or where small gaps existed between the gauze layers, showed the maximum amount of activation or sprouting. The activation of the lower layers in close contact to the upper has always been observed to be a very slow process. The spacing greatly facilitates this activation.

A continued study by the writer has shown that the capacities of two gauzes can be greatly increased, on a non-preheated gas mixture, by a proper spacing of the layers over that where close contact is employed. The reason for this increase is due, in part, to the greater available platinum surface exposed to the gas, but the more important feature is involved in the temperature-reaction velocity relationships within the gas system. When passing a cold ammonia-air mixture to a platinum gauze, a portion of the gas does not come in contact with the platinum surface of the first layer, but passes through the spaces of the mesh. The amount of ammonia passing these gaps depends upon the gas velocity.

Table I gives a fair approximation of the quantity of ammonia passing through the spaces of a single electrically heated gauze of 0.0026-in. diameter wire at

[10] Chem. & Met. Eng., vol. 20, p. 472; 1919.
[11] *Z. Anorg. Chem.*, vol. 19, p. 229; 1906.
[12] *Chem. Weekblad*, vol. 9, p. 17, 1912.
[13] *Am. Chem. J.*, vol. 33, p. 366; 1905.

80 mesh, provided we take into consideration that the decrease in oxidation efficiency is due to excessive gas velocity and a resultant passage of ammonia past the catalyst.

TABLE I.

Lb. NH_3 Per Oz. Pt Per Min.	Per Cent Eff.	Lb. NH_3 Per Oz. Pt Per Min.	Per Cent Eff.
0.025	95	0.095	80
0.035	93	0.120	76
0.045	90	0.145	70
0.060	86	0.190	62

It is evident that an increase of fivefold above a very low normal quantity of ammonia in unit time only decreased the oxidation efficiency approximately from 95 to 76 per cent. In other words, with a fivefold increase in the work thrust upon the first layer of a 0.0026-in. diameter wire and 80-mesh gauze we find it will still do 76 per cent of the work. This means that the concentration of ammonia in the gas escaping the first layer is exceedingly small, yet the excess of oxygen must also be small. The oxidation reaction develops so much heat that the expansion of the gases, by the increased temperature, must also be considered in this diluting effect. The greatly reduced concentration of ammonia indicates also a decreased reaction velocity, and the only means of speeding up the so-called "pick-up" reaction of a second gauze layer must be by a decided increase in the temperature of the ammonia-oxygen molecules of the gas phase. Since those molecules of ammonia which pass the gauze do not presumably make contact with the hot platinum, the only method of increasing their temperature is through conduction and convection. Closely connected gauze layers will not give sufficient time for the heating of the ammonia molecules to a temperature sufficiently high for the desired increased reaction velocity in the weak gas mixture for the available catalyst contract period. The hot gases from the reaction of the oxidation of the initial 76 per cent will transfer the necessary heat to the ammonia-air mixture which has passed the gas for the first layer, provided sufficient time is obtained. The simplest answer to this is by the use of a gas space between the layers. This space must be of sufficient depth to permit the ammonia-oxygen molecules to attain a temperature sufficiently high for a high reaction velocity when they next meet a catalyst surface. The limiting depth is that where the time-temperature conditions permit the reaction to proceed to the non-catalytic

$$4NH_3 + 3O_2 = 2N_2 + 6H_2O.$$

The interaction of nitric oxide with ammonia, as studied by Baxter and Hickey,[14] upon the preparation of nitrogen from the reaction

$$6NO + 4NH_3 = 5N_2 + 6H_2O$$

showed that the reaction was complete only when the mixture was heated to a high temperature in the presence of a catalyst (such as platinum). Fortunately, the actual relative rate at which this reaction occurs under the same conditions as the nitric oxide formation reaction is most favorable to the nitric oxide production even in the presence of a catalyst.

Since the "clean up" reaction involves a dilute ammonia gas mixture, the heat of reaction upon the second catalyst surface will be much lower than that of the first layer. In an effort to equalize the temperatures on the different layers the writer has used a coarse-meshed heat-conducting gauze. This must be fabricated of metals which do not destructively decompose dilute ammonia-oxygen mixtures or nitric oxide. A quarter-inch mesh platinum gauze has served excellently in this work. Such a metallic gauze layer separator permits the surplus ammonia molecules to be heated to a higher temperature than those of the intake gas and maintains a high catalyst temperature on the succeeding layer. Thus the reaction velocity can be increased to a point where the active surface of the under gauze layer will do its proportionate share of the work even when the first layer is subjected to a quantity of gas eight times its normal. The metallic coarse-meshed separator also enables the spacings between gauze layers to be maintained quite uniform.

The economical use of a two or three layer gauze involves the utilization of a high temperature of reaction within the gas phase and hence a preheated intake mixture. It also necessitates the use of exceedingly short periods of contact within the catalyst zone, in order to prevent undue decomposition reactions at the elevated temperatures.

Summary

This discussion of the factors affecting the design of ammonia oxidation apparatus may be summarized briefly as follows:

1. There are as many different commercial ammonia oxidation platinum catalyst installations as there are possible types.

2. The use of a suitably preheated air-ammonia mixture is pointed out as most important for the production of a sufficiently high temperature for a rapid reaction velocity of the desired reaction.

3. The use of a platinum gauze of 0.0025 in. diameter wire and 120 to 150 mesh is far more logical than one of 80 mesh, since it decreases the free gas space between the wires.

4. A three-layer platinum gauze arrangement represents probably the maximum upper limit of gauzes, if the economical use of platinum is considered. A mantle form of catalyst is desirable.

5. The gauze layers should be separated a sufficient distance in order to permit the much diluted ammonia-air mixture, which passes the first layer, to become raised to a higher temperature than the original more concentrated ammonia mixture. An increased reaction velocity may thus be obtained. A coarse-meshed platinum separator has been suggested as a means of maintaining uniformity of gas space and equality of temperature in the various layers. The temperature of the last layer will always tend to be much lower than the others unless a heat-conducting separator is utilized.

6. It is quite probable that NO is not the initial product formed in the ammonia oxidation reaction. If such is the case, the use of separated gauze layers will depend upon a careful application of space-time-temperature-oxygen factors.

7. The troublesome factors involved in the theoretical decomposition reactions when using separated gauze layers can be made to vanish by a proper control of the space-time-temperature factors.

[14] *Am. Chem. J.*, vol. 33, p. 300; 1905.

New Hampshire College,
Durham, N. H.

Electric-Resistance Furnace of Large Capacity for Zinc Ores
II. Operation of Furnaces and Characteristics of Process

Details of the Experimentation Work With Electric-Resistance Furnaces of Commercial Size Based on the Author's Well-Known Plan of Making Briquets With the Zinc Ore to Be Treated and Using These Briquets as Resistors for an Electric Furnace*

By CHARLES H. FULTON

Operation of Furnace C

In setting up a charge, a 0.75-in. graphite disk, the diameter of the briquet, was placed on the graphite block *a*, Fig. 1,† and thinly coated with contact material, then the first briquet placed in position, its top coated with contact material, then the next briquet was placed in position and its top coated, then the third. This last briquet had a 2-in. hole at the center 2.5 in. deep which was formed at the time of pressing the briquet by the top pressure plate, which was fitted with a slightly tapered pin. After the twelve briquet columns were placed in position, 1.75-in. graphite pins were dropped in place in the top briquet, contact material applied, and 1-in. graphite disks, with a 2-in. hole at the centers, slipped into place, and the top connectors placed into position. The top connectors, 5 in. thick, were provided with tapered holes somewhat larger than the pins, into which the projecting pins fitted. The space between the pins and the walls of the holes in the connectors was filled with finely crushed coke. By this system the briquet columns were held firmly in position and the slight shrinkage and motion in the charge provided for.

A charge was set up in from 2 to 3 hr. by two men. In the making of the briquets care was taken to have their ends parallel and perpendicular to the axis, and all approximately of the same length. The length sometimes varied slightly, in which case and when briquets broken in the handling were used, deficient height of column was made up by the use of extra graphite disks.

After the charge was set up, a fireclay luting was spread, ring form, on the base and the retort was lowered into position by the crane. The luting made a tight joint. The exit hole at the top of the retort was left open for a short time after power was applied at the electrodes, to permit the escape of pitch fumes and the first gases, after which it was closed, and the valve *X* (Fig. 4), leading to the vapor box and condenser, opened.

In Fig. 6, the passage from the base to the upper chamber of the vapor box *v*, Fig. 4, is shown in *b*. From the vapor box, the gases passed to the central condensing chamber *p* of the condenser, thence by the cross passage *k* to the outer annular condensing chamber, which was divided, by vertical walls, into four compartments in series, the carbon monoxide finally burning at an exit at the top of the last one.

The central condensing chamber drained into the vapor box, and spelter in furnace C was tapped from the vapor boxes. In the operation of this furnace, practically nothing was found in the annular condensing chamber except a very small quantity of blue powder. This chamber was provided with tap holes at the bottom. The retort ends of this furnace were satisfactory, but the condenser was too complicated. The condensation was excellent as regards the nonformation of blue powder. After six charges, the condenser was found to be practically free from blue powder and dross. At no time did the gas flame show more than the permissible amount of zinc. Some zinc was lost by leakage at the cross passage from the central to the annular chamber, which could not be kept tight. The bottom of the vapor boxes also could not be kept tight, and spelter escaped in considerable quantity into the base and ground beneath the base. It was decided that the condenser would have to be a simpler structure and that the passage from the retort to the condenser must be simple, short, and easy of access for the purposes of cleaning. The new design gave rise to furnace D.

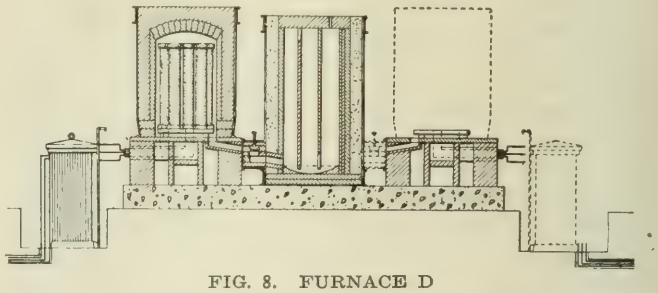


FIG. 8. FURNACE D

Furnace D

This furnace differs from furnace C in the design of the condenser. The same principle was used, but there was no heating of the retort base or the condenser. Fig. 8 illustrates the arrangement. Instead of a bottom connection from the retort base to the condenser, a top connection, shown in Fig. 9, was permanently attached to the condenser.

After the retort was placed in position, the condenser was lifted by the crane and swung into position so that the opening of the connection registered with the opening in the top of the retort. Luting was then placed around the retort opening and the condenser gently lowered to its base; this made a tight joint between the condenser and retort. When the charge was distilled, the transformer was transferred by a crane to the second retort base, the valve of the condenser connection closed, and the condenser lifted by the crane, swung around 180 deg., and set on the center of its base. The retort was then lifted about 3 in. and pulled toward the center of the building; this swept the dis-

*For Part I, describing the furnaces and process, see Chem. & Met. Eng., vol. 22, No. 2, pp. 73-79, Jan. 14, 1920.

†See Chem. & Met. Eng., Jan. 14, 1920, p. 73.

tilled briquets to the floor over an apron plate. The retort was then transferred to the other charge, the condenser set by the crane, and distillation begun on the second charge. A new charge was set up on the first base, the men being protected from the hot base by asbestos mats and shoes.

The connection was designed so that it could be readily cleaned out by the removal of the cover-plate over the graphite plug valve. The connector is by no means a perfect device and had to be cleaned every second charge, especially if the valve was not carefully closed at the end of the run. The passages also are somewhat small.

Condenser

The condenser was made of the same shell as used in furnace C, except that a steel bottom was riveted in place. It was lined first with 9-in. sil-o-cel brick followed by 4.5-in. of high-grade firebrick. Its interior diameter was 42 in. and its interior height 9 ft. It had a longitudinal partition of firebrick wall, as shown in Fig. 8, and was known as a two-pass condenser. For the initial charge, the condenser was heated by an oil burner placed into an opening at the top, the products of combustion traveling down the large pass, up the small pass, and out of the connection as a flue. Preliminary tests showed that if the condenser was heated to 940 deg. C. and then closed and allowed to stand the temperature dropped from 940 to 630 deg. C. in 16 hr. It was later found that this radiation about balanced the heat input, due to the condensation of zinc vapor, and the condenser maintained itself at a temperature of about 700 deg. C. at the inlet and 500 deg. C. at the exit. With more rapid working, it would probably have been necessary to spray the exterior with water. With less rapid working the condenser would undercool, as was the case when less than two charges were distilled in 24 hours.

Charges 7, 8, 9, 10, and 11 were distilled with this

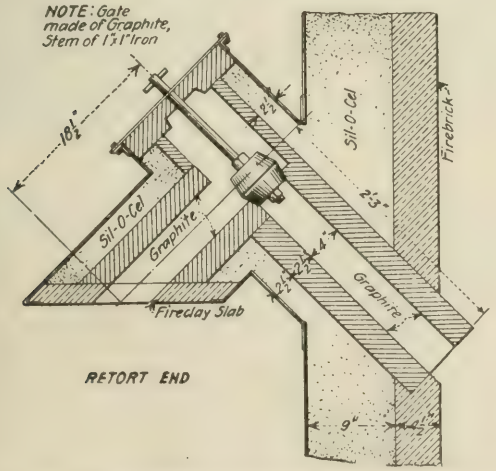


FIG. 9. TOP CONNECTION FOR ELECTRIC FURNACE

condenser, when the bridge wall collapsed at the top, at which point the temperature was about 500 deg. C. This collapse was due to carbon deposition within the firebrick localized at the iron-oxide spots of the brick. The action is due to the decomposition of carbon monoxide at the temperature existing and is elsewhere described.[1] The condenser was then repaired, the bridge wall being replaced by a 30-in. cylindrical flue tile, for a second pass. The condenser was again brought to the desired temperature by the oil burner and charges 12, 13, and 14 run, when part of the condenser brickwork, including the top tile, collapsed for the same reason as before.

[1] C. H. Fulton, "Condensation of Zinc From Its Vapor." Bulletin 140, A. I. M. E., (August, 1918).

TABLE II. METAL BALANCE

Runs Nos. 7, 8, 9, 10, and 11, May, 1917

Zinc in Baked Briquets	Lb.
Each charge	573.0
Zinc in five charges, total charged	2855.0
Zinc remaining in Distilled Briquets	
Run No. 1, 2.36 per cent	52.4
Run No. 2, 0.67 per cent	14.0
Run No. 3, 1.80 per cent	39.0
Run No. 4, 0.93 per cent	19.4
Run No. 5, 5.97 per cent	151.0
Total Zinc in Distilled Briquets	275.8
Zinc cast as spelter	1242.5
Zinc in scrapings from bridge wall, rechargeable @ 41.75 per cent zinc	899.0
Zinc in brick from condenser, @ 1.74 per cent zinc	115.3
Zinc unaccounted for	322.4

Summary

	Per Cent	Lb.
Spelter tapped	42.7	1242.5
Scrapings, rechargeable	30.8	899.0
Zinc in brick from condenser	3.9	115.3
Zinc in distilled briquets	9.1*a*	275.8
Unaccounted for	13.5*b*	322.4
	100.0	2855.0

a The amount of zinc left in briquets is entirely at the will of the operator; this is shown on the individual runs. The runs in this series were, in part, undertaken to obtain figures on power consumption, and certain runs were discontinued at given power inputs to determine proper point of stopping.

b This covers zinc absorption in retort hood base, and passageways, and includes zinc escaping uncondensed.

The condenser, when opened after each run, showed no blue powder, and the walls were covered with spelter in the form of droplets. There was some zinc dross in the bottom. The complete metal balance of these two runs is given in Tables II and III. In the first run 42.7 per cent of the zinc content of the charges was recovered as cast spelter bars; and in the second run 52.6 per cent. This recovery was from a practically new furnace in each instance.

The destruction of the condenser lining also took place with furnace E. It became evident, therefore, that the condenser lining would have to be made of refractory material free from iron. The only real difficulty in the condensation was the destruction of this lining at a temperature of about 500 deg. C. At higher temperatures the destruction is not noticeable, as the condenser failed only in the parts where this temperature existed. In the retort, lined with the same firebrick, no destructive action was noted; in fact, the retort lining was not repaired at any time that the plant was in operation. It is probably not possible to operate any large zinc condenser for a long period, even though every precaution is taken in construction and operation to keep it tight against air. One of the underlying ideas in a condenser of this movable type is to operate it as long as it is in good condition, then replace it with another one at the proper temperature and clean and reheat the first one.

Typical Electrical Record of Run

In Table III is given the electrical record of run 14, which is typical. It will be noted that the balance of the phases is good; in many runs it was still more even. The power factor ranges between 88 and 91. The total time was 15.5 hr. The average input was 143 kw., which is too low, but all that was available. The power consumption was 2109 kw.-hr. for the charge, which is equal to 2576 kw.-hr. per ton of ore. This is higher than necessary, as later work demonstrated.

TABLE III. ELECTRICAL RECORDS OF RUN 14

Time	Electrode Volts Per Phase 1–2	2–3	3–1	Primary Volts Per Phase 1–2	2–3	3–1	Primary Amperes Per Phase 1	2	3	Indicating Wattmeter		R.W.H.M.*a*	Pyrometer Reading, Degrees C. Retort Bottom 1	Top 2	Condenser Top 4	Bottom 5	
6:15	290	290	290	290	290	290	150	150	100	...	...	1508.0	...	...	...	...	In at 5:50 a.m., 220 volt. connection.
7:00	121	118	132	126	126	130	480	425	260	...	...	1510.5	...	...	...	...	
7:30	117	112	120	120	122	122	590	540	460	...	...	1512.0	...	...	...	...	
8:30	134	131	132	271	256	266	445	430	375	255	225	1513.0	480	640	650	520	
9:00	67	64	65	138	124	128	280	310	300	80	90	1515.0	460	650	630	520	
9:30	96	86	93	196	181	192	615	615	615	255	255	1517.0	500	670	610	560	Flame lit at condenser.
10:00	79	72	75	162	150	158	650	650	660	215	230	1520.0	520	680	610	585	
10:30	68	65	65	142	134	134	650	595	660	175	200	1522.0	530	690	660	610	
11:00	62	59	60	130	124	124	650	600	650	165	185	1525.0	540	690	670	600	
11:30	63	60	59	130	124	122	645	550	650	150	180	1527.0	550	710	670	590	
12:00	63	58	61	132	128	126	650	600	655	165	190	1529.0	570	730	670	590	
12:30	65	61	62	136	128	128	680	620	680	175	195	1531.0	570	730	...	...	
1:00	65	61	61	134	128	126	655	595	665	165	180	1534.0	550	720	...	...	
1:30	67	62	63	139	130	128	680	620	650	170	180	1536.0	520	680	...	...	
2:00	64	61	62	134	128	128	635	580	640	165	185	1538.0	490	670	...	...	
2:30	65	61	62	126	128	128	620	565	620	165	180	1541.0	490	660	...	...	
3:00	65	60	62	134	128	128	620	600	620	165	175	1543.0	775	920	...	470	
3:30	66	61	63	140	130	130	590	600	610	160	180	1545.0	780	930	...	470	
4:00	66	62	65	140	130	130	570	600	620	160	180	1547.0	780	940	...	480	
4:30	65	62	63	140	130	130	610	570	610	170	160	1549.0	790	960	...	480	
5:00	69	67	65	142	138	136	590	490	610	150	180	1552.0	800	970	...	480	
5:30	67	65	65	140	136	170	600	520	600	155	180	1554.0	800	990	...	480	
6:00	68	65	65	140	138	138	600	520	600	160	175	1556.0	820	1010	...	490	
6:30	69	67	65	140	138	136	590	550	590	155	175	1558.0	840	1030	...	490	
7:00	70	67	67	144	140	138	600	520	600	165	188	1560.0	850	1045	...	488	
7:30	73	70	71	154	146	144	620	550	620	180	200	1562.0	860	1060	...	490	
8:00	74	71	71	152	143	146	620	520	600	175	190	1565.0	875	1085	...	480	
8:30	74	70	70	152	144	144	600	560	590	165	185	1567.0	900	1110	...	470	
9:00	74	69	71	150	142	144	600	560	580	180	185	1570.0	920	1130	...	470	Power off at 9:10.
9:45	75	70	72	152	144	144	560	530	560	175	180	1571.0	935	1110	...	470	Power on at 9:45. Power off at 9:50.

a Recording watt-hour-meter. For kw.-hr. multiply by 33⅓.

As charge 14 was the last of a run, it was allowed to cool with the retort in place, and the briquets of every other column weighed, sampled and analyzed. The record is as follows:

Twelve columns of briquets, three each. Total height of all columns, 763 in. Weight of undistilled charge 3161 lb. Density of baked briquets, 4.15 lb. per lin.in. Density of distilled briquets, 2.82 lb. per in. Baked briquets contained 18.2 per cent zinc. Total zinc in charge, 573 lb. Total zinc in distilled charge, 0.131 per cent, or 2.6 lb. Weight of ore in charge, 1630 lb.

The density of the briquet is a measure of the distillation. The above charge lost 32 per cent of its weight; this is the proper loss for complete distillation, with the briquets used, and made of 100 parts Missouri silicate ore, 35.5 per cent zinc, 85 parts coke, and 18.5 parts pitch. A loss of 34 to 40 per cent may take place when the charge is overdistilled, in which cases only traces of zinc can be detected in the distilled briquets. In Fig. 3 are shown the resistivity curves of charges 8, 13 and 14; these are typical of briquets made of Missouri silicate ore. Toward the end of the operation the resistivity rises somewhat; and this rise, indicated at the instrument board as a drop in amperage with no voltage change made, indicates the end of the distillation period.

The distilled charge was discharged from the retort base by slightly lifting the retort and then pulling it sidewise by means of the crane. The bottom graphite electrode blocks stay in place, but the top ones are, of course, swept off with the charge. They are at once drawn from the mass of briquets and covered with crushed coke. Graphite does not oxidize readily at a low red heat, and there was very little wear on the connector blocks during the operation of the plant. The bottom blocks on the base, immediately after the discharge of the briquets, were thinly covered with crushed coke, spread by a big shovel. After an hour the base cooled to or below a dull red, when it was cleaned off by a stiff broom and new charge set up. The discharged briquets on the floor were quenched with water and then removed. With furnace F, the base was higher and the briquets were discharged directly into a steel car, quenched, and removed to the dump.

Connectors Made of Briquet Mixture

Experiments have been made with a small-scale laboratory distilling furnace, with 1¾-in. diameter briquets, in which the graphite connectors were replaced by connectors molded from briquet mixture, modified by the addition of somewhat more pitch and the use of finer coke to give additional strength. These experiments were successful and it was the intention to make full-size connectors of this type, when the work had to be discontinued. Both bottom and top connectors of this kind were to be employed, thus increasing the capacity of the retort, and doing away with the use of all graphite except the electrodes proper, which are not subject to wear. It will be noted that even with the use of graphite connector blocks, there is no regular or fixed electrode consumption in this furnace.

Use of Distilled Briquets

The distilled briquets may be used again as coke. In the briquet charges distilled in furnace F, some of the briquets were made by replacing 50 per cent of the coke by 70 per cent of distilled briquet. These caused no difficulty in the distillation, although the distilled briquets are a most unfavorable material on account of the very high percentage of residue in the ore. The distilled briquet is practically a coke containing 34.5 per cent ash, which high ash content would not be present with ordinary zinc ores in the briquet.

Furnace E

Furnace E differs from furnace D in having a bottom connection between the retort base and the condenser, this connection being part of the condenser. In order to arrange for this construction, the central part of the furnace base, which had served as a condenser support, was removed and the old passageway for zinc vapor in the retort base rebuilt. Grooves were also cut in the retort base immediately around the graphite base blocks, which drained into the vapor passage. It

was thought, in the operation of furnace D, that in the earlier stages of the operation metal sometimes condensed on the walls of the retort and drained to the base, giving rise to redistillation, which prolonged the time and increased power consumption. The results obtained with furnace E do not prove this to be true. From the construction standpoint, however, there are certain advantages in a bottom connection.

In the operation of the process, the retort from a distilled charge is usually between 1100 and 1200 deg. C., but sometimes cooler. The ideal condition for operation is one in which the retort wall temperature is always higher than the charge temperature, which can be obtained by working with good hot retorts and by rapid distillation.

Furnace E is shown in Fig. 10. It was operated in the same manner as furnace D and the results with it were about the same. The condenser was a three-pass one, the passes being made of flue tile, as shown. After nine charges, the condenser broke down in the same way as the furnace D. No metal balance was

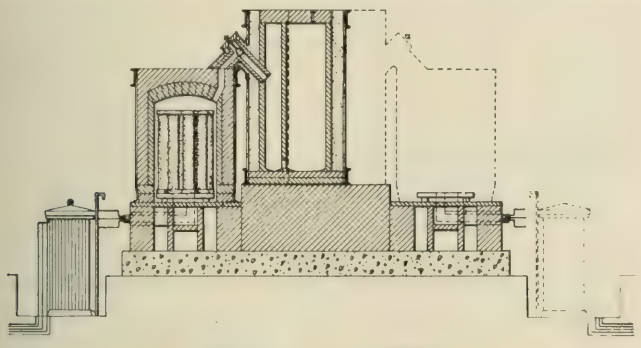


FIG. 10. FURNACE E

drawn up on this run. About 60 per cent of the zinc in the charges was recovered as cast spelter, over 1100 lb. being drawn from the condenser at one tap. When the condenser was opened, the walls were heavily coated with metal drops, dross, and dense rock oxide, and there was considerable dross in the bottom, but no blue powder. Once or twice during the campaign, the condenser valve was opened during the change from base to base and air passed through the condenser, a highly undesirable condition.

Furnace F

Furnace F was the furnace constructed for operation in connection with the new electrical equipment, consisting of three 870-k.v.a., single-phase transformers, switch connections and instrument equipment. The furnace consisted of three adjoining retort bases, two distilling retorts (identical with those used for the former furnaces), a movable combination condenser for spelter, blue powder, and oxide, and one of the old retort bases reconstructed to preheat retorts by means of oil burners. The electrical equipment was designed for extra capacity, so that it could be used in proposed subsequent work on larger units with 12-in. briquets. The foundation of the bases was built of concrete and contained a tunnel for the bus-bars from the transformers. The transformers were set as close as possible to one end of the furnace, in a shallow pit, which had waste connections to take care of the cooling water. The bases proper consisted of rectangular steel boxes filled with a firebrick arch, containing the opening for the electrodes and, on one side, a vapor passage leading to the condenser connection.

The idea was to have the extra bases form the top of the cars on which the charge of raw briquets would be set up, with the connectors in place. These cars would then be passed into the ovens and, after baking, removed, and the base with its charge picked up by crane and set on the furnace heated to a temperature of 500 to 600 deg. C. and at once distilled, thus conserving the heat energy in the hot baked charge. The movable base also served as a cover for a flue system under the base and surrounding the electrodes, which was heated by an oil burner located on the opposite side to the vapor passage. The exit flue from this system emerged from each base below the vapor passage and the products of combustion were passed to a heating chamber in the spelter condenser, to preheat this for the start of operations. This base-heating system was, in effect, the same as was used in furnace C. It was found to warp the bases and to be unnecessary, as in the case of furnace C, and was not used in subsequent operations. The electrodes were 12 in. in diameter, supported on jacks in the tunnel underneath the bases, and passed through the openings in the base, the seal between the electrodes and the openings being made by crushed carbon. The jacks afforded a ready means for slightly raising or lowering the electrode to keep it level with the top of the base. Fig. 11 shows the construction of furnace F.

The condenser proved unsatisfactory, so it was replaced with the style used on furnaces D and E. Experiments in making of zinc dust were successful, but the experiments in making oxides failed in the collecting device used. Before the spelter condenser could be again used the war conditions stopped experimental work.

The electrical system was such that the primary leads to the transformers could be connected either in delta or in Y, and the secondary leads could be brought out either in delta or in Y connection. By means of switches on the primary side, a wide range of voltage by small steps could be obtained at the electrodes. The current used was 40-cycle 13,000 volts primary, from Keokuk dam on the Mississippi River. Fig. 12 shows the wiring diagram of the three single-phase 870-k.v.a. transformers, the various connections of switches, the k.v.a. capacity of the transformers obtainable with the different connections, and the corresponding voltage at the electrodes of the furnace.

Operating With Preheated Retorts

In the furnace as at first operated, in the initial charge of any run, the retort was heated by radiation from the briquet charge, and when transferred after

FIG. 11. BASES OF FURNACE F

the distillation to the second charge was at a temperature of from 1000 to 1200 deg. C. The initial charge therefore always showed the extra power consumption necessary to heat the retort to this temperature. The ideal condition is to have the heat radiated from the retort walls to the charge rather than from the charge to the retort, which means working with hot retorts. In the case of high cost of electrical energy, the process lends itself readily to a method of working in which the retort is preheated to a temperature of 1250 to 1350 deg. C. by means of a regenerative system of preheating bases fired by gas. The use of the preheated retort reduces the time and power consumption. To the electrical power consumption in this case must, of course, be added the cost of preheating; but the electrical power consumption will be reduced by virtue of the shortened time, as this cuts down the radiation losses. In the operation of furnace F, preheated retorts were used. One of the old furnace bases was arranged for this work, the retorts being preheated by oil. In Table IV are given the results obtained.

The method adopted was as follows: A retort would be heated and then placed on the cold briquet charge, a second retort meanwhile being heated on the heating base; when this second base had attained a temperature of say 1200 deg. C., the first retort would be lifted from the charge and replaced on the heating base after the second retort was placed on the briquets; this operation was repeated until the charge was at a distilling temperature, namely 950 to 1000 deg. C.

By comparing the temperature figures, it was noted that the radiation from the retort is not rapid. The normal preheating period was 2 to 3 hr., and to obtain the total time of a charge on the base this must be added to the "Time of Distillation" given in Table IV. Under normal rapid and continuous working from base to base on the furnace, the hot retort from a finished charge would be set on a new charge, allowed to remain about 1 hr., and then replaced by a retort at 1300 to 1350 deg. C. from the heating base, and the retort just taken from the charge put on the heating base. After the second retort was on the charge about 1 hr., electrical distillation would be commenced. It need not be especially pointed out that power consumption will be lowest with such rapid and continuous working. Power consumption figures are given in Table V.

The theoretical power consumption for 60 per cent zinc ore containing 20 per cent siliceous residue, made into briquets containing 100 parts ore, 70 parts coke, and 17 parts coke pitch, is 1372 kw.-hr. exclusive of radiation losses. Of this, 421 kw.-hr., the amount required to preheat the charge to 920 deg. C., may be obtained by non-electrical means, as by preheated retorts. The carbon monoxide, which in this large-scale work may be collected, amounts to about 7200 cu.ft. per ton of ore, which at 35 cu.ft. per hp.-hr. is equivalent to 206 hp.-hr., or 154 kw.-hr. The energy in the briquet residue, in cooling from 1200 to 25 deg. C. is equal to 378 kw.-hr. Some of this may perhaps be recovered. The radiation losses can be made very

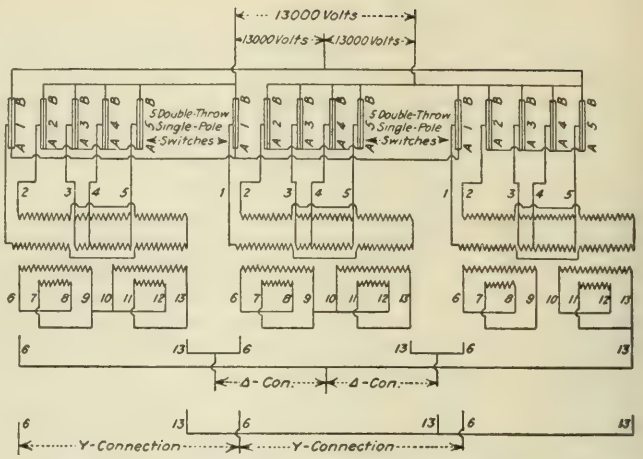


FIG. 12. WIRING DIAGRAM. 870 DEG. K.V.A. TRANSFORMERS

HIGH-VOLTAGE COILS, DELTA CONNECTIONS

K.v.a.	Connections	Voltage of Secondary Coils, Delta Connection	Voltage of Series-multiple Coils, Y Connection
495	2 to A, 3 to A, 1 to B & 5 to B	99	171
530	2 to A, 4 to A 1 to B & 5 to B	106	184
580	2 to A, 3 to A, 1 to B & 4 to B	116	200
640	2 to B, 3 to B & 1 to B	128	222
695	2 to A, 4 to A 1 to B & 3 to B	139	240
770	2 to A, 5 to A, 1 to B & 4 to B	154	266
870	2 to A, 5 to A, 1 to B & 3 to B	174	302

HIGH-VOLTAGE COILS, Y CONNECTIONS

K.v.a.	Connections	Voltage of Secondary Coils, Delta Connection	Voltage of Series-multiple Coils, Y Connection
286	2 to A, 3 to A, 1 to A & 5 to B	57	99
306	2 to A, 4 to A, 1 to A & 5 to B	61	106
335	2 to A, 3 to A, 1 to A & 4 to B	67	116
370	2 to B, 3 to B, 1 to A	74	128
400	2 to A, 4 to A, 1 to A & 3 to B	80	139
445	2 to A, 5 to A, 1 to A & 4 to B	89	154
500	2 to A, 5 to A, 1 to A & 3 to B	100	174

TABLE IV. RESULTS OBTAINED WITH PREHEATED RETORTS

Charge Number and Kind of Ore	Weight of Charge, lb.	Weight of Distilled Charge, lb.	Per Cent of Zinc in Charge	Per Cent of Zinc in Distilled Charge	Weight of Zinc in Charge, lb.	Kilowatt Intensity	Kw.-hr. Consumed	Kw.-hr. Consumed per Ton of Ore	Time of Distillation, Hr.	Temperature of Top of Retort at Beginning of Distillation, Deg. C.	Temperature at Top of Retort at End of Distillation, Deg. C.	Temperature of Base at Beginning of Distillation, *b* Deg. C.	Temperature of Base at End of Distillation, *b* Deg. C.	Weight of Zinc Dust Collected, lb.	Percentage of Recovery
24. Missouri silicate ore and dross briquets	3110	....	22.11	0.13	687.6	255	2170	2795	8.50	690	....	480	790		
25. Missouri silicate ore	3121	....	19.30	0.83	602.0	237	1300	1665	5.50	860	....	680	900		
26. Missouri silicate ore; some briquets made with old briquets as coke	3097	1759	16.23	Trace	502.0	234	1700	2190*a*	7.25	980	....	780	1415		
27. Missouri silicate ore; some briquets made with old briquets as coke	3022	1634	16.20	Trace	489.5	234	1170	1548*a*	5.00	1035	1460	560	970		
28. Franklinite briquets	3327	....	8.20	0.23	286.0	200	1185	1365	6.00	680	1125	230	400	236.0	82.5
29. Missouri silicate ore	3070	1627	16.45	0.15	505.0	225	1440	1811	6.40	970	1240	140	320	473.8	93.8
30. Missouri silicate ore	3168	1718	17.35	0.11	548.6	152	980	1237	6.50	1290	1310	520	660	523.2	95.1

a Overdistilled; unnecessarily high. *b* Temperature measured in brickwork of base.

small, since, in the nature of the process, the heat energy developed within the charge itself is at once consumed in useful work. The retorts can be heavily insulated. In Table V the low power consumption figures with a high degree distillation were obtained under condition of rapid work, and quick transfer of retorts. Continuous steady operation will also materially aid in condensation. All of the work was carried out on exceptionally low-grade ore, giving briquets containing from 16 to 20 per cent zinc. With higher grade ores, the briquets would contain from 25 to 30 per cent zinc, but it is not probable that the power consumption would increase proportionately, since the time is not necessarily increased and hence radiation losses are kept down.

TABLE V. POWER CONSUMPTION

Run Number	Kw.-hr. per Ton Ore	Per Cent Zinc Distilled *a* from Charge	Run Number	Kw.-hr. per Ton Ore	Per Cent Zinc Distilled *a* from Charge
1*b*	2540	100.0	16	2200	96.0
2	2270	100.0	17	1645	88.0
3	1540	54.0	18	2120	98.0
4*b*	3260	98.0	19*b*	3200	89.0
5	1645	98.0	20	1760	91.0
6	1720	85.0	21	1720	95.0
7*b*	2540	90.0	22	1920	97.0
8	2240	98.0	23	1760	95.0
9	2180	93.0	24*c*	2795	99.0
10	2420	96.0	25	1665	99.0
11	1760	73.0	26	2190	100.0
12	1600	70.5	27	1548	100.0
13	2700	100.0	28*d*	1365	99.0
14	2460	100.0	29	1811	99.0
15*b*	2620	100.0	30	1237	99.0

a Where less than all the zinc is distilled, the operation was purposely stopped to determine relation of extraction and power consumption.
b Initial charges.
c From hereon, operation with preheated retorts.
d Franklinite charge.

Zinc Dust Runs

Runs 28, 29, and 30 were made to produce zinc dust with furnace F. A condenser system consisting of two firebrick boxes, the first directly connecting with the vapor passage, and a 40-ft. train of 30-in. tile was connected with one base. To immediately cool the vapor at the exit of the vapor passage, an 8-in. iron pipe was passed through the first collecting box directly in front of the vapor passage; air was continually blown through this pipe. The zinc dust was of excellent quality throughout, free from oxide, 97 per cent passing a 200-mesh screen. The recoveries were very high, as will be noted from Table V.

Run 28 was made on franklinite ore, the briquets having the following composition: Ore, 100 parts; coke, 85 parts; and pitch, 28 parts. The briquets were in excellent condition after distillation, and it is probable that the coke and pitch proportions can be reduced. For the first large run on franklinite, it was considered undesirable to take any chance on composition.

General Characteristics of Process and Applications

The furnace and process presents the following characteristics:

1. It maintains the physical and metallurgical conditions of the present-day retort practice, in that it operates with a closed retort within the space of which is maintained a uniform temperature. This produces gas practically free from carbon dioxide, from which the zinc can be condensed as spelter without the formation of blue powder.

2. The energy for the distillation is generated within the charge itself, which fact, combined with proper heat insulation, will give the minimum power consumption possible.

3. It is a large unit furnace, the proposed 12-in. diameter, 72-in. high briquet, 19 per charge, will distill 8½ tons of roasted concentrate per 24 hr., counting on three distillations of 8 hr. each. The handling of material would all be done by crane, as in steel and copper plants. A general design has been worked out, in which the handling of material, the mixing of the briquet charge, the briquetting, the baking of briquets, the charging of retorts, and the discharge of the spent charge are done automatically and mechanically.

4. Probable costs have been calculated, which show a marked reduction over present costs. There will be no pottery and practically no consumption of fireclay. Labor costs will be low. Due to the completeness of distillation the recovery will be higher than in the present-day retort process. The cost of pitch in briquetting is not serious and with the great increase in by-product coke ovens the pitch supply will be plentiful. It has been suggested that the combination of a by-product plant and the electrical distilling furnace might work out well.

5. The process can be applied to any zinc ore, even to the so-called complex ores.

Platinum in 1919

The platinum market during the first quarter of 1919 was easier than in 1918, owing to the facts that the governmental restriction on the use of platinum had been removed and that the Government was disposing of its surplus stocks. The low price of $99 an oz. was reached late in March and was maintained about a month, but the price gradually stiffened until August, when the Government stocks were exhausted, and then abruptly rose to $110 an oz. Since the middle of August the price has continued to advance about $5 an oz. a month, the demand for the metal has been strong, and the supply has been short.

During the first nine months of 1919 about 40,400 oz. of platinum were imported, and if the importation at this rate continued during the rest of the year, and the normal domestic production of 7,000 to 10,000 oz. was maintained, about 54,800 oz. of new platinum should be available, aside from the stocks of platinum, about 65,000 oz., held at the beginning of 1919.

So far as known there has been little change in the domestic mining of platinum. The wide search made in 1918 for domestic sources of platinum has apparently yielded little results. Colombia may supply more crude platinum in 1920 than in the past, but its producing capacity is limited by the methods employed in washing the gravels from which the metal is obtained. Practically no supplies can be expected from Russia for several years. The osmiridium field of Tasmania appears to need only higher prices to stimulate larger production, but even with this stimulus it can probably produce not much more than 2,000 oz. a year.

According to James M. Hill of the United States Geological Survey, there seems to be little hope of any marked increase in the output of platinum in the United States or Canada over the small output heretofore made, and as the supplies are below normal and the demand is large it is reasonably certain that the price of platinum metals in this country during 1920 will be at least as high as it was during the last quarter of 1919, and possibly higher.

Foundry Test of Rotating Furnace

RECENT tests of operation of a 250-lb. Booth furnace* at Leitelt Bros. brass foundry, Chicago, in comparison with the performance of a gas-fired crucible installed in the same plant, furnished pertinent data on small electric furnace behavior. The electric equipment had been in operation for about two weeks when the test was initiated.

Detailed figures on the electric furnace for eleven days' run are given in Table I and on the gas-fired crucible for two heats in Table II. Table III shows comparison between the two equipments for an ordinary month's run, while in Table IV are assembled test data for four days out of the same month.

Notwithstanding somewhat adverse conditions under which this test was conducted, Table III shows a saving of over 36 per cent in melting cost in favor of the electric furnace. Furnace lining is estimated to cost in upkeep $1 per ton of metal, based on an estimated life of 400 heats. At the end of 425 heats, however, the lining was apparently as good as when first installed.

Conclusions From Test Data

Foundry records obtained while a furnace is hot are very misleading, because in a foundry such as the one being reported the average energy consumption will probably be more than 50 per cent in excess of the kilowatt-hours per ton consumed when melting regularly under the best conditions. Average operating results are therefore much better than records obtained under favorable test conditions. The electric brass furnace has proved itself to be a practicable piece of foundry equipment, irrespective of its energy consumption, but foundry men are apt to forget the over-all economies effected, and think only of the electric energy cost, if they find the kilowatt-hour consumption materially higher than was represented.

This furnace is not too small to melt red brass and gun metal with less than 290 kw.-hr. per ton (322 kw.-hr. per metric ton) and to melt yellow brass with about 240 kw.-hr. per ton (267 kw.-hr. per metric ton) when the furnace is hot and when it is being properly operated. It should be remembered, however, that furnaces are ordinarily used for one shift and allowed to cool down at night. This necessitates preheating each morning for an hour with about 50 kw. before the furnace is charged. Even this is not sufficient to heat up the furnace thoroughly, and it is not until afternoon that its point of highest efficiency is reached.

The inherent advantage of the electric furnace which overshadows all others is that it can melt metal with less loss than can the fuel-fired furnaces. As shown in Table III, a month's performance shows a shrinkage of 1.31 per cent in the one case as against 2.62 per cent in the other. Even a greater difference is noted when working on floor sweepings, turnings or light scrap.

In this particular foundry, concentrates from floor sweepings were sold for about 5c. per lb. before the electric furnace was installed, because it was not feasible to melt them in the crucibles. Now the electric furnace converts this material into ingots worth 15c. per pound.

Turnings and borings cost about 5c. per lb. less than ingots of the same analysis, and when charged into the electric furnace in large quantities, as can conveniently

*Described in CHEMICAL & METALLURGICAL ENGINEERING, vol. 21, p. 636.

TABLE I. SUMMARY OF DAILY RESULTS—11-DAY RUN

Day	No. of Heats	Time of Heat, Minutes	Material	Charge, Lb.	Poured, Lb.	Shrinkage Lb.	Shrinkage Per Cent	Kw.-Hr. Per Ton
1	6	59	Yellow brass	262	259	3	1.15	550
			Red brass, average	1442	1426.5	15.5	1.07	368
				1704	1685.5	18.5	1.09	394
2	7	53	Yellow Brass	710	700.5	9.5	1.34	338
			Red brass, average	963	955.5	7.5	0.78	648
				1673	1656	17	1.02	515
3	8	55	Yellow brass and manganese bronze	400	392.5	7.5	1.87	300
			Red brass and 85% copper bronze, average	1458.5	1440	18.5	1.27	428
				1858.5	1832.5	26	1.4	400
4	8	57	85% copper bronze	502	498	4	0.80	430
			Yellow brass	425	419	6	1.41	339
			Red brass, average	925	921.5	3.5	0.38	416
				1852	1838.5	13.5	0.73	402
5	5	65	Yellow brass	164	162.5	1.5	0.91	293
			Red brass and 85% copper bronze, average	1012.5	1003.5	9	0.89	544
				1176.5	1166	10.5	0.9	510
6	6	65	Red brass and 85% copper bronze	1367.75	1365	2.75	0.22	508
7	7	61	Red brass and 90% copper bronze	1723	1698	25	1.45	459
8	7	58	Yellow brass borings	83	74	9	10.83	867
			Red brass scrap, average	1697	1674.5	22.5	1.33	368
				1790	1748.5	31.5	1.80	391
9	7	51	Yellow borings	200	169	31	15.5	600
			Yellow brass scrap, average	1225	1221.75	3.25	27	488
				1425	1390.75	34.25	24	504
10	7	54	Yellow brass	125	107	18	14.4	384
			Red brass and bronze, average	1494	1490.5	3.5	0.23	380
				1619	1597.5	21.5	1.33	381
11	4	62	Red brass	977	972.5	4.5	0.44	442

SUMMARY

	Charged, Lb.	Poured, Lb.	Total Shrinkage Lb.	Total Shrinkage Per Cent
Red brass and 85% copper bronze	14,786.75	14,667.25	119.5	0.81
Yellow brass	1,961	1,933.25	27.5	1.40
Yellow brass borings	408	350	58	14.21

Analysis of the borings charged shows:

	Per Cent		Per Cent
Oil	8.28	Non-metallics charged	13.66
Non-metallic	5.38	Net metallic shrinkage	0.55
Metal	86.34		14.21

Power Consumption

Average power consumption, 441-kw.-hr. per ton.

TABLE II. TESTS ON GAS FIRED CRUCIBLES

	Heat No. 1	Heat No. 2
Character of charge	Scrap	Scrap
Metal charged, lb.	165	250
Metal poured, lb.	156	245
Loss per cent.	5.75	2.04
Time, minutes	60	105
Gas used, cu. ft.	2040	3560
Gas, cu.ft. per ton	24,720	28,480
Average crucible consumption per ton, per cent.	44	44

TABLE III. COMPARATIVE COSTS

(Average cost of melting brass in electric furnace and gas-fired crucible during one month.)

	Electric cost per ton melted	Gas Cost per ton melted
Lb. of metal poured during month	35,215	18,210
Electric energy (480 kw.-hr.)	$13.64	.....
Gas (18,600 cu.ft.)	.....	$12.65
Labor	6.25	8.00
Lining	1.00	1.00
Crucibles	.....	7.00
Metal shrinkage, electric, 1.31 per cent at 18c. per lb.	4.71	.....
Metal shrinkage, gas, 2.62 per cent at 18c. per lb.	.....	9.42
Electrode consumption, 4 lb. at 27c. per lb.	1.08	.....
Gas for heating ladle 600 cu.ft. at 68c. per 1,000.	.41	.....
	$27.09	$38.07
Saving by use of cheaper scrap made possible by electric furnace	$2.88	.....
	$24.21	$38.07

TABLE IV. FOUR DAYS' TEST DATA, ELECTRIC MELTING

Day of test	1	2	3	4
Number of heats	6	8	4	1
Character of charge	Scrap	Ingot	Ingot	Gates
Weight charged, lb.	1698	2236	1012	275
Weight poured, lb.	1676	2229	1007	.....
Loss per cent.	1.3	.32	.47	.....
Energy per ton, kw.-hr.	354	412	474	436
Power factor, primary	.....	.....	.....	63
Power factor, secondary	71	70	70	71
Average weight per heat, lb.	283	280	252	275
Melting time per heat, min.	47	59.5	57	61
Copper charged, per cent.	80.58	76.59	85.30	81.81
Copper poured, per cent.	77.04	75.48	85.23	82.65
Lead charged, per cent.	6.97	10.18	4.92	4.67
Lead poured, per cent.	6.66	10.24	4.86	5.77
Tin charged, per cent.	4.66	8.04	1.83	2.25
Tin poured, per cent.	3.93	7.92	1.91	2.10
Zinc charged, per cent.	7.09	3.28	8.11	7.91
Zinc poured, per cent.	12.25*	2.93	9.48*	9.94*

*Zinc added in ladle.

be done, this one item will greatly increase the saving actually shown by the electric furnace in Table III.

Melting costs are really less vital than the better and more uniform quality of castings made from electrically melted metal. Up to the present time both gas and electric furnaces have been used in this foundry, and definite data are available in a number of castings made to meet navy specifications. Seventy-five per cent of the castings which were poured from the electric furnace passed this inspection, but only 10 per cent of those poured from crucibles came within the Government requirements.

Wood Distillation Study at Virginia Polytechnic Institute

An intensive study of wood distillation has been authorized by the Virginia Polytechnic Institute. Dr. J. B. McBryde, of the department of chemistry and chemical engineering of the Institute, who will be in charge of the work, points out that wood distillation already is being conducted on a commercial scale at several points where success has attended the efforts to recover the by-products from stumps and the waste material made during the manufacture of pine lumber. He believes that a careful study of the chemical problems involved will make possible a much more effective distillation and the recovery of many valuable byproducts which can be obtained from pine.

Recent Chemical and Metallurgical Patents

American Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Concentrating Nitrous Gases.—There are several drawbacks in the processes used to concentrate nitrous gases. Thus when using alkaline solutions as absorbents, large quantities of liquid have to be evaporated. When absorbing in dry metal oxides, for instance in zinc oxide, these are usually of a so weakly basic nature that their absorbing effect is very small. A more efficient absorbent has been devised by BIRGER FJELD HALVORSEN of Christiania, Norway. A mixture of sodium hydroxide and ferric oxide or other metal oxide such as zinc oxide or aluminum oxide is used in the form of briquets. The reactions taking place when zinc oxide is used may be formulated as follows:

$$2NaOH + NO_2 + NO + ZnO = 2NaNO_2 + ZnO + H_2O$$

$$2NaOH + N_2O_4 + ZnO = NaNO_2 + NaNO_3 + ZnO + H_2O$$

The temperature of the gases not being too high, the zinc oxide remains unaltered.

Heat is then applied to cause the base and oxide to combine and we have

$$2NaNO_2 + ZnO = Zn(ONa)_2 + NO + NO_2$$

$$2NaNO_3 + ZnO = Zn(ONa)_2 + N_2O_5$$

Nitrous gases and sodium zincate are thus obtained. The gases are led off for use, and the residue, sodium zincate, is used over again at a lower temperature, acting as mixture of ZnO and Na_2O as follows:

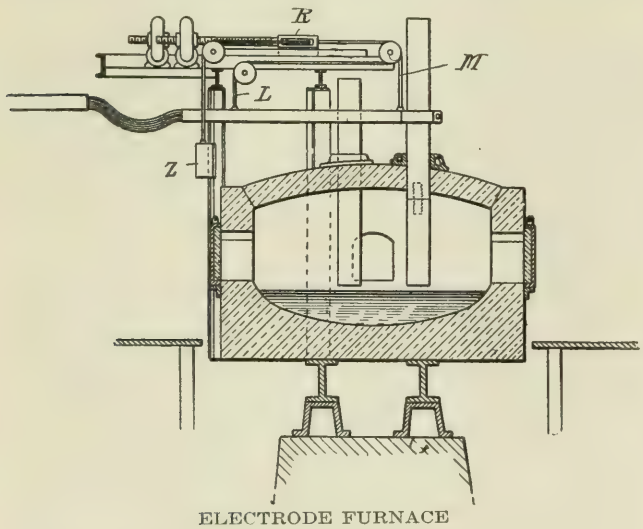
$$Zn(ONa)_2 + N_2O_4 = NaNO_2 + NaNO_3 + ZnO$$

(1,316,950; assigned to Norsk Hydro-Elektrisk Kvaelstofaktieselskab; Sept. 23, 1919.)

Process and Apparatus for Extracting Sulphur.—WILLIAM D. HUFF of LaFayette, La., has invented an apparatus for the economical recovery of sulphur from sulphur ore or other similar material containing native sulphur associated with gangue. The efficiency of the apparatus is dependent upon the melting of the sulphur in the absence of air and the conservation of a large portion of the heat imparted during the melting of the sulphur to the gangue and the parts of the apparatus which carry the sulphur-bearing material through the melting chamber. The sulphur ore is fed automatically to a series of buckets attached to rollers and formed into a continuous chain by means of links. This bucket conveyor dips beneath water contained in a tank, rises from the tank, passes through a melting chamber, and is again immersed in water in a second tank, passing over a sprocket wheel at the discharge end of the apparatus, where the gangue is dumped into cars for disposal. The two tanks containing water act as water seals for the melting chamber, thereby preventing the entrance of air to the chamber. The air is removed from the ore and the ore heated in the first tank. The heat of the gangue from which the sulphur has been removed in the melting chamber and the heat of the buckets, rollers and links are absorbed in the water in the second tank. The water is circulated through the tanks by a pump. Heat is provided to the melting chamber by means of a furnace. (1,317,625; Sept. 30, 1919; assigned one-half to James J. Connolly, of Roanoke, Va.)

Improved Sulphur Dyes From Waste Sulphite Liquor.—The fact that sulphur dyes can be prepared from concentrated waste sulphite liquor has been known for some time.[1] Such dyes may be improved, however, in the manner suggested by JACOB S. ROBESON of Pennington, N. J., by converting the calcium lignosulphonate into the corresponding salt of a heavy metal base. For example: 100 lb. of commercial 30 deg. Bé. waste sulphite liquor is mixed with 10 lb. of $FeSO_4$ dissolved in 40 lb. of H_2O. The precipitate of $CaSO_4$ is filtered off and the iron lignosulphonate precipitated from the filtrate by "salting out" with 30 lb. NaCl. After filtering and drying, the press cake is powdered, mixed with 42 lb. commercial sodium sulphide, 42 lb. sulphur and fused. When cold, the melt is pulverized. It is a black material which, dissolved in sodium sulphide solution, dyes cotton a brownish black, fast to sunlight and alkali. Sulphates of aluminum, copper, zinc, etc., may also be used, the dyes produced giving red brown, seal brown and gray brown respectively. (1,316,742; Sept. 23, 1919.)

Electrode Furnace.—WALDEMAR DYOSSEN of New York has developed an improved method of supporting the electrodes and electrode holders for furnaces of the Herould type, illustrated in the figure. The electrodes and holders are supported by cables *M* and *L* attached



ELECTRODE FURNACE

to common block *R*, which in turn is attached to threaded rod. This rod is movable by means of worm wheel and motor. An additional cable is looped through pulleys in blocks *R* and stationary pulleys located between the electrode holders. The free end of the cable is attached to counterweight *Z*. This arrangement makes possible the balancing of the weights of the electrodes and holders against each other, the weights *Z* being half the weight of one electrode and holder. This arrangement is advantageous in permitting the design of a furnace as free as practicable from heavy parts, the load on the motors being a minimum. (1,317,911; Oct. 7, 1919.)

Electrode.—SIGURD HEIER of Rjukan, Norway, increases the durability of rod electrodes in electric arc furnaces of the Schönherr type. This he accomplishes by modifying the shape of the furnace wall and also by providing a covering ring 5, Fig. 2. In Fig. 1 is illustrated the usual form of flame chamber, the flame taking a shape as shown by dotted lines 1. The rod electrode is shown at 2, the arrangement for water-cooling the electrode at 3. An insulated guide in the form of a ring is shown at 4. By modifying the shape of the furnace the arc flame takes the shape as shown

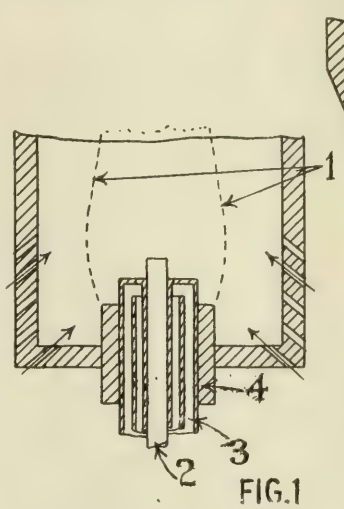


FIG. 1

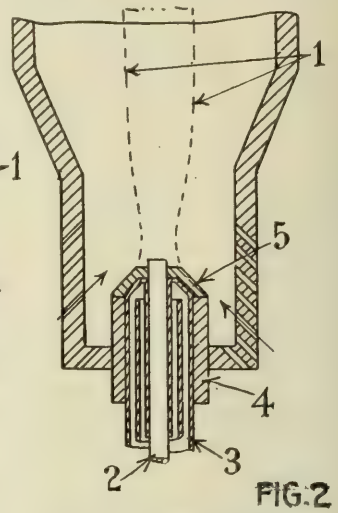


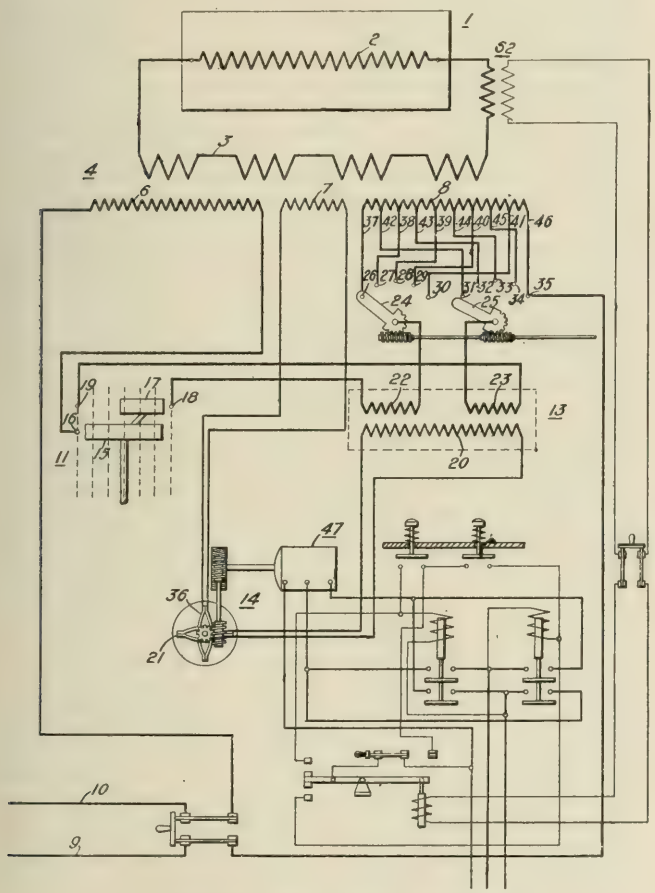
FIG. 2

by dotted lines 1 in Fig. 2. This together with the addition of the protective ring 5 increases the life of the electrode. (1,317,576; Sept. 30, 1919; assigned to Norsk Hydro-Elecktrist, Kvaelstofaktieselskab, of Christiania, Norway.

Furnace Regulator System.—EDWIN LEHR, of Pittsburgh, Pa., has devised a method of automatically or manually regulating the power input to electric resistor furnaces without causing abrupt changes in the furnace circuit. Where electric resistor furnaces have resistors with negative temperature coefficients it is desirable to avoid overheating of the furnace and resistor by reason of any abnormal flow of current. It is also desirable to maintain a uniform temperature within the furnace and therefore to regulate the power input. To be able to perform this regulation without causing excessive variations in the load upon the generator, furnace and other electrical equipment is decidedly advantageous. This method of accomplishing the regulation without causing either breaks or abrupt changes in the furnace circuit is best understood by referring to the sketch. The furnace 1 has a resistor 2 directly connected to the secondary 3 of the main transformer 4. The main transformer has two sets of primary windings 6 and 8, the portion 8 being provided with a series of taps 37 to 46, also an auxiliary winding 7. The primary windings of the main transformer are connected to the supply conductors 9 and 10 through a transfer switch 11 and through the switch arm 24 or 25. The transfer switch consists of a band 15 in contact with 16 at all times, and a segment 17 which extends slightly more than half around the circumference of the drum on which the band and segment are mounted. The segment 17 may make contact with either 18 or 19 or with both. The taps of section 8 of the main transformer are connected to contacts 26 to 35 and to the main circuit through switch arms 24 and 25. There is an auxiliary transformer 13 which has a primary winding 20 connected in series with the stationary coil 21 of the inductor regulator 14 and a secondary winding with two coils 22 and 23. The inductor regulator has

[1] Cf. Austrian patent 2336 (1889); *Paper Making*, vol. 36, p. 351 (1917).

in addition to the stationary coil 21 a movable coil 36 connected in series with the auxiliary winding 7 of the main transformer. The inductor regulator 14 and the tranfer switch 11 are rotated in unison by motor 47 through gearing which also controls the motion of switch arms 24 and 25. During one-half revolution of the transfer switch and the inductor regulator switch arm 25 makes contact with 31, then switch arm 24 breaks contact with 26, disconnecting that portion of the main transformer between taps 37 and 42. The switch arms are so proportioned that circuit through one arm is made before the circuit through the other arm is broken. The control of the voltage impressed upon the secondary of the main transformer is effected automatically by means of a control magnet and relay switches which control the motor 47. The changes in the electrical circuit and



FURNACE REGULATOR SYSTEM

the effect of these changes caused by a half revolution of the inductor regulator and transfer switch are these: The rotation of coil 36 of the inductor regulator impresses a voltage on the primary winding 20 of the auxiliary transformer 13, and, therefore, the energy input to the furnace. Just before the coil 36 has been rotated through one-quarter turn the impressed voltage has reached its maximum, which is one-half the voltage across two adjacent taps of the portion 8 of the main transformer. Switch arm 25 is now in contact with 31 and segment 17 of the transfer switch is in contact with 19. Accordingly the two secondary windings of the auxiliary transformer are connected in opposition and across the taps 37 and 42. The flow of current through coil 23 opposes the voltage of the supply current by an amount equal to one-half that across the taps 37 and 42. The further rotation of the transfer switch breaks the contact between segment 17 and 18, disconnecting coil 22. The current now flowing through coil 23 impresses a voltage in opposition to that of the main supply current and in amount equal to one-half that across the taps 37 and 42. The rotation of the inductor regulator through another quarter turn decreases the impressed voltage to zero and switch arm 24 has been disconnected from 26. This sequence of operations has therefore gradually increased the voltage impressed on the secondary of the main transformer by decreasing the number of turns in the primary winding and this change has been made gradually and without break in the circuit. (1,320,071; assigned to the Westinghouse Electric & Manufacturing Co., Oct. 28, 1919.)

Personal

Prof. WILDER D. BANCROFT has been delivering a series of scientific lectures of a popular nature on various phases of colloid chemistry. On Jan. 17 he addressed the Indiana Section of the American Chemical Society at Indianapolis, and he will speak on Jan. 22 and Jan. 29 before the Delaware Section, at Wilmington.

Prof. C. H. DESCH has resigned from the professorship of metallurgy at the Royal Technical College, Glasgow, to become professor of metallurgy at the University of Sheffield, England, in succession to Prof. C. O. Arnold.

C. H. FARNHAM is the chemist in charge of the laboratory recently equipped by the Spencer Heater Co., at Scranton, Pa.

F. A. J. FITZGERALD, of Niagara Falls, N. Y., has returned to the United States from a trip to Ireland.

JOHN CALDER HEBDEN has just returned from Europe, where he made extensive investigations of the chemical industry in France, England and Germany.

Dr. L. O. HOWARD, chief of the Bureau of Entomology of the United States Department of Agriculture, and for the past twenty-two years permanent secretary of the American Association for the Advancement of Science, has been elected president of that institution. Dr. EDWARD L. NICHOLS was elected general secretary in his place.

Major A. NAGELVOORT, who since receiving his discharge from the Chemical Warfare Service has been with the Matheson Alkali Works, Providence, R. I., is now with Arnold Hoffmann Co., Inc., selling agent for the Matheson Works.

ABRAHAM A. ORLINGER has been awarded the Chemists' Club Hoffman scholarship for 1919-20. Mr. Orlinger received his Bachelor of Science degree at the College of the City of New York, having specialized in chemistry, and is now pursuing the chemical engineering course at the Massachusetts Institute of Technology.

Dr. R. F. RUTTAN of McGill University is scheduled to deliver an address on "The Training of the Chemical Engineer" at the annual meeting of the Engineering Institute of Canada, Jan. 27-29.

LEWIS B. SKINNER, who recently severed his connection as general manager and vice-president of the Western Chemical Co., Denver, Col., will enter the consulting chemical and metallurgical field, with offices in Denver. He has recently been retained as consulting engineer for the Midwest Oil Co.

Prof. HAAKON STYRI has resigned from the faculty of the Carnegie Institute of Technology to assume the position of chief of the research laboratory of the S. K. F. Industries at Philadelphia, Pa.

Dr. LOUIS E. WISE has resigned from E. I. du Pont de Nemours & Co., with whom he was engaged in research at

their Jackson Laboratory at Wilmington, Del., to become professor of forest chemistry at the N. Y. State College of Forestry, Syracuse University, Syracuse, N. Y.

Obituary

RICHARD COCKBURN MACLAURIN, president of Massachusetts Institute of Technology since 1909, died on Jan. 15 of pneumonia at his home in Cambridge. During Dr. MacLaurin's eleven years as president, the Institute has received large endowments and increased its educational facilities enormously. Being primarily a mathematician and an investigator of the phenomena of light, Dr. MacLaurin became a close friend of George Eastman, who has just been identified as the mysterious Mr. S-MIT-H and donor of $11,000,000 to Tech.

Dr. MacLaurin was born at Lindean, Scotland, June 5, 1870. In 1896 and 1897, he received the Bachelor of Arts and Master of Arts degrees from St. John's College, University of Cambridge. For the next ten years he was professor of mathematics and during the two last years was dean of the law school of the University of New Zealand. In 1907 he was professor of mathematical physics at Columbia University and had just been appointed head of the physics department, when he resigned to become president of Technology.

Dr. MacLaurin's work in advancing the Institute to its present dominant position will place his name foremost among the educators of the present era.

Current Market Reports

The Non-Ferrous Metal Market

New York, Jan. 19—Copper is quoted at the same figure as last week. Nickel and lead advanced 1c. and ¾c., respectively; while tin declined 1¾c.

	Cents per Lb.
Copper, electrolytic	19.50
Aluminum, 98 to 99 per cent.	31½ @ 32½
Antimony, wholesale lots	10.12½
Nickel, ordinary	43.00
Nickel, electrolytic	46.00
Tin, Straits, spot	62.75
Lead, New York, spot	8.75
Lead, E. St. Louis, spot	8.37½
Zinc, spot, New York	9.55
Zinc, spot, E. St. Louis	9.22½
Silver (Dollars per oz.)	1.30¾

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23½ @ 24½
Aluminum, sheet scrap	22½ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp.	14½ @ 14¾
Copper, heavy and wire	13¾ @ 14
Copper, light and bottoms	12½ @ 12¾
Copper, heavy cut and crucible	15¾ @ 16
Brass, heavy	7½ @ 8¼
Brass, casting	10½ @ 10½
Brass, light	5½ @ 6⅜
No. 1 clean brass turnings	8¼ @ 8⅜
No. 1 comp. turnings	12 @ 12¼
Lead, tea	4¾ @ 5
Lead, heavy	6¼ @ 6½
Zinc, scrap	4¼ @ 4½

RARER METALS

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	93.00

The Iron and Steel Market

Pittsburgh, January 16, 1920.

The famine in steel products is unabated, as is evidenced by as high prices as formerly being paid for prompt shipment of certain products, particularly sheets, merchant bars, wire nails and plates, and in a few instances still higher prices. Also it is observed that in occasional instances, particularly in the case of sheets, mills that were obtaining large premiums for first quarter deliveries are now able to effect some future sales at the same prices.

PRODUCTION INCREASING

Production of steel continues to increase, though at no rapid rate, and may now be estimated at a trifle over 80 per cent of capacity. Labor shortage is much less a limiting factor than formerly, there being now relatively little labor shortage, in point of numbers, but there is still much to make up in point of efficiency, so many men being new to their employment, either from having shifted from one mill to another during the strike or from being entirely new to the steel industry. As the difficulty is almost wholly with common labor, it is to be expected that the teaching necessary can be completed with a month or two. The wire mills have been exceptionally short of labor, but have had a noticeable accretion of men in the past week.

The coke supply continues to be an important limiting factor in pig iron and therefore also in steel production. The shortage, as it appears in the market, is substantially as great as a few weeks ago, but the shortage has continued not because of production being curtailed, but because the consumptive demand has increased. The by-product ovens are doing distinctly better week by week, while the Connellsville region is increasing slightly, by a very few per cent in each of the past two or three weeks. The limiting factor in coke production is car supplies, at the beehive ovens of the Connellsville region and at the coal mines attempting to serve the byproduct ovens.

SALES AT VARIOUS PRICES

The occasional or chance buyer can secure steel, in the case of most of the finished products, only at prices much above the March 21 or "stabilized" price schedule, while consumers with regular mill connections frequently pay similar prices on extra tonnages, beyond what their regular sources of supply will allot them. In one sense these advanced prices represent "the market," though even from that viewpoint the market is not a quotable one, seeing that the price varies according to the buyer, the tonnage and the delivery. The great bulk of the business transacted, however, is at the March 21 prices, and in that sense the stabilized schedule is still "the market." Of sales made in December probably more than 75 per cent were made at the March 21 schedule. There are some predictions that the market will be a runaway, getting out of control of the Steel Corporation and other interests that desire to hold it to the March 21 schedule, and there are even claims made that the control has already been lost. Such statements and predictions appear to be premature. When time has been allowed for increased production to show what impress it can make upon the situation, a better basis for prediction will be afforded.

Sales in December may be analyzed with some closeness on account of the Steel Corporation's operations being known. The corporation's unfilled obligations at the end of December amounted to 8,265,366 tons, showing an increase during December of 1,137,036 tons. Shipments were about 950,000 tons, so that bookings were in the neighborhood of 2,100,000 tons. No sales were made by the corporation at above the March 21 schedule, but a portion of the business booked and reported as unfilled obligations, probably a relatively small proportion, did not have a price affixed, delivery being so extended that the price matter was left open. While the Steel Corporation by last accounts represents about 44 per cent of the steel industry (excluding the iron mills from the reckoning), the independents sold in December a much smaller tonnage. Those that have refrained from advancing above the March 21 prices were very reserved in selling, while in the case of those who were asking higher prices there was the double restriction that they were not willing to sell large tonnages and the

buyers were unwilling to contract for large tonnages. Thus it is safe to guess that three-fourths, and probably considerably more, of the steel business done in December was at not over the March 21 schedule.

Railroad Buying

While in practically all quarters the steel market situation is painted as being a very strong one, it can be observed that some of the colors used are not necessarily permanent. In particular, there is the assumption that the railroads will be large buyers after March 1, when the lines are to be returned to their owners. This view is hardly entitled to be called even a theoretical conclusion. Steel mills will not be operated upon what the public or even the railroad interests think they ought to have, but upon orders for steel the railroads are able and willing to buy and pay for. The president of the Pennsylvania Railroad has expressed himself that it is a waste of energy to consider at this juncture a program of extensive expansion of railroads during the next few years, explaining that the three things to be considered first are: Funding of the debts due from railroads to the Government for improvements made during the control period whereby the roads are handed back to the owners in better condition than when received, providing for obligations soon to mature, and providing for capital expenditures of the ordinary size.

As to large purchases of rails being about to exercise an influence upon the steel market situation, it ought to be observed that reservations have already been made, and are therefore a part of the reckoning of the steel mills, and that these reservations, with orders previously placed and stocks of rails now held by the roads, are sufficient to take care of a year's normal replacement plus any deficit that may have occurred in the past two years. The figures available are probably not consulted by those who make predictions as to rail purchases. Replacements during the three years taken as the test period to fix the rental to be paid by the Government should furnish a criterion, and averaged 1,328,316 tons a year. Replacements in 1918 were 1,111,638 tons and in 1919 about 1,350,000 tons, the two years thus showing a total deficit of 200,000 tons as compared with the experience in the test period. Stocks Jan. 1, 1920, were 375,000 tons and rails on order about 200,000 tons, while reservations already made amount to nearly if not quite a million tons.

The Chemical Market

New York, January 16, 1920.

Large manufacturers have avoided speculation and are serving their customers on the old basis wherever possible. It has become a habit of many engaged in the trade to have large stocks on hand when a shortage threatens and then dump it out at a greatly increased price. The result is an uncertainty in supply and price, as the mere rumored report of a scarcity has sent prices bouncing skyward. A fair example of this is the recent jump in *bichromate of soda*, which had a sensational rise until some hitherto unknown stocks were discovered and turned loose. Prices continued upward, then came the break and descending action back to normal. It is not often that business men of ripe experience are bitten twice by the same insect and it is the consensus of opinion that this latest rise is due to a real scarcity.

Bicarbonate of soda is again tending upward, due to a real scarcity, being quoted at 20@21c. per lb. Spot stocks on this item are scarce and it is rumored that under the present demand new price levels will be reached. *Wood alcohol* is unobtainable, the quotation remaining nominal at $4.80@$4.95 per gal. for carlots, $5.50@$7 per gal. for less than carlots. *Denatured, 188 proof*, is quoted at 76@78c. per gal., while 190 proof is quoted at 71@73c. It is rumored that the Government has withdrawn formula 1 for the manufacture of denatured alcohol, substituting a new one which will use considerably less wood alcohol and substitute pyradine, thus lowering the price on denatured and lessening the demand on wood alcohol. Manufacturers of wood alcohol are confronted with the difficulty of obtaining raw materials, and the orders placed by Japan last June and July for January delivery are now being filled, which accounts for the extreme shortage of wood alcohol

Oxalic crystals remain firm under an increased demand, and at present there is some difficulty in obtaining this item on spot. *Caustic soda* has been the center of interest, the quotation remaining $4.30@$4.50, but some sales have been reported as high as $4.65 per cwt. As all of the producers are sold up on this, it is practically impossible to obtain this item on early delivery. A strong market on *sal ammoniac* is the record for the past week, being quoted at 12¾@14c. per lb., with very little material available at this price. The coal supply is responsible for the strengthening in the ammonia grades, and this shortness will continue until there is a settlement in the coal industry. Formaldehyde has probably been the strongest feature of the market, speculation increasing and the actual supply diminishing. A larger production of alcohol is the only relief in sight from this present stringency. *Potassium carbonate* is now quoted at 26@27c. per lb., against 25c. of last week.

Coal-Tar Products. The shortage of raw materials is interfering with the manufacturers of these materials, some of the firms having withdrawn their names as producers of certain items in order to keep them for their own use in producing the finished product. The prices asked for *alpha naphthylamine* range from 35c. to 45c., while *crushed naphthaline* used as a base for beta naphthol is sold up to July by some producers. Among the short items of the coal-tar products, *benzol*, pure water white, remains nominally quoted at 27@31c. per gal. The shortage on this item is an aftereffect of the recent coal strike, but it is expected that there will be some material available around March 1.

Interest in the *waxes* has quickened during the past week, but prices still stand firm. There has been an increase of ¼c. per lb. on the two highest grades of *paraffine*, quotations now being on 133 to 135 m.c., 12c. and on 135 to 137 m.c., 13c. per lb.

In sympathy with the Savannah market, local dealers have advanced the price on *turpentine* to $1.97, with some sales recorded as high at $2.05. This jump from $1.60 of a few weeks ago has not been caused by any shortage in supply, but principally because of speculation in the London markets, where it was reported this item was short. The tremendous building campaign planned in England has caused this speculation. The London market at present is quoted around $2.10.

Vegetable Oils. The *linseed oil* market is very dull, business being at a minimum. Consumers are well covered for some time to come. The quotation of $1.77 per gal. still holds. The arrival of flaxseed from Buenos Aires continues heavy, several ships having arrived with reported cargoes of 53,000, 8,000 and 7,000 bags on board. The entrance of soap manufacturers as buyers in the vegetable oil field has had a tendency to strengthen all items on the list, noticeably *palm lagos*, which has increased to 17@18c. per lb., and peanut oil, which also jumped a cent to 24½c. per lb. It is the opinion of some that the price of 20@20¾c. per lb. for *cocoanut oil*, Ceylon grade, is not sufficient to meet the increased expenses of the crusher and this item will have a rise shortly.

Ores and Semi-Finished Products

Ferro-alloy market. General firmness in price and stronger demand in some lines marks the past week. Import and export inquiries have been heavy on ferromanganese, quoted at $140@$150 gross ton. Large demands and small stocks have occasioned this gradual rise from $130 of a few weeks past. *Spiegeleisen* continues under heavy demand because of its manganese contents of from 19 to 20 per cent, and is now quoted at $40@$50 per ton.

Among the *ores* and *semi-finished* products, *manganese* is probably the most active, inquiry being very heavy. The present quotation remains at 50@75c. per unit. *Coke* production still remains from 30 to 60 days behind schedule, and with only 30 to 35 per cent of the normal number of cars in operation, no relief is in sight. *Barytes*, white floated domestic, remains $35@$40 per ton in quotation for January contract, but it is expected there will be a rise in price for February quotations.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	2.25 –	..... – 2.50
Hydrofluoric, 52 deg.	lb.	.12 –	.14 – .....
Lactic, 44 per cent tech.	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	..... –	4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.06½ – .07	.08 – .....
Oxalic, crystals	lb.	.31 – .32	.32 – .35
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	..... – .....
Sulphuric, 60 deg., drums	ton	..... – 30.00	..... – .....
Sulphuric, 60 deg., carboys	ton	..... –	..... – .....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	..... – .....
Sulphuric, 66 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	25.00 –	30.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P.	lb.	..... –	1.35 – 1.45
Tannic (tech.)	lb.	..... –	.42 – .55
Tartaric, crystals	lb.	..... –	.69 – .74
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	..... –	.76 – .78
*Alcohol, denatured, 190 proof	gal.	..... –	.71 – .73
Alum, ammonia lump	lb.	.04½ – .05	.04½ – .04¾
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02¾
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	..... –	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½ – .14	.13½ – .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	..... – .....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	..... –	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..... – .....
Barium chloride	ton	80.00 – 85.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.09½ – .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03¾ – .04
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.90 – .95	..... – .....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	..... –	.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	..... –	2.50 – 3.75
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .80
Calcium sulphate, pure	lb.	..... –	.25 – .30
Carbon bisulphide	lb.	.05½ –	.06 – .09
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..... –	.75 – .....
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Cobalt oxide	lb.	..... –	1.50 – 1.55
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	..... –	.28 – .31
Copper cyanide	lb.	..... –	.65 – .70
Copper sulphate, crystals	lb.	.07¾ – .08¾	.09 – .09¼
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	2.30 – 2.50
Formaldehyde, 40 per cent	lb.	..... –	.51 – .52
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.24½ – .26
Iodine, resublimed	lb.	..... –	4.10 – 4.30
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.75
Lead acetate, normal	lb.	..... –	.20 – .23
Lead arsenate (paste)	lb.	..... –	.13 – .17
Lead nitrate, crystals	lb.	..... –	.30 – .35
Litharge	lb.	..... –	.09½ – .10½
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	..... –	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	..... –	.75 – .90
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	..... –	.56 – .60
Potassium bromide, granular	lb.	..... –	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.23 – .32	.35 – .42
Potassium iodide	lb.	..... –	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	..... –	.65 – .95
Potassium prussiate, red	lb.	..... –	1.10 – 1.20
Potassium prussiate, yellow	lb.	..... –	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	..... – .....
Rochelle salt (see sodium potas. tartrate)		..... –	..... – .....
Sal ammoniac (see ammonium chloride)		..... –	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake (sodium sulphate)	ton	18.00 – 21.00	..... – .....
Silver cyanide	oz.	..... –	1.25 – .....
Silver nitrate	oz.	..... –	.81½ – .82½
Soda ash, light	100 lb.	2.05 –	2.25 – .....
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.20 – .21	.22 – .25
Sodium bisulphate (nitre cake)	ton	3.00 – 8.00	10.00 – .....
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	..... – .08	.08½ – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..... –	4.30 – 4.50
Sodium hyposulphite	lb.	..... –	.03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04¼	.04½ – .05
Sodium potassium tartrate (Rochelle salt)	lb.	..... –	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .04¼
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.43 –	.60 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran.	lb.	.12½ –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	..... –	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.34 —	.37
Aniline oil, drums extra	lb.	.34 —	.37
Aniline salts	lb.	.43 —	.48
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.75 —	.....
Benzidine, base	lb.	1.10 —	.....
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.31
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.75 —	.80
Cresylic acid, 95-97%, dark, in drums	gal.	.72 —	.75
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	2.25
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.70 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12¼ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 —	.60
Salicylic acid, U.S.P.	lb.	.45 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white, pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.43 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.06½
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.09½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.13
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.30
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.30
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref	gal.	.49

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl	280 lb.	$17.00 —	$17.50
Rosin E-I	280 lb.	17.85 —	18.40
Rosin K-N	280 lb.	19.75 —	22.50
Rosin W. G.-W. W	280 lb.	22.50 —	24.25
Wood rosin, bbl	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	.... —	1.97
Wood turpentine, steam dist	gal.	.... —	1.70
Wood turpentine, dest. dist	gal.	1.64 —	....
Pine tar pitch, bbl	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl (500 lb.)	bbl.	15.00 —	15.25
Rosin oil, first run	gal.	.... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	.... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.47½ —	$0.48½
Upriver coarse	lb.	.34 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.53½ —	.54½
Ribbed smoked sheets	lb.	.53½ —	....
Brown crepe, thin, clean	lb.	.48 —	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23¾ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.20 —	.20¼
Cocoanut oil, Cochin grade, in bbls	lb.	.20½ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	$ .04½ —	$ .06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00 —	45.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C	lb.	.... —	....
Shellac, V. S. O	lb.	.... —	....
Shellac, Diamond I	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	140.00 —	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluorspar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

* Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq. ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.15½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil ,5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

EMERYVILLE (Oakland P. O.)—The American Rubber Mfg. Co., Park Ave. and Wait St., has awarded the contract for the construction of a 2-story factory and power house, to R. W. Littlefield, 565 16th St., Oakland. Estimated cost, $100,000.

SAN FRANCISCO—The Schmidt Lithographing Co., 2nd and Bryant Sts., retained F. Whitton, 805 Exch. Blk., to superintend the construction of a 5-story addition to its lithographing plant. Estimated cost, $228,000.

WATSONVILLE—The Ferro Products Co. is installing a modern plant on Monterey Bay and the Southern Pacific R.R., for the production of 99 per cent blank metallic oxide, that will supply a carload every 24 hours.

Indiana

FORT WAYNE—The Ft. Wayne Wks. of the General Electric Co. plans to construct a factory between Anthony Blvd. and Winter St., for the manufacture of incandescent bulbs.

Iowa

BOYDEN—The city has awarded the contract for the construction of a sewage disposal plant in connection with the proposed sewer improvement and water-works, to Ward & Weighton, 516-17 Davidson Bldg., Sioux City, at $12,200.

DES MOINES—The Pittsburgh Des Moines Steel Co. will build a 1-story, 135x300-ft. steel shop. Cranes and fabricating equipment will be installed in same. Estimated cost, $100,000. Work will be done by day labor.

Massachusetts

HOLYOKE — The American Writing Paper Co., 9 Main St., will build a 1-story, 90x92-ft. manufacturing building. Estimated cost, $25,000. Work will be done by day labor.

MONROE—The Monroe Bridge Paper Co. has awarded the contract for the construction of a 1-story manufacturing plant at Monroe Bridge, to George H. Stebbins, North Adams. Estimated cost, $25,000.

Michigan

DETROIT—The Western Gear Mfg. Co., 1040 Scotten Ave., has awarded the contract for the construction of a 1-story, 40x80-ft. heat-treating plant on Scotten Ave., to the Lundblad Co., Penobscot Bldg., Cyanide furnaces, annealing ovens, tumblers etc., will be installed in same. Estimated cost, $25,000.

Missouri

ST. LOUIS—The Century Electric Co., 19th and Pine Sts., has awarded the contract for the construction of a factory, to Stone & Webster, 120 B'way, New York City. Estimated cost, $500,000.

New Hampshire

NORTH STRATFORD — The Warner Sugar Refining Co., 79 Wall St., New York City, plans to construct a sugar refinery. Estimated cost, $1,000,000.

New Jersey

HALDEN—The town plans to improve water-works system, including a reservoir, filter plant, 16-in. main, etc.

JERSEY CITY—The Air Reduction Sales Co., Pacific Ave., plans to construct a 4-story factory building. Estimated cost, $124,000.

TRENTON—The American Steel & Wire Co., Hamilton Ave., has awarded the contract for the construction of a 1-story 60x100-ft. steel mill on Hamilton Ave., to James H. Morris, 137 East State St. Estimated cost, $25,000.

TRENTON—The Puritan Rubber Co., [illegible] Ave., plans to construct a 1-story, 25x128-ft. rubber factory. Estimated cost, $7,500. J. O. Hunt, 114 North Montgomery St., engr.

TRENTON—The Star Porcelain Co., Muirhead Ave., has awarded the contract for the construction of a 2-story, 34x68-ft. porcelain plant, to C. R. Randall, 43 North Hermitage St. Estimated cost, $6,000.

New York

CHESTER—The village plans to improve its waterworks system, including a reservoir, filter plant, etc.

ROCHESTER—The city will soon award the contract for the construction of a 3-story, 304x321-ft. junior high school at Wilson Park. Chemical equipment will be installed in same. Estimated cost, $1,200,000. Address J. M. Tracy, supt. of public school bldgs.

North Dakota

MINOT—The city will receive bids about Feb. 15 for the construction of a sewage disposal plant. F. Bass, Minneapolis, Minn., consult. engr.; E. J. Thomas, city engr.

Oklahoma

HUGO—The city voted $75,000 bonds for the construction of filtration plant.

Ohio

CLEVELAND — The Cleveland Rubber Mold & Machine Co., East 17th St. and Euclid Ave., has awarded the contract for the construction of a 1-story factory on Warner Rd., to the Moss Iron Wks., Leader-News Bldg. Estimated cost, $200,000.

CLEVELAND—The Cleveland Welding Machine Co., West 117th St. and Berea Rd., will soon award the contract for the construction of a 1-story, 42x106-ft. blacksmith shop and welding room. Estimated cost, $50,000.

CLEVELAND—The Westinghouse Electric & Mfg. Co., West 54th St., will build a 1-story, 128x165-ft. foundry addition at 1228 West 48th St. Estimated cost, $50,000. Work will be done by day labor.

Pennsylvania

ESSINGTON—The Westinghouse Electric Mfg. Co., Union Bank Bldg., Pittsburgh, has awarded the contract for the construction of a factory addition, to Westinghouse, Church, Kerr Co., Inc., 37 Wall St., New York City. Estimated cost, $2,000,000.

PHILADELPHIA—The city has awarded the contract for the extension of the Queen Lane filter system, to Edward Fay & Son, 2 South Mole St., at $367,734.

PHILADELPHIA—The Franklin Process Co., 291 Promenade St., Providence, R. I., has awarded the contract for the construction of 2-story, 75x103-ft. addition to its present manufacturing plant here, to J. W. Bishop Co., 109 Foster St., Worcester, Mass. Estimated cost, $45,000.

PHILADELPHIA—John T. Lewis & Bros., Lafayette Bldg., have awarded the contract for the construction of a 1-story, 120x150-ft. paint factory on Aramingo Ave. and Cumberland St., to the Turner Construction Co., 1713 Sansom St. Estimated cost, $100,000.

Tennessee

CHATTANOOGA—The Somerville Iron Wks., Somerville, N. J., have awarded the contract for the construction of a plant for the production of cast-iron pipe, on a site near the Signal Mountain Line, to the Austin Co., West 102nd St. and Berea Rd., Cleveland, Ohio. The plant will produce about 50,000 tons of castings annually. Estimated cost, $1,500,000.

Vermont

ST. JOHNSBURY—The Cary Maple Sugar Co. is having preliminary plans prepared for the construction of a maple sugar factory on Portland St. Estimated cost, $150,000. Webster & Libby, 534 Congress St., Portland, Me., engrs.

Wisconsin

SHEBOYGAN—The Badger State Tanning Co., South Water St. and Maryland Ave., is having plans prepared for the construction of a 4-story, 60x250-ft. tannery. Estimated cost, $50,000 to $60,000. Juil & Smith, Irving Bldg., archts. Noted Oct. 22.

British Columbia

VANCOUVER—The Canadian Carbonate Co., 1050 Hamilton St., has awarded the contract for the construction of a 1-story, 95x60-ft. factory at 11th Ave. and Yew St., to Baynes & Horie, 836 Howe St. Estimated cost, $70,000.

Quebec

MONTREAL—The Dominion Glass Co., 285 Beaver Hall Hill, has awarded the contract for the construction of a 3-story, 52x52-ft. glass factory on Wellington St., to Church Ross & Co., 10 Cathcart St. Estimated cost, $25,500.

SHERBROOKE—The Howard Pulp & Paper Co. has purchased a 9½-acre site on the bank of the St. Francis River and is having plans prepared for the construction of a wood pulp mill on same. Estimated cost, $750,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, New York Section, will hold a meeting, Jan. 23, on "Cheap Cyanide and Its Disposition."

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16 to 19.

THE AMERICAN WELDING SOCIETY will hold a meeting at Witherspoon Hall, Philadelphia, Pa., Jan. 23, at 8 o'clock, at which four papers on welding will be presented.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

Industrial Notes

THE MORSE BROS. MACHINERY & SUPPLY Co., Denver, Col., announces that it is dismantling the complete 500-ton concentrator and 250-ton copper smelter of the Penn-Wyoming Co. at Encampment, Wyo. The 16½-mile Leschen tramway is also being prepared for shipment. The tramway was built in four sections of four miles each.

THE ELECTRIC FURNACE Co., Alliance, Ohio, added a number of installations during the last quarter of 1919 which are of special interest on account of the new type of equipment involved and the special alloys which are to be melted in these furnaces. Among other installations may be noted the following for melting brass: The Standard Sanitary Mfg. Co., Louisville, Ky.; Akron Bronze & Aluminum Co., Akron, Ohio; Union Brass & Metals Co., St. Paul, Minn.; American Hardware Co., New Britain, Conn.; Roberts Brass Works, Detroit, Mich.; Kayline Co., Cleveland, Ohio. Mitsui & Co., of Japan, have purchased a 105-kw. nose-tilting furnace of one-ton capacity, together with a special motor-operated casting table, so designed that metal may be poured directly into the molds. Similar equipment, but with three casting tables, has been purchased by the Parrish Tool Co., Cleveland, Ohio.

PROF. W. F. COOVER, head of the department of chemistry of Iowa State College, delivered the principal address on Jan. 14 at the dedication of the new chemistry building of the State College of the University of Montana, at Bozeman, Mont.

THE CARBONDALE MACHINE Co., Carbondale, Pa., has recently opened a branch office in the Ellicott Square Bldg., Buffalo, N. Y., in charge of H. J. Botchford.

THE ALBERGER CHEMICAL MACHINERY Co. of 50 East 42nd St., New York City, has been formed for the marketing of special machinery for chemical plants and the purchase and sale of new and used equipment. A. H. Alberger, formerly president of the Howard Iron Works of Buffalo, is president of the new company.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, January 28, 1920 — *Number* 4

A Grand Old Man

THE award of the Perkin Medal to Professor CHARLES F. CHANDLER meets with general approval. There is something about a man hale and wholesome in the ripeness of his years that appeals to the affections of men very much as a beautiful child appeals to women. It was he who put a definite meaning to 66 degree sulphuric acid, and it was he also who fixed standards for the cuts of petroleum sold for lighting and substantially put an end to lamp explosions. He has maintained an open mind and the golden merit of intelligent curiosity all his days. He has walked along the road of a long life with a good word for every neighbor that behaved himself and a cheerful boost for those whose loads were heavy.

He has stood four square and upright for chemistry when the science was in the doldrums of neglectful years, and his many thousands of students rejoice in his friendship and are thankful for his illumination and encouragement.

When he enters a room there is a surge of warmth that makes all hearts beat faster because of the contagious quality of his charity, his enlightenment, and his ever young good fellowship. All honor and praise to him!

Fraudulent Branding Of Imported Articles

OUR attention has been directed to the fact that surgical instruments are being imported into the United States, after which the "country of origin" is polished off or otherwise removed. The substitution of a domestic dealer's name or trade mark then gives the instrument the appearance of domestic manufacture, and the purchaser is consequently defrauded.

The Federal law relating to the removal of the "country of origin" from imported articles, U. S. Tariff Act of 1913, Sec. 4, Par. F, Sub-Sec. 2, reads as follows:

> If any person shall fraudulently violate any of the provisions of this act relating to the marking, stamping, branding, or labeling of any imported articles or packages; or shall fraudulently deface, destroy, remove, alter, or obliterate any such marks, stamps, brands, or labels with intent to conceal the information given by or contained in such marks, stamps, brands, or labels, he shall upon conviction be fined in any sum not exceeding $5,000, or be imprisoned for any time not exceeding one year, or both.

We bring this to the attention of American chemists and metallurgists so that they may be on their guard against similar fraudulent practice in connection with laboratory apparatus or small-scale equipment. No cases of this kind have come to our attention, but the trick may crop out at any time, and we believe a warning is warranted.

Summary Dismissal Of College Professors

THEY have been having another grand row at the University of Saskatchewan and the board of governors has dismissed summarily the heads of four departments, including those of physics and chemistry. There was, it is said, neither a hearing nor a discussion of the subject with the persons involved; they were just fired in the good old way.

We happen to be acquainted with the late head of the department of chemistry, and while we have not heard his story or that of the governors who dismissed him, we are of the opinion that he will not need to look very hard to find employment. But there are far too many of these university rows. The trouble usually has its origin in politics, because a complaisant Governor appoints some old political hacks who are not good for anything else, to serve on the board of overseers. Sometimes the only thing to do is to dismiss certain professors as speedily as possible. Sometimes a public hearing washes so much dirty linen that it is a mistake, a psychological error. Again, it may make a big row out of a little one over a single man in the wrong place. Sometimes a wild man like SCOTT NEARING, late of the University of Pennsylvania, will cause trouble, no matter what happens. But professors are hard to get, and good ones are exceedingly scarce. Teaching is the most subtle of all the arts, and only the gifted ones can really acquire it. The practice involves considerable strain to get the attention of students, and if it is to be kept the student must be made to understand. A professor has to possess, besides scientific knowledge, some of which he has to try to impart to his students, all the wiles of the professional gambler who must arouse the cupidity of his victim, often against his will and better judgment.

The faculty of a university is not a section gang with the trustees acting as joint foremen. They cannot instruct the professors how to teach, for the reason that they don't know how. There is a reasonable dignity of bearing that is and always has been necessary in dealing with those who work with their minds. A gang boss with a lot of laborers under him who cannot be instructed beyond their dead weight may achieve results by yelling and cursing and firing anybody that doesn't push with the rest, but when he advances in rank and becomes head of the corporation he can't talk to his engineers that way.

The fact is, more particularly in regard to state institutions—and this is said with all the reservations and exceptions that the conditions may warrant—we need more culture at the top. Boards of trustees and occasionally a president need the graces of life; for the benefit of all concerned it is desirable that they be gentlemen.

The Railroads And You

A DOZEN years ago "JIM" HILL, whose railroads opened up our great Northwest and who knew railroads, said that the steam lines of this country would require an expenditure of one billion dollars a year to keep them in shape to serve and aid the national growth. They didn't get it; in those days a billion dollars a year was too large to imagine. A part of it was found, but even that part steadily decreased, and during the past three years an unprecedented event occurred in American railroading—the mileage actually decreased. Mileage not only decreased, but equipment did not properly expand, with the result that right now the railroads are working to utmost capacity and there are thousands of tons of freight standing still because there is no equipment with which to move it. Railroads have reached capacity because unified control and its accompanying economies in routing have not been able to increase tonnage perceptibly. That potential freight in huge volume is dormant is evidenced by non-completion of many highway programs due to lack of construction materials, and by statistics showing that during the coal strike the railroads moved nearly twice their usual amount of freight other than coal.

Car shortage, freight and passenger congestion have become endemic, solely by virtue of lack of funds for new construction, until now, as a recent estimate by the well-informed *Railway Age* puts it, six billion dollars and three years time is the minimum by which we can expect relief! How this money and credit is to be provided is a difficult question to answer, and that aspect we do not wish to discuss at this time, but merely aim to draw attention of our readers to undoubted facts with an urgent suggestion that they give their best thought to all available angles of the situation.

The outstanding truth is this: the railroads need, *immediately*, billions of dollars for essential expansion.

But is this an important thing for me? the reader may ask. From the most selfish standpoint one might rejoin, "What engineer is there but will be favorably affected by a construction program involving two billions a year? What person, from capitalist to laborer, but will reap good times from that amount of money put into circulation?" Even the most narrow-minded manufacturer or producer could get behind a program providing new railway facilities, for it would enable him to get his supplies more freely and to ship a larger volume of products with promptitude, an asset difficult to estimate in money value.

A curious thing comes to mind in connection with the poverty of our carriers. They are poor not because there is no money or credit available, for millions are daily going into the flotation of new industrials or the development of older businesses. In order that this investment may earn its expected return, the institutions must be able to do business; but how can they function normally when the railroads could not handle the traffic offered them last year? Without being an alarmist, one could seriously doubt whether we are not at the portal of a financial panic from industrial overexpansion similar to that of the '70s caused by optimistic railroad building. Then, we built railroads into country which had no traffic to carry. Now, we are producing traffic with no railroads to move it.

But finally, each engineer, each American citizen, should consciously work for speedy expansion in sound railway facilities simply because it will redound to the everlasting benefit of the whole people. Unquestionably unrestricted exchange of intelligence and of goods is essential for our national existence. How the thing can be done is a matter where opinions can well differ; the first thing to sink into consciousness as a certainty, however, is that, to avoid national disaster, railroad facilities must keep ahead of the procession.

When we know it must be done, then we know it can be done!

Dewatering Coal in the Byproduct Coke Industry

LONG ago a low-ash coke from a high-ash coal proved to be an easy engineering proposition, for the solution of the problem had been started centuries ago in the hands of the early gold panner and perfected in the modern ore-concentration tables. It was only necessary for the coal concentrator to reverse the usual mineral process by taking his cleaned coal from the tailing discharge of either a Deister or Wilfley concentrator and draw off his mineral-ash impurities at the ore discharge. However, the solution of the ash problem did not remove all the troubles, but only substituted others of only slightly less importance. The washed coal having been in intimate contact with almost thirty times its weight of water comes out from the draining elevators and conveyors with a water content of not less than 16 per cent. Draining for twenty-four hours reduces this to 12 per cent and draining for seventy-two hours reduces it to 10 per cent. Shipment in cars over reasonably long distances often shakes the water content down to 8 per cent. The result is that from 8 to 16 per cent of water is carried into the coke retorts in the various plants throughout the country.

Hot coal possesses an oily water-repellent surface which causes all the free water contained in a coke-oven charge to segregate and flow to the floor of the oven. It is not an uncommon sight to see water flow out at the base of beehive or even byproduct ovens. At any rate, all the water of a coke-oven charge will usually be found in the lower layers which will carry a content as high as 50 per cent of water. The quenching action of this heat conductor swiftly and certainly gnaws its way deep into the refractory silica lining. In one plant the rate of spalling of the brick at the base zone is reported to be an inch and one-half per year. One-fourth this much is said to be exceptionally good practice.

This destructive action of water on the retort walls is an enormous cost, but the simultaneous loss in gas, oil, tar and ammonia is even greater. All the gas must be used in furnishing fuel when coking such wet coal, due to longer coking hours and higher heats being used. One-third of the tar and oil yields is also destroyed where coals containing a high water content are coked, and 25 per cent loss of ammonia helps to swell the losses. It is a safe conclusion that "watered stock" is death to profits in the coke industry as well as elsewhere.

A centrifugal drier capable of handling seventy-five tons per hour with thirty-five horsepower has been put into operation recently, in which well-drained coal direct from the washers has been dewatered to 6 to 8 per cent. Installation of such equipment will be but a slight addition to the average byproduct coke plant. If arrangements could be made to heat the coal, a better separa-

tion would undoubtedly be had in the centrifugal and the water not separated mechanically could be largely volatilized subsequently. What the result of charging dry, warm coal into the coke retorts will lead to is highly problematical, but it will certainly be very profitable. That it will prolong the life of the retorts and give larger yields of byproducts is certain. The big question to be answered is whether it will lead to preheating the coal previous to charging into the coke retorts and make 12-hr. coke possible.

Dr. Percy and the Intellectual Misers

DURING the first half of last century there flourished in England the Grand Old Man of Metallurgy, one of those men before the days of infinite specialization whose erudition embraced not only all branches of his own art, but stretched over philosophy and humanity as well. Fortunately, he had time for the very important task of collating and publishing practically all the available information on metallurgy, a task which he has done so well that research is seldom required to seek out original sources antedating Dr. PERCY'S books. And the fact that he spoke with discrimination may be gathered when it is remarked that, among many other things in non-ferrous metallurgy, he suggested the possibilities of hyposulphite leaching —later utilized in the Patera process for silver extraction—he realized thoroughly the limitations of bag-filtration of fume, and was able to diagnose accurately the effect of oxide in tough pitch copper.

Once, Dr. PERCY, in discussing with Mr. GILCHRIST the causes of some failures in high-sulphur irons, said: "Remember, too, that it is of very little importance to the world who discovers a fact—that is, a truth; but it is of great importance that it should be published as soon as possible, so that the discoverer may repay in some very small measure the almost overwhelming debt that he owes to the labors of others."

His life was a constant exemplification of this thought —in short, Dr. PERCY to his contemporaries and juniors was a teacher and guide whose influence will never vanish. Give us more men like Dr. PERCY and fewer miserly investigators of narrow vision who imagine that because it cost them something to discover a fact they can erect a fence about that atom of Nature with a sign, "No Trespass."

The Steel Needs Of the Railroads

IT IS a common experience of the individual, when considering his own affairs, to find that it is much easier to estimate his requirements, or draw up a schedule of what he wants, than it is to obtain means for meeting the desires. The same conditions as to wants or requirements and ability to meet them obtains also in the case of more public affairs of various descriptions, and then there are controversies. In the case of railroads, for instance, a great many people have been talking about the "needs" of the railroads without giving much thought to the ability of the railroads to pay.

If some of the suggested programs for the railroads were carried out, a very large quantity of steel would be required, and the common viewpoint is that this would mean a great deal for the steel industry. There seems to be little disposition to look at the matter from the other viewpoint—that it would also mean a very great deal of money to the railroads.

One method of approach to this subject of the steel needs of the railroads has been to take the pace at which railroad development proceeded during one period or another in the past, and then compute the amount by which the railroads have fallen short of continuing the expansion, this amount being taken as a deficiency which must be made up.

In arguments of this sort there is very frequently a fallacy, that of not considering the individual activity in question as part of the general industrial activity of the country. Generally speaking, no individual activity can increase indefinitely at a rate out of proportion to the increase in the total activity of the country. This is a perfectly obvious fact, but usually it is noted as to a given activity only when a short-range comparison brings it out. For instance, in the five years, 1895 to 1900, the production of portland cement was multiplied by 8½, while in one year, from 1900 to 1901, the production increased by 50 per cent in addition. Quite obviously that pace of growth could not continue indefinitely, for in a few decades everybody would have to be at work making or consuming cement, and when that point was reached those who were consuming cement would have to begin leaving their jobs to go to work at cement factories in order to maintain the rate of increase in production.

Now in the case of the railroads there are statistics to show that freight movement in ton-miles per inhabitant increased by 50 per cent from 1888 to 1898, ten years, then from the 1898 standard increased 50 per cent in seven years to 1905, and then from the 1905 basis increased 50 per cent to 1916, eleven years. The successive periods in which the freight movement per capita increased by one-half were ten years, seven years and eleven years. Hence, from a narrow viewpoint it might be argued that a corresponding geometric rate of increase should be provided for the future. As a matter of fact, however, these statistics show that there is something wrong. The per capita freight movement was 1,013 ton-miles in the fiscal year 1888 and 3,840 ton-miles in the calendar year 1917. At it dropped to 3,820 ton-miles in 1918, the size of the movement cannot be attributed simply to the war. This proves rather plainly that in future the individual will have to curb his desires for ton-miles. He may get a few more ton-miles each year, but not the same percentage increase year after year. The individual, however, will take care of that. He has other things to do besides consuming ton-miles.

Speaking more generally, we cannot year after year put more and more of our work into one particular activity. When an activity has caught up with the general procession it must simply take its place there. There is one thing we can do, however. Instead of building a lot more freight cars to move nineteen miles a day, we can devise means for making the existing cars carry freight further than nineteen miles a day. We can replace small steam locomotives with large electric locomotives, and instead of double tracking a single track road we can signal the single track and make it yield more service.

All this will require careful planning, and it is along such lines quite largely that the railroads are going to develop, not along the line of rushing to buy indiscriminately rails, cars, locomotives and bridges just like those that have been bought in the past.

Readers' Views and Comments

Melting Non-Ferrous Metals and Their Alloys in the Electric Furnace

To the Editor of Chemical & Metallurgical Engineering

SIR—The article entitled "Melting of Some Non-Ferrous Metals and Their Alloys in Electric Furnace," which appeared on page 673 of your Nov. 26-Dec. 3 issue, is one of great interest to the brass industry in general, and particularly to those firms and individuals that are making an intensive study of the economics involved in electric brass-melting. It would be well if every technical or semi-technical writer who discusses this subject would employ the same comprehensive and meticulous attention to detail which characterizes Mr. Collins' article.

Nor should the author be expected to give equal space and attention to each of the several electric furnace types now in commercial use for the melting of brass. He is describing a comparatively new type of furnace, hardly out of the experimental stage as yet, and, in a commercial sense, almost unknown to the brass-melting industry. Naturally he describes in considerable detail the design and performance of the furnace in which he is particularly interested, and discusses others only in a comparative way, particularly with reference to those points in which he considers his own design to be superior. Under these circumstances, it should merely be required that the author confine himself to the facts, and be reasonably fair, as well as accurate, in his comparisons. An inference which leads to an inaccurate conclusion in the mind of the reader is as misleading and as dangerous as a deliberate misstatement of fact.

In the article in question one such inference has certainly been made, possibly through ignorance of the real facts. Perhaps it should not be expected that one who has concentrated intensely upon the development of a single furnace design should, at the same time, have a broad, general knowledge of the field and of the equipment which is already in commercial use for the purposes he has in mind. On page 674, after classifying electric furnaces as, (I) solid resistance type, (II) liquid resistance type, and (III) arc type, the author discusses the application of these three types to the melting of non-ferrous metals as follows:

> In the making of brass, furnaces lying in each of the three classes have been tried out. Furnaces lying in Classes I and II lend themselves readily to the generation and control of a mild, "soaking" heat such as is required for melting volatile alloys. As illustration, the common resistance furnace lies in Class I, and the induction furnace in Class II. Furnaces in Class III generate a too intense and burning heat to be used with even questionable success in melting volatile alloys without the use of much unnecessary manipulation and watchfulness requiring much skill. Control of the electric arcs in atmospheres high or low in volatile gases, freedom from surging, low power factor and high metal loss are some of the serious problems confronting the man who would melt volatile alloys in the Class III arc furnace. Their employment had best be left for steel.

Is it not reasonable to suppose from the substance of the above paragraph that the arc type of furnace has been thoroughly tried out for melting brass and has proved a failure; that it is not and cannot be used for the purpose mentioned? That would appear to be the unmistakable inference. What are the facts? There are at present in commercial use for melting brass in the United States four distinct types of electric furnace, counting the one described by Mr. Collins. Three other types, limited in their use to a single installation in each case, may be neglected. In all there are about 200 of these furnaces, with a melting capacity in the neighborhood of 400,000 tons of brass and other non-ferrous alloys per year. Fifty of these furnaces, or 25 per cent of the total, are of the arc type. The induction furnaces in use are all of small size, while the resistance furnaces, with their "mild, soaking heat," melt metal very slowly and have a correspondingly small annual production. As a consequence, out of 400,000 tons total annual capacity, approximately 250,000 tons must be credited to a single type of arc furnace, familiarly known as the "rocking electric furnace." In other words, more than 60 per cent of the annual production of electrically melted brass is from the arc-type of furnace.

Is it going too far to say that the inference of the quoted paragraph is misleading and therefore dangerous?

The specific objections to the arc-type of furnace, listed by Mr. Collins, are: Difficulty of control, power surges, low power-factor, and high metal loss. These objections are based on theory, definitely disproved by experience. So far from requiring exceptional skill, most "rocking" furnaces are operated by men of quite ordinary intelligence who have received perhaps a week's training before taking complete charge of the furnace. Power input to the furnace is very steady and there are no surges objectionable to the power supply company, which, after all, is the party most interested in this phase of furnace operation. These furnaces consistently operate at a power factor from 85 to 95 per cent, which is entirely satisfactory to the most exacting power company. As for metal loss, the values shown in the table herewith, taken from the everyday experience of five representative plants with rocking arc furnaces, are better than those claimed by Mr. Collins for his furnace and, on the whole, rather better than the best figures so far reported for any other type of electric furnace.

OPERATING PERFORMANCE DETROIT ROCKING ELECTRIC FURNACE

Plant	Metal	Melting Time	Daily Production Tons in 9 Hr.	Kw.-Hr. per Ton	Gross Metal Loss, per Cent	Net Metal Loss, per Cent
Foundry	Yellow brass	1 hr., 13 min.	5	299	....	0.9
Foundry	Red brass	1 hr., 1 min.	6	280	0.44	....
Rolling mill	Yellow brass	57 min.	6	262	....	0.9
Rolling mill	Yellow brass	51 min.	6	224	....	1.02
Rolling mill	Yellow brass	43 min.	6	206	1.0	....

It should be noted that in four cases out of five these metal loss figures are for yellow brass—containing, in the case of the three rolling mills, from 37½ to 40 per cent zinc—and that the losses actually experienced are approximately one-third lower than those claimed by Mr. Collins for his furnace. In the case of the foundry melting red brass, the *gross* loss is less than one-half of 1 per cent, more than one-third lower than the value claimed by Mr. Collins for similar alloys.

The author of the paper has accurately listed and summarized the general advantages of electric melting,

but in stating the elements of design which must be incorporated in the electric furnace in order to realize these advantages, he has apparently been influenced almost entirely by his own experience with the resistance-type of furnace. The writer of this letter wishes to take the following exceptions to the statements made.

1. While, in order to avoid excessive maintenance costs, it is necessary to employ a "mild, soaking heat" in all furnaces which heat their refractory linings and roof to a temperature considerably above the pouring temperature of the alloy, this gentle and inefficient method of heating is entirely unnecessary in the arc furnace, where the source of heat is much nearer to the metal than to the refractories.

2. Similarly, volatile alloys do require gentle heating if they are melted in a quiescent bath, no matter how shallow, but may safely be heated much more rapidly and efficiently if the metal is stirred vigorously by the rocking motion of the furnace, and lack of uniformity in heating thus eliminated.

3. Properly speaking, a resistance furnace cannot be forced, nor a high rate of melting attained while melting brass, without seriously shortening the life of the refractories and increasing the metal loss.

4. The author states: "If the source of heat is such that its temperature lies in the temperature zone safely below the destructive distillation point of the metal, then the bath can in no manner exceed it." True enough, but in melting yellow brass (65 per cent copper, 35 per cent zinc) which requires to be poured at 1075 deg. C. and boils at 1115 deg. C., a heat source which did not greatly exceed the latter figure would never succeed in bringing the metal up to the specified pouring temperature. Even with red brass, where the range between pouring temperature and boiling point is much greater, the same thing is practically true.

It has long been admitted that the electric-arc furnace inherently possesses qualities of simplicity, reliability, efficiency and melting speed which cannot possibly be equalled by the resistance furnace. For this reason, the arc furnace is used almost exclusively in melting steel. In the case of brass, the only valid objection to the arc furnace has been that rapid heating of a volatile alloy, coupled with lack of uniformity in the application of heat—a characteristic of all stationary furnaces, whether arc or resistance—resulted in an excessive metal loss. That this difficulty has been completely overcome by rocking the furnace during melting, and so stirring the metal as to keep it thoroughly mixed, can be testified to by every user of this type of furnace, as exemplified in the instances given in the table.

In the interests of perfect fairness, it should be added that Mr. Collins has not been entirely just to the fuel-fired crucible furnace. It must be admitted by every proponent of electric melting that the electric furnace is far more costly in its initial installation than an equivalent installation of combustion furnaces. This initial handicap is, of course, readily overcome by the far greater operating economy of the electric furnace, but any fair comparison between the two should include, as an operating charge, a reasonable sum for interest and depreciation on the investment. This often means an item of a dollar or more per ton of metal melted, in favor of the combustion furnace. To ignore this item, and at the same time include a charge of 10c. per ton against the crucible furnace as interest on the cost of crucibles held in stock, which the author has done in Table I, page 677, is an absurdity.

There are other points in the article, both technical and economic, to which exception might reasonably be taken, but the above discussion covers the more important ones. The principal point for emphasis is that the article states, by implication at least, that the arc furnace is entirely unsuited for melting brass and cannot properly be used for that purpose. The fact that considerably more than half of the electrically-melted brass in the United States, including both red and yellow alloys, is melted in the rocking arc furnace is perhaps a sufficient answer to the statement. It might be added, however, that no arc furnace of this type has ever been rejected by the user as unsatisfactory in its performance, which is more than can be said of any other type of electric brass furnace, with the probable exception of the induction furnace.

H. M. St. John.
Detroit Electric Furnace Co.,
Detroit, Mich.

Dangers of Denatured Alcohol

To the Editor of Chemical & Metallurgical Engineering

Sir—Many of the daily newspapers and other publications have been filled recently with scare heads in which "wood alcohol" has been prominently featured as responsible for many deaths which have taken place among the more ignorant and debased (or at least thirsty) of our population at widely different locations.

Wood alcohol is now sold at about three times the cost of fully denatured alcohol and is not available in large quantities at drug stores, and its sale is not pushed.

On the other hand, denatured alcohol must contain by law 10 per cent of an especially poisonous wood alcohol containing, according to regulations, 10 per cent of acetone and other ketones and aldehydes which are much more poisonous than methyl alcohol. This denatured alcohol is for sale at all drug stores in convenient packages and is advertised at garages for use as an anti-freezing remedy.

Prof. Baskerville (Chem. & Met. Eng., Dec. 10-17, 1919, and elsewhere) has warned against wood alcohol and quoted the internal revenue regulations which emphasize the poisonous properties of fully denatured alcohol.

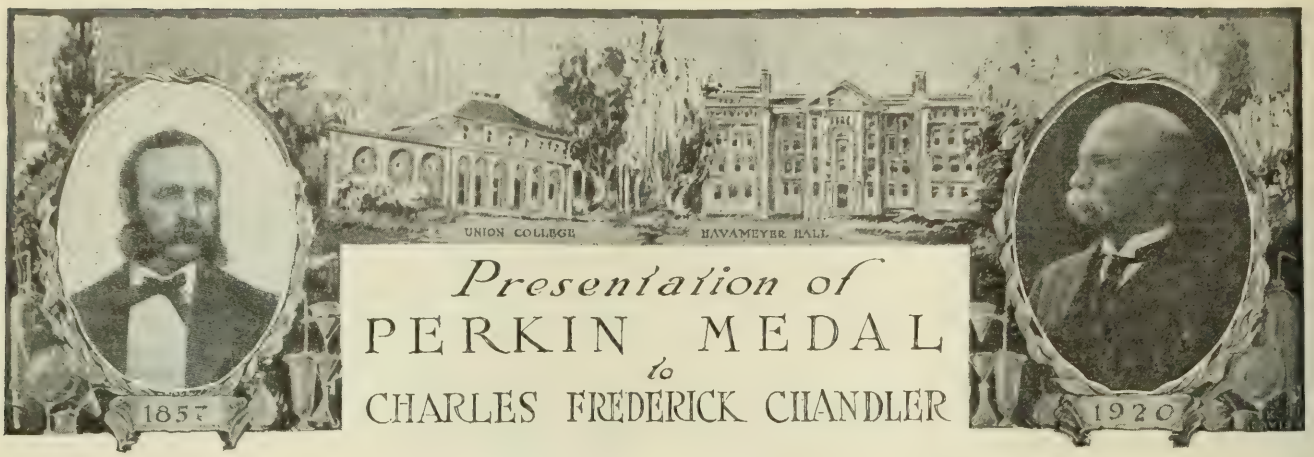
It is our professional duty to warn the public that drinks composed of *denatured alcohol* crudely doctored up will be the most likely poisonous drink to be offered surreptitiously and to caution against this danger.

H. O. Chute.
New York, N. Y.

Electrochemists Discuss Cyanide

The New York Section of the American Electrochemical Society devoted its meeting on Jan. 23 to a discussion of cheap processes for the production of cyanide. Herbert Philipp reviewed past and present methods of manufacture, pointing out the advantages and disadvantages, and also reviewed the uses of cyanide, which are mainly in the metallurgical industry for the treatment of gold and silver ores; for the fumigation of buildings, vessels, trees and food products; electroplating and case-hardening. There is apparently a market in the United States for 25,000,000 lb. per year.

W. S. Landis described a new cyanide product which has found extended use in the metallurgical industry for the treatment of gold and silver ores. Both papers will be published in full in early issues of this magazine.



Presentation of PERKIN MEDAL *to* CHARLES FREDERICK CHANDLER

AFTER introductory remarks by Charles E. Sholes, chairman of the New York section, at the fourteenth annual Perkin medal presentation meeting of the Society of Chemical Industry, Friday night, Jan. 16, and some humorous reminiscences by Dr. M. C. Whitaker, who has been intimately associated with Prof. Chandler for the past twenty years, the Perkin medal was graciously presented to Dr. Chandler by Prof. Marston T. Bogert of Columbia University. Abstracts of the addresses follow:

Personalities

By M. C. Whitaker

To attempt to tell you something new about the personal side of Dr. Chandler's career is a difficult undertaking, when speaking to people who have been his friends and associates for years. It seems on second thought, however, in view of my twenty-one years of intimate acquaintance with him, that I might be able to recall a few instances to illustrate prominent characteristics and record the impressions which these observations have left upon my mind.

Tact is one of Chandler's great achievements.

It used to be, and probably still is, a source of great amusement to the students in the upper laboratories of Columbia to drop paper bags filled with water on the heads of pedestrians. Now and then, when marksmanship is good, they hit a Fifth ave. bus.

On one occasion, the victims were two handsomely gowned, unusually dignified, middle-aged ladies of evident social position. They swung into the Havemeyer Building, almost immediately after the accident, fairly sputtering with indignation and rage, and were met at the door by the ever-ready Chandler. They were somewhat disarmed by his genial smile, glistening eye and ready wit, and accepted his invitation to his office to discuss ways and means of properly punishing wayward students. Tea was served with liberal proportions of a flavoring extract made in New England, but named after what is destined to be a famous West Indian island. Negotiations leading to the punishment of the students soon began to take a more hopeful trend, and in the course of half an hour the two ladies left the building, much improved in spirits, with their anger and rage replaced by smiling countenances and very audible laughter.

Chandler's Generosity

Chandler's earnings from his profession probably far exceed those of any other chemist in America. His generosity to others, however, keeps pace with his earnings. No one knows, not even Chandler himself, of the great financial assistance which he has given to many students. A few years ago an old Columbia graduate, unknown to most of us, died in the far West, and provided in his will that the money loaned him by Chandler from time to time should constitute the first claim upon his estate. It was with a great deal of difficulty, and without much assistance from Chandler, that we were able to determine how much money was involved. It turned out to be several thousand dollars, in loans scattered over many years.

There are doubtless many cases of this kind, because during the forty-six years that Chandler was dean of the School of Mines, he was the friend, confidant and father confessor of every one of that great army of students whose troubles are innumerable. It is out of the question for a man of Chandler's tender heart to refuse needed aid to a student. In proportion to his wealth, he gives away more than any American millionaire.

His money is not spent on automobiles, yachts, fine wines or lobster palaces, but is spent on others.

Chandler's Collection

A few months ago I was invited to attend the private exhibition of the household effects of a late citizen of New York, chiefly known for his diamonds. As I stood in the center of a special room, gazing at the wonderful collection of necklaces, bracelets, handbags, slippers, garters and stockings, I was suddenly struck with an idea. I thought of the Chandler Museum at Columbia, and recalled the innumerable times when Chandler would rush up to the University and disgorge from his pockets the most mysterious collection of teacups to illustrate some particular kind of porcelain, saucers typifying a style of decoration, vases of wedgwood, decanters showing particular design of cutting or etching, wine glasses with special features, napkin rings and even spoons. I wondered if there was anything in common between Chandler and "Diamond Jim," and then my thoughts turned to what a place must have looked like after a *joint raid* by these two collectors.

I have touched briefly upon Chandler's intuition, his ability to inspire others, his good fellowship, his tact, his good will toward others, and his hobbies. It seems to me that all of these qualities go to make up a great case for the human side of Chandler's character. I believe that we should write in large letters, and place high in the list of his distinguished achievements, and in words which I must leave to others to coin, something to express the human side of Chandler.

Presentation Address

By Marston Taylor Bogert

Dr. Chandler, Ladies and Gentlemen: The accomplishments of sixty years of tireless, skillfully-directed activity cannot be reviewed in the brief time at my disposal this evening in more than a hasty, imperfect and superficial way, and I know that my colleagues fully appreciate the magnitude of the task assigned me and the impossibility of telling Dr. Chandler in any one evening all that we would like to say in eulogy of his many notable contributions to civilization and in expression of our affection for him personally.

A day for toil,
An hour for sport,
But for a friend,
Life's all too short.

[After reviewing the ancestry, boyhood and educational training at Harvard, Göttingen and Berlin, where Dr. Chandler received the degrees of A.M. and Ph.D. in 1856 when but twenty years of age, Dr. Bogert gave an account of his teaching at Union and Columbia.]

As Educator

In January, 1857, Dr. Chandler was appointed assistant to Prof. Joy at Union College, Schenectady, N. Y., and in the spring of that year they opened the chemical laboratory there, enrolling six students in the first class. In those days, Union was one of the largest colleges in the United States, ranking even Harvard. The place was designated as an assistantship, but the budget item provided, namely, $400, was for a janitor, and, as a matter of fact, the new incumbent actually did janitorial service as well as teaching, making the fires, carrying the coal and ashes, and doing other tasks of like character. In April of the same year, Prof. Joy was called to Columbia College, and Dr. Chandler succeeded him at Union, lecturing to 150 seniors, most of them older than their teacher. The late United States Senator Warner Miller was a later pupil.

Little attention had been paid at Union to instruction in the sciences, so that permission was obtained without difficulty to introduce new courses from time to time, with the result that he was soon giving lectures in general, inorganic, organic, analytical, and agricultural chemistry, blowpipe analysis, mineralogy, and geology.

For more than seven years he remained at Union in charge of the laboratory and lecture work in chemistry and other subjects, rapidly building up a strong and influential branch of the college's work.

Columbia School of Mines

Union College possessed a wonderful collection of minerals which had been gathered together by Charles M. Wheatley of the Wheatley and Perkiomen mines of Pennsylvania, and had been purchased for the College by Mr. Delavan, owner of the Delavan House at Albany, N. Y., for $10,000.

It was the existence of this splendid collection of minerals that brought Dr. Egleston to Schenectady in 1864, and made him acquainted with Prof. Chandler. He was somewhat startled to see the latter conducting commercial assays of ores for gold and silver, and to learn that he gave lectures on the subject also, as he had been under the impression that only the graduates of foreign schools of mines were equipped to do work of that nature. This was one of the things that led Dr. Egleston to the conclusion that Chandler was the man needed to join General Vinton and himself in the project of establishing a school of mines in New York City as part of Columbia College. A formal invitation arrived not long afterward, and Dr. Chandler signified his acceptance. To the credit of his deep sense of patriotic duty be it recorded that he delayed his departure from Schenectady until after election day, 1864, in order that he might not lose his vote for Abraham Lincoln.

Few Technical Schools at That Time

There were at that time but few technical schools in the country, and no school of mines, and many people regarded this project of founding a school of mines in New York City as decidedly visionary and unpromising. Nevertheless, the three professors concerned were so enthusiastic on the subject and had such faith in its ultimate success that they agreed to undertake the work without any guaranteed salary whatever, other than the fees from such students as might register for the course.

George T. Strong, William E. Dodge, Jr., and several other good friends provided a total of about $5,000 to equip the laboratories. A fine cabinet of minerals was donated by Gouverneur Kemble, and President Barnard, Dr. Torrey and other Columbia trustees encouraged the enterprise in every way possible.

Some vacant rooms in the basement of the old college building on Madison Ave. and 49th St. were fitted up for the laboratories and accommodation there provided for twelve students. The new school opened its doors Nov. 15, 1864, and twenty-four students presented themselves for admission on that date. Chandler has often told, in his own inimitable way, how he used to open the laboratory at 7 a.m., start the fire to warm it up, sweep and clean the room, and do all in his power to make the place as attractive as possible and the lot of the students a pleasant one. It was inevitable that there was passed on to these students at the same time some of his own overflowing energy and enthusiasm.

Growth of the School

The school was a phenomenal success practically from the beginning. During the entire winter, carpenters and plumbers were kept busy installing new desks for new students, and the number of students for the first year finally rose to forty-seven. During the following vacation a large four-story factory building on the campus was placed at the disposal of the school, and sufficient funds were provided to equip it with suitable laboratories, lecture rooms, etc. Accommodations were arranged for seventy-two students. Eighty-nine registered for the second year and the school was thronged. The success of the venture being so great and so obvious, the trustees finally arranged to place it on a substantial basis as an integral part of the college work. Prof. J. S. Newberry was called to the chair of geology, relieving Chandler of this subject, and a complete faculty of professors and junior officers was established. A new building was erected especially for this new school, the plans of which were drawn up by Dr. Chandler himself. It was designed to accommodate 150 students, and was soon overflowing.

The school continued to prosper and its field to unfold and expand until what began as the School of Mines in a few basement rooms with twenty-four stu-

dents has now become a whole group of great technical schools (mines, engineering, chemistry, architecture and pure science) with many thousands of students and six splendid buildings and with a reputation which is not merely national, but international.

Thirty-three Years as Dean

Although at first appointed professor of geology, analytical and applied chemistry and assayer, Dr. Chandler soon was made dean of the school and became its leading figure, all-pervading geuius and chief driving force. For thirty-three years he served as dean, and of the many able and devoted men who have built their lives into this splendid institution, none have contributed so much as he. In 1897, when the university moved to its new site upon Morningside Heights, Prof. Chandler resigned his post as dean, but continued in charge of the department of chemistry as the "Mitchill professor of chemistry" until his retirement from active service, July 1, 1911. In the early days, he lectured upon all branches of chemistry, both theoretical and applied, but as the staff grew in numbers he transferred to his younger associates most of this, so that during the later years of his professorate his lectures were mainly upon general and industrial chemistry.

It was largely through Dr. Chandler's personal solicitation and influence that the Havemeyer family generously provided the funds for the erection of a splendid chemical building at the new site. Before drawing up the plans for this building, Dr. Chandler made a special trip to Europe for the purpose of examining the construction of the leading chemical laboratories there, with the result that Havemeyer Hall, when finally completed, embodied the best that was then known in regard to laboratory construction, and was universally regarded as the finest chemical laboratory in the United States.

Created Chemical Museum

The Chemical Museum of Columbia University is his own creation, begun and expanded through his indefatigable labors and personal generosity and, in recognition of this fact, the trustees have very appropriately named it the Chandler Chemical Museum. For many years it was unique, and is believed to be still the most complete of its kind in the world. There the visitor will get a very vivid impression of the extent to which our modern civilization is dependent upon the science of chemistry.

[Dr. Bogert here read the resignation of Prof. Chandler from the faculty in 1910 and several glowing tributes paid to him at that time. His work at the New York College of Pharmacy and the College of Physicians and Surgeons was briefly stated.]

As Author and Editor

As an author, Prof. Chandler has a long list of publications to his credit, embodying the results of research and invention, official reports, public addresses, sanitary regulations, analyses of waters, minerals, milk, etc., a survey of which shows at once the wide range of his interests and the versatility of his genius.

As an editor, he supplied for several years an American Supplement to the monthly edition of the *Chemical News* (of England); and, in July, 1870, in association with his brother, Prof. William H. Chandler, of Lehigh University, founded the *American Chemist*, and continued its publication until April, 1877, when it was given up, to make way for the *Journal of the American Chemical Society*. Another editorial task, and one which proved most laborious, was that of chemical editor for Johnson's Encyclopedia.

As Industrial Chemist

Chandler was one of America's first great industrial chemists, and aided and enriched almost every chemical industry which this country supported during the two decades following 1866.

His services have always been in demand by those great corporations whose manufacturing processes are based upon chemistry, for he has not only a thorough knowledge of that science, but also an alert mind stored with original and valuable ideas. He has been generally acknowledged to be the highest authority in this country in the field of industrial chemistry. While other able and eminent chemists have their single specialties, Chandler has been called a specialist in all branches, and is especially expert in sugar refining, petroleum refining, the manufacture of illuminating gas, photomechanical processes, and calico printing. He has served as chemist for the N. Y. Gas Co., and for the N. Y. Steam Sugar Refining Co., as consultant for the Standard Oil Co. and for various other great business interests.

He has no rival to the title of dean of the industrial chemists of the United States. Even now, at the ripe age of eighty-three, he is laboring daily in the offices of the Chemical Foundation, Inc., helping to prepare our country for the German chemical competition.

As Contributor to the Progress of Chemical Industry

One of his first and far-reaching contributions to the progress of chemical industry was the invention of the system of assay weights, as outlined in his article entitled "A New System of Assay Weights," which appeared in the American Supplement of the *Chemical News* of August, 1869. Although this system has been for years the one used by all assayers and metallurgists, it is safe to say that but few of them are aware of the fact that it was Chandler who introduced it, with the aid of Becker & Son, who manufactured the weights according to his specifications.

His observations and belief in the possibilities of the Castner process for the production of caustic soda by electrolyzing sodium chloride in a "tipping cell" with a flowing mercury cathode were communicated to the Matheson interests and they later, acting upon his advice, purchased the American patent rights and established in this country a great electrochemical industry at Niagara Falls, N. Y.

Water was one of the subjects to which he early turned his attention, and complete analyses were made of nearly all the famous Saratoga Springs waters. His first important commission was the investigation of boiler incrustations and feed waters for the New York Central R.R. Co., which investigation was begun in 1863 and completed in 1864 at the School of Mines.

It may be of interest also to note, in passing, a fact which is probably unfamiliar to many of this audience, namely, that it was due to Chandler's advice and urging that the firm of Eimer & Amend started their laboratory supply business in 1874. The founders of this firm were German apothecaries who were dissatisfied with the standard of purity of the American pharmaceutical products of that day and therefore began the

importation of alkaloids, etc. Chandler, who was personally acquainted with them through his connection with the College of Pharmacy, called at their office and urged them to extend this branch of their business and to include also the importation and manufacture of chemical apparatus. How great an assistance it has been to the cause of American chemistry to have had at hand the stores of fine chemicals and apparatus provided by this firm, it is difficult to over-estimate.

As Patent Litigation Expert

So much of his time was occupied in great patent suits that but little was left for investigation. I well recall his advice, when I asked him to give me some guiding principles in serving as chemical expert in such litigation. His answer was brief and to the point: "Know your lesson. Tell the truth. Don't be afraid to say 'I don't know.'"

The most famous suit in which he participated was that brought in the interest of the widow and assignees of the Rev. Hannibal Goodwin, an Episcopalian minister of Newark, N. J., and an amateur photographer, who was the first successful inventor of a flexible nitrocellulose film for the kodak camera and for moving picture negatives and positives. Goodwin's opponents kept him in the Patent Office ten years before he could get his patent, when he died. Thirteen years of most strenuous litigation was required to win against the infringer. Rather than have a court investigator examine the books to determine the proper award, the defendant settled with the plaintiffs by the payment of $5,000,000, which is believed to be the largest amount ever secured in a patent suit.

Other noteworthy suits were the first synthetic coal-tar color cases, of which there were five concerned with artificial alizarin, and others later which had to do with the Roussin patents, owned by Poirier & Co., of Paris, for the azo dyes obtained by diazotizing sulphanilic or naphthionic acid and coupling with suitable amines, amides or phenols; but to review even briefly the many notable suits in which he has been engaged would take an entire evening, as they include subjects in almost every branch of chemical industry.

As Builder of American Chemical Organizations

As a builder of American chemical organizations, Dr. Chandler has played a notable rôle.

He was president of the convention of chemists which gathered at the grave of Dr. Joseph Priestley, Northumberland, Pa., July 31 and Aug. 1, 1874, to celebrate the centennial of chemistry, and where the first seeds were sown of what was later to become the largest and most powerful national organization of chemists the world has ever known, and of which Chandler has been twice president and many times a director—the American Chemical Society.

The founding of this society is described in the issue of the *American Chemist* of May, 1876. After the centennial meeting in 1874, the project of establishing a chemical society was often discussed by many of the New York chemists, and it was finally decided to call a meeting for the purpose. As was to be expected, Chandler at once became the recognized leader in the movement and, under date of Jan. 22, 1876, a self-constituted committee, of which he was the guiding genius, sent out a circular letter to all chemists in New York and vicinity inviting co-operation in the formation of a local chemical society. Emboldened by the number of favorable replies received to this communication, the same committee, on March 22, 1878, distributed a second circular letter suggesting the desirability of organizing a national instead of a local chemical society, and submitting a tentative draft of a constitution and bylaws for an American Chemical Society. So many approved the proposal that a call for an organization meeting was issued on March 27, 1876, and on April 6, 1876, this meeting was held in the rooms of the New York College of Pharmacy, with thirty-five chemists in attendance and with Dr. Chandler as presiding officer, and the American Chemical Society was born.

There were, to be sure, some conservative and timid souls who feared for the success of the venture, but they were in the minority fortunately, and the progressives rallied in overwhelming numbers to Chandler's support. Among the latter was another of the great builders of American chemical industry, a former president of this society, Dr. William H. Nichols, who at that time uttered the following prophecy: "We do not come here expecting to find a society ready formed, with a library and a fine building; those will come in time. There is enough enthusiasm among the chemists to give us them by and by." Two of the men largely responsible for the fulfillment of that prophecy were Chandler and Nichols.

Chandler is thus the father of the American Chemical Society. The handful of members has grown to over 13,000, and this vast membership is drawn not only from our own land but from all quarters of the globe. The few hundred dollars income of those days has swelled to an annual budget of close to a quarter of a million. There are more local sections now than there were chemists at the organization meeting forty-four years ago. To take the place of the *American Chemist*, the society publishes three great journals, which circulate among all the civilized nations of the world.

It is also just to refer to Dr. Chandler as the father of the Chemists' Club, for, although he was not the originator of the movement which led finally to its establishment, he had always spoken in favor of such an affiliation of our New York chemists, and he was the unanimous choice for the club's first president. Without his wise and experienced guidance, his unquenchable optimism, and his financial assistance, the club would have had a hard struggle for existence. He has been its chief reliance through good and bad weather.

Other Honors Received

In addition to the honors already recorded, the University of Göttingen, upon the fiftieth anniversary of his Ph.D. degree, officially renewed this degree and sent him a parchment to that effect.

He received the M.D. from the University of New York in 1873, and the LL.D. from Union College the same year. In 1900, Oxford University conferred upon him its D.Sc. This was indeed a signal distinction, as the only previous recipient of this honorary degree from Oxford had been the Prince of Wales. Chandler was thus the first scientist upon whom it was conferred. In 1911, Columbia also awarded its LL.D.

He is a member of the National Academy of Sciences, of practically all the leading chemical societies both here and in Europe, and of many other scientific, learned, and philanthropic organizations.

On April 30, 1910, a huge banquet was given in his honor by the chemists of America and a bronze bust of life size was presented to Columbia University. It is

an excellent likeness, and now is housed in Havemeyer Hall where all may see it.

When the Society of Chemical Industry decided to recognize its large and influential American Section, and to draw closer the bonds uniting the two nations, it made inquiry as to whether there was any one American chemist who, by the common consent of his colleagues and in virtue of his achievements, might properly be regarded as first among our industrial chemists. There was no question that Chandler was, and had been for many years, the leading figure in this field, and he therefore received the unprecedented compliment of election to the presidency of this great international society, being its first American president, and thus joined the group of distinguished men who had held that high office previously.

The Medalist

Were Sir William Perkin himself alive, I am sure that nothing would have given him more pleasure than to have seen the Perkin medal presented to his dear friend Chandler, for when Sir William and his family last visited our shores, the Chandler home was their home.

Perkin's contribution to applied chemistry was the founding of a great industry, which has had a most marvellous development and by which civilization has been brilliantly advanced. Chandler's greatest contributions have been in the most important chemical industry of all—the making not merely of chemists, but of men, and in applying his chemical knowledge in the service of mankind to protect the health of the community and to save human life.

Thousands of lives and an immense amount of suffering are saved annually as the direct benefit of the sanitary reforms which he initiated. Other thousands of lives have been so profoundly impressed by his noble example and inspiring altruism that the world is a better and a happier place to live in. The bounds of such an influence are far-reaching indeed, and its duration outruns the lives of many generations.

No student ever attended his courses without being immediately struck with the fact that here was a man of lofty ideals and noble aims who was honestly and unwearyingly trying to be of service to his day and generation, and whose actuating impulse might not improbably have been expressed somewhat as follows:

> If men can say—if they but can—
> "He did his best; he played the man;
> His way was straight; his soul was clean;
> His failings not unkind, nor mean;
> He loved his fellow men and tried
> To help them"—I'll be satisfied.

I am sure that I speak not alone for myself, but also for this entire gathering and for all who know him, when I say that in our judgment he has consistently lived up to that standard throughout his long and useful life, and that he has achieved a wonderful measure of success in the sense of that work as defined by Dr. William H. Nichols, who regards it "not as the acquisition of property but the making the most of oneself."

The Presentation

The medal is awarded this year to Dr. Chandler because, in the opinion of the jury of award, in addition to his many valuable contributions to other branches of applied chemistry, he has made such notable advances in the great fields mentioned that he has placed the entire world in his debt and brought added prestige and dignity to the profession of which he is such a conspicuous ornament.

And now, my dear teacher, guide and friend, I cannot tell you how happy I am to be the agent selected to present this beautiful medal to you—I who have received so many favors at your hands, and who would not exchange for any amount of chemical knowledge the inspiration and encouragement derived from your example of a life worth while, and a character, like this medal, of pure gold.

May it be to you a token not only of our high appreciation of your brilliant scientific achievements, but also of our deep and abiding affection! May it bring to you and to those dear to you immeasurable happiness, and may you long be spared to continue your useful work and to be the friend and guide of those setting out on life's journey.

> For, after all, life is a highway,
> And its milestones are the years,
> And now and then there's a tollgate
> Where we buy our way with tears.
>
> It's a hard road and a rough road,
> And it stretches steep and far,
> But it leads at last to a haven of rest
> Where peace and happiness are.

Address of Acceptance

By Charles F. Chandler

Mr. Chairman, Ladies and Brother Chemists: I never was more surprised than when I was notified that the Medal Committee representing the different societies interested in the Perkin medal had awarded it to me. I had never really considered myself eligible, as I supposed the medal was intended particularly for discoverers and inventors of important processes in industrial chemistry. Nevertheless, I accept it with gratitude as an expression of appreciation and affection on the part of my brother chemists.

The selection of Milton C. Whitaker and Marston F. Bogert to speak for me this evening is most gratifying. There are no two men in the chemical profession for whose attainments I have a greater respect or for whose personal qualities I have a greater affection.

After having had the pleasure of presenting this most valued token of appreciation to eleven distinguished chemists, it seems odd to stand tonight in a position of the receiver instead of the giver. It is, however, eminently appropriate that Dr. Bogert should take my place on this occasion, as it falls to the lot of the senior available ex-president of the Society of Chemical Industry residing in the United States to make the presentation.

I happen to have been the first to receive this honor from the Society, there never before having been a foreign president. The experiment must have been satisfactory, as it was soon followed by the election of Dr. W. H. Nichols, then Prof. Ira Remsen and finally by Dr. Bogert. Dr. Nichols and Dr. Remsen are not available tonight, and so the duty falls upon Dr. Bogert as the representative of the Society of Chemical Industry.

I think that there was another reason for selecting Dr. Bogert to make the presentation address. He has had experience at the banquet of the chemists, April 30, 1910, and conspicuously demonstrated his ability to say the kindest and most flattering things about his "old professor."

Dr. Bogert has given you such a comprehensive account of my life and experiences, it is hardly necessary

for me to go very deeply into the subject. I will therefore select only a few incidents which may possibly interest you.

What Determined Dr. Chandler's Career

When I was about fourteen years of age and attending the New Bedford High School, the incident occurred which settled my career for life. There was a young instructor who had a class in chemistry which I attended. He made the subject so interesting that I decided that I must be a chemist. I had a little workshop which I promptly converted into a chemical laboratory, had the tinsmith make me a gas holder and amused my three or four intimate playmates by making oxygen, hydrogen, olefiant gas and various other experiments. The impression which this teacher made upon me has lasted ever since. Two or three years ago I had occasion to give a lecture in New Bedford and I opened it by recalling my school days and I enlarged upon the influence which this young teacher had exerted upon my life. I was subsequently informed that he died while still very young. It was in 1851-52 that I attended his courses. A few days after my lecture I received the most touching letter from his aged widow, who is still living and had been told what I had said of her husband. Her letter brought tears into my eyes.

In 1853 I entered the chemical laboratory of the Lawrence Scientific School and spent a year under the instruction of Prof. Eben N. Hosford, a most charming man. Here I pursued a well-arranged course of instruction in qualitative and quantitative analysis. Here another incident occurred which had a profound influence on my subsequent life. Two strangers visited the laboratory one day and we half dozen young chemists were introduced to them. One was Prof. Josiah D. Whitney, the eminent mining engineer and geologist who five or six years afterward became a very intimate friend of mine; the other was Dr. Charles A. Joy, who had just been appointed professor of chemistry to take charge of the new laboratory at Union College, Schenectady. Prof. Joy told us that he had just returned after a course of four years' study in Germany in the laboratories of Friedrich Wöhler and Heinrich Rose. I subsequently wrote him for further information on the subject of studying in Germany and received a full and enthusiastic account of the advantages not only of studying in Germany but of studying with these particularly distinguished chemists. It resulted in my spending my next year in the University of Göttingen. I was fortunate in being placed at once by Prof. Wöhler in the laboratory for advanced students, which was under his personal direction. I took several courses of lectures and practical instruction, not only in chemistry but in physics, botany and mineralogy.

Companionship With Celebrated Professors

We had a large colony of Americans in Göttingen during the year, most of whom were studying chemistry and some of whom have subsequently held most important positions in the United States. As I was the youngest of them all, it was a great privilege for me to enjoy the companionship which was quite intimate in that small town with such men. One of them, Prof. Goodwin, was a Harvard professor of Greek; another, Prof. Harkness, who was there with his wife, was professor of Greek in Brown University. At the end of the year Prof. Wöhler, who had been a father to me and had invited me frequently to his house, induced Prof. Heinrich Rose to take me into his private laboratory as an assistant, where I spent a year working in the same room with him. He, too, was a father to me, and invited me frequently to his house. His brother, Gustave, with whom I studied mineralogy, was equally friendly. I attended several courses of lectures in general chemistry by Heinrich Rose; industrial chemistry and physics by Prof. Magnus and physics by Prof. Dove. At the houses of the two Roses I used to meet some of the most distinguished scientists in Berlin, particularly Poggendorf and Ehrenberg, the father of microscopy. I also had the great pleasure while in Berlin of spending a couple of hours with Baron von Humboldt in the Royal Palace in Potsdam. Both Wöhler and Rose gave me the most interesting material to work upon in their laboratories either for the purpose of preparing a constituent in some quantity or for making accurate analyses of the minerals. For example, I worked upon the following materials; that is, minerals containing them when the mineral itself is not mentioned: Selenium; tellurium; lithia; thoria; yttria; molybdic acid; tungstic acid; cerite; columbite; tantalite; sarmaskite and yttrotantalite, and other more common materials.

At the end of my second year in Germany, I was asked to put the work that I had performed in the laboratories of Wöhler and Rose into the form of a dissertation, which I did. It was accepted and printed in Göttingen at the University Press in 1856 and I received without examination, in consequence, my degrees of A.M. and Ph.D., or, as they call it in Germany, Dr.Phil.

Begins Professional Life at Union College

On my return to America late in the summer of 1856, I found an invitation awaiting me from Prof. Joy inviting me to come to Union College and accept the position of assistant in the laboratory. This invitation I promptly accepted and on Jan. 9, 1857, I began my professional life. I felt under such obligations to Prof. Joy for having directed me to Europe that I did everything I could in the laboratory for his convenience and comfort. In four months he was called to Columbia College and left at once to take the position. Fortunately for me, the venerable president of Union College, the Rev. Eliphalet Nott, had so much confidence in my abilities that he offered, if I could lecture to the senior class, to put me in charge of the chemical department and give me the title of professor when I was old enough to merit it. I remained at Union College until the fall of 1864; was married, given a house which had formerly been occupied by President Nott and had established courses of lectures in the different branches of chemistry, including agricultural chemistry, and in mineralogy and geology.

Established Columbia School of Mines

Then by a happy accident I was invited by Prof. Eggleston to join him and General Francis Vinton in establishing the School of Mines at Columbia College, which has proved such a great success. The most fortunate circumstance in connection with this embryo school of mines was the fact that we had no salaries. My friends ridiculed and lamented what they considered my rashness in acccepting what seemed such an unpromising appointment. But it turned out a great success. The school not only grew rapidly into a large enterprise but it gave a most powerful impetus to the growth and development of Columbia College, which

although it had been in existence for more than 100 years had only 155 students, almost exclusively residents of New York City. This school of mines, which quickly became a school of every variety of engineering and chemistry, drew students from all over the United States, and spread the name and reputation of Columbia College everywhere, while the graduates, particularly the mining engineers, carried the name of Columbia to Australia, New Zealand, South Africa, South America and Mexico.

If I should continue in this vein to tell you all of my experiences during the sixty-four years that have elapsed since I received my degrees, I should be obliged to keep you here for hours.

Starting at Columbia with no salary at all, with only the expectation of receiving one-third of the fees that might be paid by any student who might attend, we were naturally permitted to take any outside work that was congenial which did not interfere with our duties in the School of Mines. I was soon enabled to take advantage of this privilege by giving afternoon lectures from 5 to 6 at the College of Physicians and Surgeons and evening lectures at the College of Pharmacy and also to accept invitations for professional work of different kinds.

Work for Excise Board

One of the most promising invitations I received came to me from the Metropolitan Board of Excise. The members of this board, not being chemists, were imbued with the idea that there was an enormous amount of adulterated alcoholic beverages in New York and as they had a very high license and a million dollars to their credit in the bank, they started out to put a stop to this adulteration and I was invited to act as their expert to analyze the samples and to appear in the courts as their representative. When they inquired of me how much I would demand for making these analyses and appearing in court, I told them it would depend upon the number they were likely to have. They told me that there were 8,000 liquor dealers and they would certainly average three samples each, so I agreed to a fee of $20 for each case, no matter how troublesome it might be. This they considered reasonable, and when I figured it up I saw a prospective $480,000. They promptly sent me forty samples, upon which I exhausted every possible chemical test. These samples came from Mulberry Bend and other localities where the poorest liquors are probably dispensed. They consisted of brandies, whiskeys, rums and gins. Some were of very good quality, some were not so good, but not a single one contained any objectionable constituent; not one was adulterated. I must confess that I was not much surprised, because I had had some previous experience in making such analyses, especially for the Vermont State Liquor Agency, and I knew that the newspaper stories of adulterated and poisonous liquors were without foundation. I received a check for $800 according to contract and never another sample for analysis, and I charged $479,200 to profit and loss.

Kerosene Industry

I have been told that some members of your committee were of the opinion that my work in putting an end to kerosene accidents and stabilizing the manufacture and the quality of kerosene was my most important work, and I will give you a little account of that and then bring my remarks to a close.

In the year ended Oct. 31, 1869, there were ninety-eight fires caused by kerosene accidents in New York City, and thirty-one in Brooklyn. There were fifty-two persons burned to death in New York City from the same cause, mostly women and children. It was generally supposed that these accidents were due to the fact that kerosene consisted of hydrocarbons, similar to those of camphene and burning fluid, which were known to be inherently dangerous and which could not be made safe. When this matter was called to my attention, I said at once, "Kerosene can be made safe," and took up the investigation of the subject at once.

Manufacturers of kerosene and chemists had decided that all that was necessary to make the oil safe was to separate the lighter oils benzine and gasoline. And I believe that they did so. A standard of quality had been adopted by them. The kerosene oil must not evolve combustible vapor at 100 deg. F., and must not take fire below a temperature of 110 deg. F. On purchasing seventy-eight samples in shops in the city, I found that one sample was pure naphtha, while every one of the seventy-eight others was adulterated with naphtha. Not one of them came up to the standard of the manufacturers. I had a sample of real kerosene for comparison which I obtained from the works of a friend of mine, Dawner of Boston, which had a flash point of 109 deg. F. and a burning point of 128 deg.

Report on Kerosene Spread Broadcast

Just as I finished my experiments there was a terrible accident in New York in which a mother and child were burned to death. I sat up all night and wrote my report. It was manifolded at the Board of Health and given to all the papers, in which it was printed in full, and later published all over the country. The Board of Health of New Orleans had it printed and left a copy at every door. It was quoted in Berlin and in Rome. On Jan. 21 a supplementary report was made showing the temperatures reached in twenty-three house lamps, of glass and of brass, of different sizes, after periods from 1 to 7 hr. After 1 hr. the highest was in a brass lamp, 100 deg. F., the lowest in a glass lamp, 77 deg. F. After 7 hr. the highest was in the same brass lamp, 91 deg. F., the lowest in a glass lamp, 78 deg. F.

The investigations were continued, and later in the year a third report was made containing the following additional results, with a new collection of samples from retail shops in New York City:

	Samples
1. Safe oils complying with requirements	21
2. Dangerous oils, flash point below 100°	280
3. Still more dangerous, flash point below 100°, burning point below 110°	306
4. Pure naphtha	29
Total number of samples	636

A fourth investigation was made and reported, March 18, 1891, of a much more elaborate character which covered 110 printed pages. This was published and Charles Pratt asked permission to print 10,000 copies, placing an advertisement on the cover of his famous extra safe oil, known as Pratt's Astral Oil, which flashed at 125 deg., and burned at 138 deg. F. Permission was cheerfully granted.

The board adopted a sanitary ordinance limiting the sale of oil having a flash point below 100 deg. or a burning point below 110 deg., and appointed inspectors and equipped a testing laboratory, and before long kerosene accidents became very rare, and when they did occur generally resulted from kindling the fire with kerosene

or some other kind of criminal carelessness. Not long after this I was engaged, in company with Prof. Silliman, to act as an expert witness in a suit brought by infringers by Downer & Co. of Boston. This company had worked on oils obtained from the destructive distillation of coal, and also on petroleum. By employing a special process they produced, among other products, two specially high test oils: Downer's Standard Kerosene, flash point 115 deg., burning point 128 deg.; and Downer's Mineral Sperm, flash point 262 deg., burning point 300 deg.

Combustion

I will quote here a few paragraphs from a lecture on "Combustion" which I gave before the American Institute Jan. 5, 1872, immediately after the great fire in Brooklyn which was so disastrous to life.

"Naphtha is not explosive; vapor of naphtha is not explosive; it is a mixture of naphtha vapor and air, in certain definite proportions, which is explosive. If, in experimenting, we do not hit the proper proportions, we fail to produce an explosion. Any oil that will emit an inflammable vapor at any temperature below 100 deg. F. is liable to form explosive mixtures of vapor and air, and is dangerous. I know of no process by which the lighter products of petroleum, gasoline, naphtha and benzine can be made non-explosive or safe, nor do I believe that there is any such process. If any oil takes fire at ordinary temperatures, or below 110 deg. F., it is proof positive that it is dangerous, and no argument or experiment can prove anything to the contrary.

"This coat on its iron frame is a good representation for our purposes of a victim to kerosene. I will drench him with good kerosene; you see now that though I hold a candle to him he is in no danger. I will now throw a little of Smith's 'Safety Oil' upon him; you see the moment the candle is brought near him he bursts into flames. I will save the poor wretch from a painful death by bringing the Babcock Fire Extinguisher to bear upon him. I have put him out; but were he human his days would be numbered, as a painful death would be sure to follow such frightful burns as those he has suffered from Mr. Smith's safety oil. It is said, and I believe with truth, that the burning of a square foot of the human body is sure to cause death.

"Before leaving this portion of the subject, I want to show you how safe it is possible to make petroleum oil. I have here a pail containing 3 gal. of Downer's 'Mineral Sperm Oil.' Into it I will plunge this mass of cotton waste till it becomes saturated with the oil; now as I raise it you see it is dripping with the oil. On holding the candle to the oily mass you see I have considerable difficulty in setting it on fire, but by heating it in one spot I shall finally heat a portion to a temperature above 300 deg. F., its burning point, when it will take fire. Now you see I have succeeded in starting combustion, and the burning oil quickly heats the rest of the mass till we have a flame 10 or 15 ft. high. You need not feel alarmed, for I have the flames entirely under my control. I will now plunge the burning mass into the pail of oil; you see it is at once extinguished. The 'Mineral Sperm' is actually a fire extinguisher.

"But this oil will stand a much more severe test. Here we have a large pan of oil on a water bath. These two large alcohol lamps have raised the water to boiling; you see the steam escaping from this vent; the oil is at 212 deg. F., 112 deg. above the standard flashing point and 102 deg. above the standard burning point of safe oil. Yet you now see that this mass of cotton waste which was saturated with the oil and was but a moment ago wrapped in flames, is now quietly extinguished. The 'Mineral Sperm' is a fire extinguisher even when heated to 212 deg. F. Am I wrong in saying it is practically as safe as whale oil?"

Work on Petroleum Oils

The Standard Oil Co., recently organized, manifested a great interest in my work on kerosene, and employed me as an expert in law suits, brought against them by persons who erroneously believed them using their patents, generally worthless, without their consent. Some years later when what was known as "Ohio oil" was obtained in Ohio, Indiana and Illinois in considerable quantities, the company received word from its German associates that the German Government had been informed by rivals that while the Standard Oil Co. was supplying the American market with the superfine Pennsylvania oil, it was sending to Germany the poor, offensive "Ohio oil." In consequence, the Imperial Government was about to permanently forbid the importation of this poor oil into Germany. A high officer of the Standard Oil Co. came to me and begged me to go at once to Germany and convince the German Government that the Ohio oil which his company exported was first purified by the process invented by Herman Frasch. This was one of the inventions for which your committee, a few years ago, awarded to Frasch the Perkin medal.

President Low granted me a leave of absence, and I immediately visited the great works erected at Whiting, Ind., for the special treatment of Ohio oil by the Frasch process. The impurities which had rendered the oil and all its products so offensive were certain compounds of sulphur, of which element the oil contained about 1 per cent. Frasch's process consisted in first dividing the crude oil by distillation into three fractions:

1. Lighter constituents, gasoline, naphtha and benzine.
2. Medium oil for lamps.
3. Heavy oil for lubricating and paraffine.

These three fractions were then entirely freed from the sulphur compounds by distillation in huge stills, while mixed with large quantities of oxide of copper, with constant stirring. The effect was magical. Not a trace of the offensive odor was retained by either of the products.

I met at the Whiting works the chemist in charge, Dr. William M. Burton, a Heidelberg graduate. He showed me everything and answered every question. When I told him that I was going to Berlin to explain the situation, a longing look overspread his face, and he remarked that he had not been in Germany since he graduated. I caught the look and asked him if he would like to go with me. He replied that he would give anything to go. I found no difficulty in persuading the company to give him a leave of absence, and so I had a most agreeable and useful companion.

Before I sailed I visited the works at Olean, N. Y., at Philadelphia, and at Brooklyn. So there was nothing in the treatment of petroleum that was not imparted to me. We went off together. It seemed wise, before we called upon the representatives of the government, to

visit and satisfy the men who would be most likely to be consulted by them. So after visiting the representatives of the Standard company in either Bremen or Hamburg, I have forgotten which, we went to Karlsruhe and explained the whole matter to Dr. Engler, the German expert on petroleum, giving him samples of the Ohio kerosene, and explaining how he could prove the absence of sulphur, if the entire freedom from offensive smell did not satisfy him.

Convinces German Government of Purity of Ohio Oil

Then we went to Zurich and explained the matter of Dr. Lunge, the distinguished industrial chemist. On arriving in Berlin, we adopted the same tactics with the Imperial Health Department, with the same success. With all these parties I had enjoyed an acquaintance for some years, so we were cordially received and our statements readily accepted. An hour spent with Count Posidowski, the Imperial Minister of the Interior, settled the business.

A few years later I was sent to Germany to again try and prevent the threatened establishment of an extra high standard for all imported oils, to be considerably above "100 deg. flash and 110 deg. burning." This time I did not have the company of Dr. Burton. As before, I first went to Karlsruhe to argue the matter with Dr. Engler, but to my discomfort I found that he was in the Austrian Tyrol, near the glaciers. There was nothing to be done but to follow him, so I crossed Lake Constance and took the train for Vienna, leaving it the next morning at Bludence. Here I hired a man to drive me to my destination, which was a day's journey. At noon we stopped at a cross-road village for lunch and to change horses. After eating my simple lunch of "Butterbrod" and "Schweitzerkäse" and drinking my "Bayerisch." I started out to see if there was anything interesting in the village. Strolling into the country store, I inquired of the proprietor in German if he sold petroleum. He replied, "Yes, indeed." I inquired what kind and he said "Amerikanisches." "Is it not much more expensive than that from the neighboring wells in Rumania and Galicia?" "It is, indeed," he replied, "but it is so much purer; it will burn in any lamp without smoking, while the other oils will burn only in a special lamp." He assured me that the peasants willingly paid the extra price. This interview gave me my trump card. Engler saw the point at once, and so did the Imperial Board of Health at Berlin, and so did Count Posidowski. I made it clear to them all that if they raised unnecessarily the standard of oil to be permitted to enter Germany, the only result would be that the Standard Oil Co. would get 50 gal. of such oil out of 100 crude, while they were getting 60 at that time. It would have no real advantage, while the German people would pay as much for the 50 gal. as they were paying for the 60 gal. He saw the point and that was the end of it.

Some years later a bill was introduced in Parliament to accomplish the same result in order to help the Scotch manufacturers, who made a comparatively small amount of kerosene from the Bog Head mineral. I was in Paris at the time and in response to a telegram from the Standard company I went before a parliamentary committee and made the same argument. A member from the Bog Head district, who was working for the bill, had a copy of my last report of 1871 before him, identified me as the author, and then asked me if I had not intimated therein that "the higher the flash point, the safer the oil." I replied that I had, but at that time we had not had as much experience as at present. Time had shown that "100 deg. flash" was sufficient to insure safety, and that that grade of oil was generally used in the United States and exported all over the world, and that lamp accidents were very rare.

Further I reminded him of an English nobleman who lost his life by the explosion of an extra high test oil, because the oil evolved just enough vapor to make an explosive mixture with the air in the lamp, while the 100 deg. flash evolved enough vapor to render the air in the lamp non-explosive.

Several distinguished English chemists, Sir Henry Roscoe, Sir Boverton Redwood and others gave similar testimony, and the bill never passed the committee.

I should like to add here that my friend Dr. Burton invented a most successful process for breaking up heavy oils into gasoline substitute for motors. He distills and condenses under a pressure of 90 lb., the heat required being sufficient to break up the molecules of the heavier oils into smaller molecules which constitute the lighter and more volatile gasoline, benzine and naphtha. There are now in use 1,000 sets of his stills and condensers, 240 of them at Whiting.

The Metropolitan Health Department of New York

In 1867 Dr. Elias Harris of the New York Health Department came to see me and told me that the Commissioners were not chemists and did not realize how much chemistry had to do with the public health and did not care to devote any portion of their income to this subject. He asked me if I would be willing to do some work for the department without charge. I promptly accepted his invitation and interested myself at once in a great variety of subjects, most of which I shall have to omit discussing.

Water

There are two or three matters, however, which interested me very much; one of these was water. I began analyzing the Croton and Ridgewood waters every week during the three or four summer months, and I continued for several years, either myself or when I became president of the Health Department through Prof. Waller, to keep informed with regard to the water supply of these two cities. I found that these waters were then and have been ever since among the purest waters supplied to any cities in the world. I do not believe that a case of sickness was ever caused by either one of them. General Green, who was at one time the engineer of the Croton aqueduct, was so interested in my work that he had me appointed consulting chemist for the department, and took me all over the Croton watershed that I might become familiar with the sources of the water. It is a source of constant regret to me that ill-informed persons, even physicians, are so ignorant on this subject that they advise families not to drink the Croton water unless it has been filtered or boiled or both, and the result is that millions of dollars are spent in New York every year for bottled waters, not only in families who can ill afford the expense, but in downtown business offices. During the fifty-six years that I have lived in New York, I have used the Croton water in my family without filtering or boiling, and never has anything occurred to lead me to suppose that the water was not

perfectly satisfactory and wholesome in every respect. Another phase of the water question occupied my attention for a year when at the request of the New York Central R. R. Co. I studied the subject of boiler corrosion in locomotives, boiler incrustations and feed water. I began this work at Union College and completed it in the School of Mines, publishing my results. I analyzed numerous specimens of incrustations, finding that some of them consisted of carbonate of lime; others of a mixture of carbonates of lime and magnesia; others of sulphate of lime. I also investigated the different brands of boiler medicines, most of which were frauds and the one which seemed to be an excellent one was sold to the railroads for five times what it cost to make, and the engineers couldn't bring their trains in on time unless this particular medicine was supplied by a particular firm. In the end, I analyzed all the feed waters employed on the road between Albany, Buffalo and Niagara Falls, classified them as to quality, indicating those that were too bad ever to be used and causing the water stations to be abandoned, and directing the best choice to be made among the others.

Hudson River Water

I was called upon by the Water Commissioner of Albany to investigate the waters of the Hudson River, to ascertain whether it would be safe to take the water above Albany and below Troy to supply the city, as they had found it almost impossible to procure an adequate source of supply within reasonable distance and at such cost as the city could afford to pay. I took up this investigation with great doubts of the fitness of this water for the city supply. I made the most careful investigations and analyses and was surprised to find that there was no reason why this water could not be used in the city of Albany. I sent in my report in 1872, stating my conclusions, with a special discussion of the destruction of the sewage contamination of large rivers caused by dissolved oxygen. I had obtained a great deal of information on this subject from the annual reports of the British Water Commissioner. The report was published and indignation meetings were held in Albany and no end of abuse was poured upon my head. The Water Commissioners were very sensible men, however. They said there was no sense in abusing Chandler; disprove his facts, meet his arguments or keep quiet. My facts could not be disproved and my arguments could not be met and consequently the Water Commissioners put up the pumping station, supplied the water to Albany, and in a short time the Health Officer of Albany informed me that the water was entirely wholesome and satisfactory.

In 1885 it became necessary to increase considerably the pumping facilities above Albany, and the Water Commissioners wrote me, calling attention to the fact that since I made my first investigation and report in 1872 bacteria had become fashionable and were now supposed to be terrible creatures capable of producing all kinds of diseases, and whether I cared to revise the opinion which I gave them thirteen years before. It happened that I was quite familiar with what had been published with regard to bacteria, having quite a library on the subject and having had occasion to make myself specially familiar with them in order to prepare an article on fermentation for Johnson's encyclopedia about 1874, so I wrote the second report on the waters of the Hudson River, which was published in Albany in 1885, containing a discussion of possible bacterial contamination of water.

Fourteen years ago while in Europe I was cabled to look up the ozone treatment of city waters. Accordingly, I visited Berlin, Paderborn and Paris, where experiments had been carried on. At Paderborn the process was in full operation, although the water supply was entirely above suspicion. The water descended slowly through a wide circular cylinder, while the ozonized air bubbled up through it. The effect was marvelous. The ozone seemed to destroy the organic matter, which though minute, was sufficient to conceal the true color of the water, for when the treated water was poured into a large snow white vat, it was very distinctly blue.

Saratoga Waters

In the early years of my residence at Union College, I became interested in the Saratoga waters. I found a great diversity of opinion as to the nature of these waters, some local physicians telling their patients that there was such a great difference in the waters that it was not safe for them to drink them except after the physician had carefully diagnosed their cases; had directed them as to which waters they should imbibe, what quantities of each, and at what times of day. The owners of the Star Spring employed me to make a careful analysis of their water and soon it became the fashion to have the waters analyzed by me, as the waters contain a great variety of constituents, including small quantities of iodine, bromine, baryta and lithia, etc. I had to charge a good round figure, which those who could afford it cheerfully paid, and as I was extremely anxious to analyze all the waters for those who could not afford to pay my fee, I made the analyses gratuitously, including springs and artesian wells. I analyzed about a dozen different springs in Saratoga and three at Balston. Instead of the waters differing from one another, I found that they all contained the same constituents, counting out one or two sulphur waters in out of the way places which I never took the trouble to analyze. The total amount of solids varied from a minimum of 302 grains in one United States gallon to 1,184 grains, the latter being the amount in the Balston artesian lithia well, which was bored over 600 ft. There is an interesting story about the High Rock Spring at Saratoga. It is the oldest known spring there and it consists of a volcano-shaped rock about 4 ft. above the level of the surrounding ground with a hole or crater in the center supposed at that time to be of almost unknown depth. This hole had a diameter at the top or mouth of 8 or 10 in. and the water rose to within about a foot of the top. Saratoga was first visited by a white man when Sir William Johnson went there in 1767. He was told by the Indians that according to their traditions the water formerly rose and overflowed regularly, continuously, but not within their recollection. This must evidently have been the case, for the High Rock is composed of tufa, carbonate of lime and contains the impressions of leaves and the shells of snails here and there. It had evidently been formed gradually by a deposition of carbonate of lime from the water, which is a common occurrence with this class of waters. After a time during my association with Saratoga, this spring changed hands and the enterprising purchaser decided to make the water resume its old habit of overflowing

the rock. In order to do this, he had oblique holes drilled on different sides around the edges of the rock toward the center. He then introduced wedges and succeeded in detaching the rock from its base. He then put chains underneath and hoisted it off one side. Then they enlarged the hole up through which the water came and went down expecting to find some leak which had prevented the water from rising any higher, and which they intended to close. They found beneath the High Rock a layer of tufa 7 ft. thick, including some muck, below that they found 2 ft. of tufa clean, below that 1 ft. of muck and below that again 3 ft. of tufa. Just below the rock itself they found four well preserved logs put crosswise at right angles to make a curb for the spring, which must have been placed there before the High Rock was formed, and, finally, at a depth of 17 ft. they found a considerable quantity of half-burned embers and charcoal, showing that at some previous time visitors had made fires before that 17 ft. of material had been deposited.

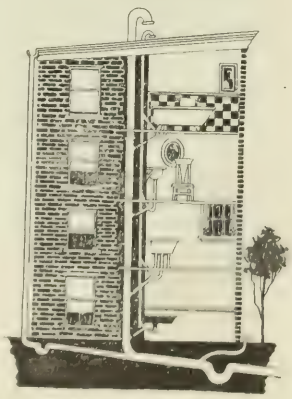
An enterprising citizen of Saratoga was very anxious to ascertain when those fires had been made, and remembering that the botanist ascertained the age of a tree by making a cross-section of the stem and counting the lines or rings from the center of the circumference ascertained the number of years it had been growing. He took a piece of the High Rock, smoothed it against a grindstone and found it showed 81 lines to the inch, so he said it must have taken 3,840 yr. to form. The following table shows his figuring:

THE HIGH ROCK

	Yr.
The High Rock 4 ft.—81 lines to in.	3,840
Muck and tufa 7 ft.	400
Tufa 2 ft.—25 lines to in.	600
Muck	130
Tufa 3 ft.	900
Total	5,870

According to his education, the world had only existed 4,004 years before the Christian era, and 1,870 years after the Christian era, or 5,874 years in all. As the fire was made 5,870 yr. in the past, it was made 4 yr. after the creation. Consequently, there was no one living on the face of the earth excepting Adam, and he was four years old. I hope you will pardon my frivolity in presenting this ridiculous proposition to you, but it went the rounds in Saratoga.

There is one other interesting matter connected with the Saratoga Springs. Some years ago a sanitarium near the Hathorn Spring set up a pump, and drew large quantities of water from a tube of some depth, with the result that the Hathorn well was very seriously affected. A law suit resulted in which my testimony and that of others was taken in favor of Hathorn, with the result that the sanitarium was enjoined. At or about the same time, a company began to bore numerous wells some little distance from the springs, introduce steam pumps, commercialize the carbonic acid gas, and permit the water to run to waste. In a short time the springs began to show the disastrous effects. The waters no longer spouted from the spouting springs, the others no longer came to the surface, and pumping had to be resorted to. In addition to this the diminished pressure of water in the springs permitted fresh water to permeate and dilute them.



CHANDLER PLUMBING SYSTEM

Again I was called as an expert, and testified to the ruinous effect of this pumping. The company produced experts who declared that it was absolutely impossible for this pumping to have any effect whatever on the springs, and that the falling off of the springs must be due to natural causes. The judge, however, was a second Solomon. He directed the defendants to stop pumping for 48 hr. to decide the question, and ordered the sheriff to see that the order was obeyed. Within 24 hr. the whole town gathered around the Hathorn Spring to see the water again rising, brilliant in the sun with gas bubbles, and overflowing the large glass cylinder placed over the spring. In the end the state bought all the springs and established a State Reservation.

Lead Poisoning

The lead question in drinking water came to my attention at an early day. Physicians reported cases of lead poisoning. I will mention a single example. An elderly gentleman's case was diagnosed as lead poisoning. No probable source of the lead could be suggested till the doctor interviewed the cook, and learned that her first duty in the morning was to place the old gentleman's "wheaten grits" cereal in a bowl, draw water upon it and after a while boil it. This fact suggested lead in the water. My attention was called to the subject and I found that water which had stood all night in the pipe of my own house contained a little lead, which might, as lead is a cumulative poison, ultimately produce serious results, if such water were often used. Looking further into the matter, I found that owing to the low pressure in the water pipes a great many houses were provided with pumps, and tanks to supply the upper stories. Examination of the tanks developed the fact that they were usually lined with lead, and the water thus became contaminated.

Examinations were also made of Croton water which had been in contact with lead for different lengths of time, under usually occurring circumstances, of which the following are the results:

1. A gallon of Croton water from a lead-lined cistern, in which it had stood several weeks, was found to contain 0.06 grain of metallic lead.

2. A gallon of water which had remained 6 hr. in the lead pipes of my residence yielded 0.11 grain metallic lead, a considerable portion of which was visible to the eye, in the form of minute white spangles of the hydrated oxycarbonate.

3. Water drawn from one of the hydrants of the School of Mines laboratory, in the middle of the day, when the water was in constant motion, yielded traces of lead. This water reaches the school through 100 to 150 ft. of lead pipe.

These results indicated the source of many hitherto unaccountable cases of lead poisoning, and are of a character to alarm the residents of New York, and lead them to adopt precautionary measures for protection against this insidious cause of disease.

A celebrated case occurred in the royal family of France, at Claremont, where one-third of the persons who drank of the water were affected. This water contained only $\frac{1}{10}$ grain of lead in a gallon. As little as $\frac{1}{100}$ grain of lead to the gallon has been known to

produce palsy in persons who habitually drank it. It is a great pity that the peculiar advantage of lead as a material for the manufacture of water pipes is more than counterbalanced by the danger of lead poisoning. These last paragraphs are quoted from a letter delivered before the American Institute in the Academy of Music, Jan. 20, 1871.

This subject attracted a great deal of attention at that time. The Board of Health put an end to the use of lead-lined tanks and the public was warned against drinking water that had stood long in the pipes. About this time tin-lined lead pipe was invented. It was made by casting lead around a hollow cylinder of tin, and then drawing the mass down to a pipe of the desired size. I found that the heat of the melted lead was liable to soften the tin lining to such a degree as to alloy it with the tin even clear to the inner surface of the tube. A suggestion of mine overcame this difficulty. A separate hollow cylinder of tin was placed in a surrounding cylinder of lead of such size as to leave nearly $\frac{1}{4}$ in. space between the two. Then melted solder was poured between the two cylinders; they were perfectly united without melting the tin perceptibly, and a perfect tin-lined pipe was produced. I used this pipe throughout my country house at West Hampton, and one of the spring companies at Saratoga employed it for a deep spring, using a very large-sized pipe. A test of the proper condition of the pipe was easily made by cutting off a section about 1 in. long, holding it in forceps and carefully heating it over a bunsen burner. If it was in good shape, the solder would first melt, as could be seen by the eye, and the tin tube could be shaken out in a sound condition. If, on the contrary, the lead had alloyed the tin, the entire lining sloughed off on heating. Special joints were devised and the invention was a complete success. But the cost of plumbing was considerably increased, both for material and labor, and the invention never came into general use.

Poisonous Cosmetics

Before I leave the subject of lead poisoning I must say a word with regard to the poisonous cosmetics which I examined in 1869. Hair tonics, washes and restoratives were much advertised and sold. The following are the results of my examinations of those sold in New York City. Only one was free from lead, that was Hoyt's Hiawatha Hair Restorer, which was an ammoniated solution of nitrate of silver, and harmless. Here are the others:

TABLE SHOWING GRAINS OF LEAD IN ONE FLUID OZ.

Clark's Distilled Restorative for the Hair	0.11
Chevalier's Life for the Hair	1.02
Circassian Hair Rejuvenator	2.71
Ayer's Hair Vigor	2.89
Prof. Wood's Hair Restorative	3.08
O'Brien's Hair Restorer America	3.28
Gray's Celebrated Hair Restorative	3.39
Phalon's Vitalia	4.69
Ring's Vegetable Ambrosia	5.00
Mrs. S. A. Allen's World's Hair Restorer	5.57
L. Knittel's Indian Hair Tonique	6.29
Hall's Vegetable Sicilian Hair Renewer	7.13
Dr. Tebbett's Physiological Hair Regenerator	7.44
Martha Washington Hair Restorative	9.80
Singer's Hair Restorative	16.39

These fluids consist of an aqueous solution of acetate of lead, generally containing a sediment of flowers of sulphur. They are to be well shaken before use and when applied at intervals to the hair are said to "gradually restore the originally youthful beauty and color." Six lotions or washes for the complexion were examined, and one contained corrosive sublimate and sulphate of zinc. Seven enamels for the skin were examined; three contained oxide of zinc, three others contained carbonate of lead and only one of the enamels submitted was free of lead.

The Plumbing System

I should be very glad to have had time to explain the improved system of plumbing which resulted from the experimental set of plumbing arrangements which I erected at the Board of Health building, where with a kitchen sink, butler's pantry sink above it, a wash bowl above that, and a bath tub above that, all with glass traps for ready observation, it was easy to demonstrate the absolutely unsafe condition of the plumbing not only in New York but everywhere else in this country.

The result of this was an improvement resulting in carrying the soil pipe through the roof, of undiminished caliber; the back airing of all traps by means of a separate pipe running through the roof; the running trap between the house and the street sewer; and the inlet for fresh air between the house and this trap. This system was approved by the plumbers and fixed by law, and was placed under the control of the Board of Health. It was generally adopted throughout the country, and there was no more talk about sewer gas as a cause of disease. Microbes took its place. Patent traps were not accepted as substitutes for good old-fashioned "S" traps. By the way, I have just learned from A. E. Hansen, hydraulic and sanitary engineer, who is adviser to the Master Plumbers' Association, that an effort is now being made to force the plumbers to adopt a "patent trap." To adopt this would be a crime.

Brief Mention of Other Activities

There are many other topics to which I would delight to call your attention, such as:

My connection with the first production of oleomargarine, that cheap, wholesome article of food which has been so handicapped by the government.

Introduction of cheap water gas here and in Boston, and sustaining the Lowe process for its manufacture.

My study of sugar refining in Europe in 1869, and the Hunters Point nuisance.

I should also enjoy telling you of the splendid work of Miss Louisa Lee Schuyler in rescuing 2,500 pauper insane from the state poorhouses and placing them in state insane asylums, where they had some chance of recovery. And of Mrs. Kinnicutt's very successful campaign to secure an efficient street cleaning department.

In both of these enterprises I was honored with the responsibilities of president of the associations which the ladies organized, but the credit of these great reforms belongs entirely to them.

I must also call attention to the lion's share of the work in my report on the air of the subway, published when that public utility was first opened and certain individuals erroneously pronounced the air therein so unwholesome. Dr. Floyd J. Metzger performed the laborious portion of the investigation.

I wish I could take the time to tell you how much certain members of this Chemists' Club have contributed to the success of the City and State Health Departments: Elwyn Waller, Samuel A. Goldsmith, Edward G. Love, Arthur H. Elliott, Charles E. Munsell and others whose names I do not just now recall.

In conclusion, let me express my appreciation and warmest thanks to the members of your committee, who have considered me deserving of this medal.

Teaching Chemical Engineering in Columbia University

Outline of the Chemical Engineering Curriculum at Columbia University as Instituted in 1915—Theory and Practice Combined in a Manner Considered to Meet the Demands of Industry

By ELLWOOD HENDRICK

COLUMBIA UNIVERSITY, founded in 1754 as King's College by royal grant of that second scion of the house of Hanover who called himself "Shorsh," is now the most largely attended university on the continent. Indeed we believe that it holds the world's record for attendance, the registration for this year being about 25,000. The fact, however, is of less importance to us than that Columbia addresses itself more particularly to post-graduate studies than most other American institutions of learning. With this in view, and bearing in mind its development as a university, the authorities decided that the engineering professions were of a learned nature, and that the same measure of preparation—but not the same preparation—is necessary for any of its seven engineering courses as is required for law, divinity, or medicine. The question whether, for instance, a chemical engineer should be an astute pipe-fitter or a cultured professional man with all the consciousness of professional obligation and with training in pure science to understand the philosophy of his work as well as its details was answered very clearly by the Columbia authorities. And its present engineering schools which require a minimum of six years from college entrance are founded upon the theory that engineering is a professional institution. This must not be taken to mean that years of drilling in Latin and Greek are called for. These studies remain optional with the student. What the School of Chemical Engineering demands is at least three years' special preparation in pure science in college, to meet its requirements. A Bachelor's degree in arts without this preparation is inadequate. These requirements involve a working familiarity with calculus and modern languages, and a good grounding in general and inorganic chemistry, as well as in qualitative analysis and in physics. They call for sufficient preparation to enter an advanced physical laboratory course. High school physics and chemistry courses are inadequate.

Pre-Engineering Course in the College

The College gives a pre-engineering course of three years which leads to the entrance of any of its engineering schools, but a Bachelor's degree in science is obtainable only after one year of additional study. The pre-engineering studies cover a course in general chemistry and qualitative analysis, drafting, descriptive geometry, English, history, and economics, mathematics and modern languages, philosophy, physical education, physics and mechanics, with surveying as an elective.

In the Chemical Engineering School there follow three sessions per year instead of the ordinary winter and spring sessions. That is, it is held that the students are men, and that two to four weeks constitute enough of a vacation during hot weather, so that they are required to work during the summer as well as in terms. The same measure of work is demanded for a diploma that was heretofore required for a Doctor's degree; and a Chemical Engineer's degree from Columbia at present indicates that its possessor has completed as much study as is required anywhere else for a Ph.D. degree.

Of course it stands to reason that the degree of Ch.E. indicates a different design in training from that of Ph.D. The Chemical Engineer is prepared to be first a plant foreman, then superintendent, and then manager. The Ph.D. course, on the other hand, is one in which the research idea dominates, and in the industrial field it points toward work in the development of new methods and new articles for chemical manufacturing.

The three-year graduate curriculum for the Ch.E. degree is a full one, as has already been intimated, and it includes three courses in physics, three courses in electrical engineering, four courses in mechanical engineering, three courses in civil engineering, two courses in metallurgy, etc., also courses on chemical factory equipment, factory design, factory management, applied colloid chemistry, and treatment of water and sewage. Not the least important are the two summer requirements and the theses. In the first summer the student spends two weeks in factory inspection, and follows this by eight as a workman in some factory. In the second summer the student works in the Chemical Engineering Laboratory for six weeks, using large-scale apparatus.

From the foregoing we do not learn of a number of features that are included under more general headings. Thus the introduction of biological chemistry in the industrial organic and colloid courses is made an important part of these. It is the opinion of many organic chemists that the use of micro-organisms in organic synthesis is capable of remarkable development, and that it will soon play a far more important part in the economics of chemical industry than at present. This and other subjects are presented to the students in such a

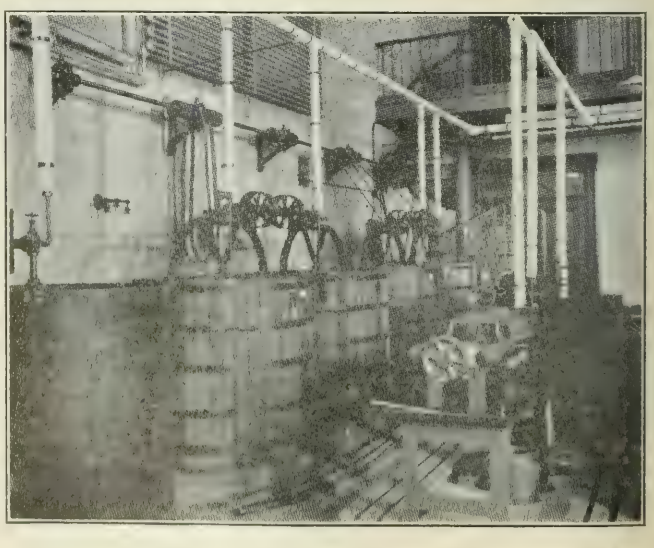


FIG. 1. FILTER PRESSES, PUMPS, SIPHONS, TANKS, AGITATORS, ETC.

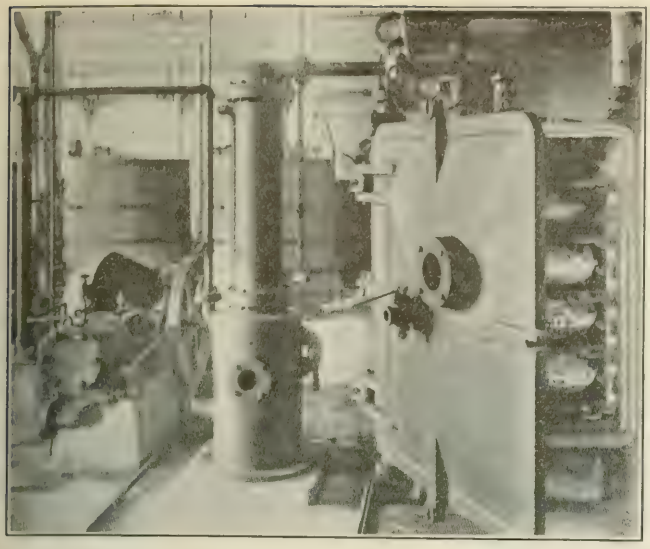


FIG. 2. VACUUM SHELF DRIER, CONDENSER AND PUMP, 42-IN. SHELVES

manner as to enable them to carry on their studies along these lines whenever it may seem profitable to do so. The laboratory has all facilities for biological work. Again, in electrochemistry a great deal of the time devoted to its study is within the organic field. Here also the student gets a medium of research which proves itself constantly in the solution of organic problems.

Enthusiasm of the Students

During the six weeks' summer work in the chemical engineering laboratory at the end of the second year, it is required of each student that he make ten preparations in quantity. This year the students asked for an extra week to complete their work—and they were not availing themselves of labor union hours either. They were working all day and every day. The fact that the course is known to be advanced and severe has caused a group of "selects" to undertake it, and, according to one of the professors, "they fairly eat up work." The Chemical Engineering Laboratory has a great deal of small-factory-scale apparatus. We noted, in passing through, a Kelly, an Oliver, and an Industrial Filtration press, all three gifts this year; of which the same may be said of a Badger drying oven, and a new de Laval separator. We saw a pot still, an autoclave tested to 1,000 lb., a Dopp kettle, a double effect vacuum evaporator, a Pfaudler kettle, and one from Elyria; a Devine drier, a Lummus still, a continuous still, and a Lummus extraction apparatus, a Duriron pump, a small paper beater and drier, a 600-gal. and several 300-gal. tanks and still more. The presence of these apparatuses makes the student familiar with them and their uses, and enables the advanced classes to attack new research problems on an industrial scale under the guidance of the faculty. Through donations of manufacturers who are anxious that students become familiar with the uses of their apparatus the Chemical Engineering Laboratory is becoming almost a Chemical Engineering Exposition!

Carvacrol From Crude Spruce Turpentine

A good example of students' work in the Chemical Engineering Laboratory in which several were engaged was the production of carvacrol from crude spruce turpentine, from a sulphite digester, containing about 85 per cent cymene. This involved roughly ten technical steps as follows: (1) It was steam distilled in a pot still, (2) sulphonated by stirring with 66 deg. Bé. sulphuric acid in a Dopp sulphonator, (3) diluted with water and neutralized with milk of lime, (4) filtered in a Sperry filter press, (5) filtrate treated with soda ash and (6) filtered in a Shriver filter press—to use both types—(7) evaporated to dryness, (8) fused in a Stuart & Peterson fusion kettle with NaOH, the fused mass dissolved in water, (9) acidified with sulphuric acid, and after separation (10) distilled.

Now the recorded yield of the original process was about 60 per cent, but these students, by their care and watchfulness, achieved a yield of over 75 per cent, based on the crude cymene used. Carvacrol is an isomer of thymol, and possesses similar properties. By a new analysis developed during the work it was found that about 8 per cent of their carvacrol *was* thymol. Therefore it is the thesis of another student to develop thymol in the place of carvacrol, from the cymene. That, if it succeeds, will be a noteworthy industrial achievement, for very large quantities of thymol are used.

In the third year, "Chemical Engineering Thesis" takes up six hours per week during the spring session. A satisfactory thesis is required of each graduate, but the research problems in hand are always of an industrial type, and many of them of a major nature.

In addition to students' theses there are several industrial fellowships, and students may be assigned to assist on these whenever feasible. Of such is one on the utilization of sulphite waste liquors which is extremely promising. It is worth while to remember that in the United States and Canada there are daily thrown into rivers, killing fish, and generally polluting their waters, 4,000 tons of material that should be employed in organic chemical industry.

Some Typical Problems

Some of the typical thesis problems on which young men are laboring this year are:

1. Silica gel and its adsorbing qualities.
2. Commercial production of benzoic acid starting from benzene and not toluene.
3. Prevention of rancidity of artificial butters.
4. Clarification of oils from the colloidal side.
5. Theory of sulphonation: a study of conditions which determine sulphonation.
6. Effort to devise an electrode that will stand between graphite and platinum; an electrode that may be used in an acid oxidizing solution.
7. Production of acetic acid from acetylene without passing through the aldehyde stage.

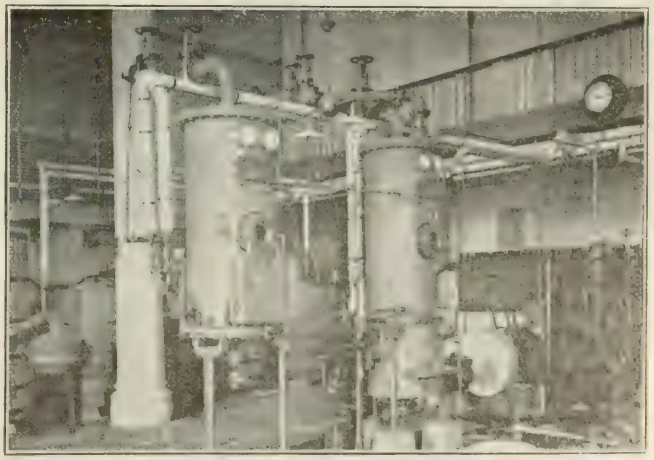


FIG. 3. DOUBLE EFFECT VACUUM PANS (24-IN.) WITH COMPLETE EQUIPMENT—CONDENSER, VACUUM PUMP, CIRCULATING PUMP, SALTING-OUT CHAMBER, ETC.

8. Study of the physical constants of phenol condensation products.

9. Determination of the physical constants of oil shale and its oil on which apparatus may be designed, including heat conductivity, and specific heat of shale, and the specific and latent heat of shale oil.

A typical group of problems given to students of the Engineering course is shown in the following:

(Show Calculations)

1. In the steam distillation which is made from the reducer after the completion of the reduction of nitrobenzene to aniline, how many pounds of 3-lb. steam will be needed to remove in seven hours 900 lb. of crude aniline to the condenser and receiver? (Use 50 per cent over the theoretic amount to care for radiation losses and the slowness with which the last traces distill over.) (Vapor pressure at 98.5 deg. C. is for aniline 45 mm., and for water 715 mm. The latent heat of aniline is 104 calories.)

2. How many gallons of cooling water entering at 70 deg. F. and leaving at 190 deg. F. will be needed for use in the condenser in connection with the above operation?

3. If a copper coil condenser of thin pipe, 1½ in. diameter were used, how long should the coil be built?

4. Show a heat flow sheet, including calculations, giving the heat changes involved in the reactions where, starting with 800 lb. of benzene, there is obtained successively 1,200 lb. of crude nitrobenzene and 900 lb. of crude aniline?

It will be seen from the above that the course is for thinking students rather than for memorizing ones. Teaching is done as much as possible through the eye. Long lectures are discouraged, and all lectures are made as informal as possible. Machines and pictures of machines are shown, and many lantern slides are used. The Chandler Museum, to which the old Dean of American Chemistry gave so liberally of his time and substance, is a mine of wealth to the faculty.

The school as now constituted has been in operation since 1915. The first class of 6-yr. men graduated in 1918, and there were but three of them. In 1919 there were seven. The class of 1920 has twenty; 1921, twenty-one, and 1922 has twenty-four. It is now up to the same numerical basis as when it was a 4-yr. course. It would be inconvenient with the present facilities to care for larger classes than 30 for each of the six years. The present students come from all over the world: South Africa, China, Japan, East India, France, Spain, England, Chile, and all parts of the United States. All admit that the course is not too long, and some students are returning for an extra year and the Ph.D. degree.

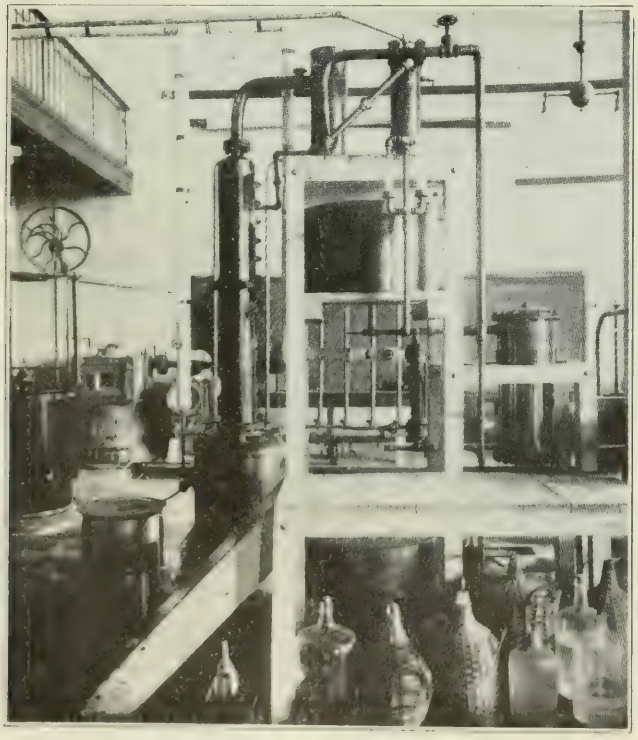


FIG. 4. COLUMN STILL AND EXTRACTION APPARATUS—CAPACITY, 10 GAL. PER HR.

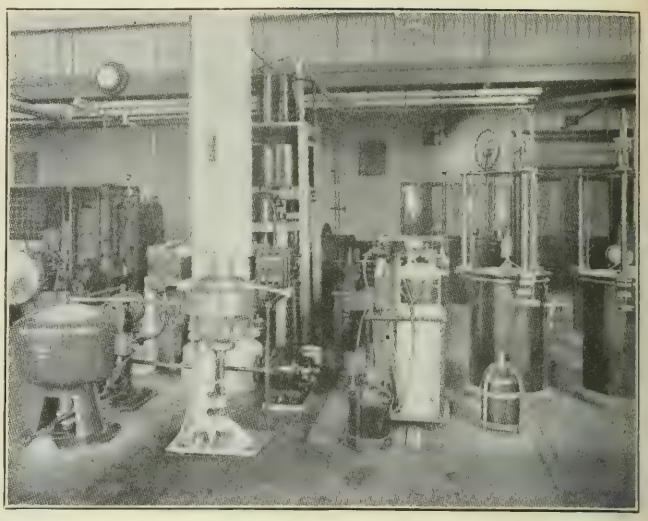


FIG. 5. GENERAL VIEW SHOWING WHIZZER CLARIFIER AND FILTER, WELDING OUTFIT AND GAS HOLDERS

The Faculty of Applied Science of Columbia is headed by the dean, Prof. George B. Pegram, who is also head of the Department of Physics of the college. In the School of Chemical Engineering Dr. Leo H. Baekeland is honorary professor, and gives occasional lectures. He is also a power in council. The executive officer of the department is Prof. D. D. Jackson, and with him is Dr. Ralph H. McKee, also a full professor. In this department are also Dr. A. W. Hixson, Associate Professor and Dr. J. J. Morgan, and Associate Assistant Professor H. B. Faber, with a number of lecturers and assistants having to do specifically with chemical engineering. For all other subjects the school draws upon the great faculty of the university.

New Elmore Process for Zinc-Lead Ores

The new Elmore process for the extraction and separation of lead sulphide from mixed ores, which has been tried out in connection with the ores from the Burma Mines, Ltd., and other ores, is in its main features substantially as follows, according to a note in the *Bulletin* of the Canadian Mining Institute:

"When a mixture of lead and zinc sulphides is treated with concentrated sulphuric acid at 100 deg. C., under proper conditions as regards fineness, proportion, time of contact, etc., the lead sulphide is converted into sulphate, while the zinc sulphide remains practically unaffected If the product is then washed in hot strong brine, the lead sulphate is dissolved, and can then be separated from the undissolved zinc sulphide by filtration, etc. By cooling the hot brine, the lead sulphate is precipitated—except for the amount that cold brine will keep in solution—and the brine can then be reheated and used again. The details, of course, vary for different ores and there are alternative methods for handling the sulphur dioxide, sulphuretted hydrogen or free sulphur liberated during the treatment."

Problems in Electric-Furnace Smelting*

A Description of Investigations to Determine the Best Arrangement of Electrodes, Leads, Etc., of the Ultimate Relation Between Electrical and Metallurgical Phenomena Within the Furnace and of How to Operate a Furnace to Obtain the Highest Output

By F. HOLMGREN

Introduction by Translator

IT IS well known that the earliest blast furnaces were built in Sweden, and so also Sweden first successfully solved the problem of the use of electric furnaces for the production of pig iron directly from the ore. The reason for this is naturally to be found in the facts that Sweden has an abundant supply of very high-grade iron ore and cheap water power, which are essential for the commercial success of the process. Coal is very expensive in Sweden and with a small exception the entire consumption has to be imported. It is for that reason that it has been more profitable in the past to export millions of tons of ore annually; but it is hoped that with the successful solution of the electric furnace and its more general adoption, a large part of this ore may be reduced at home and used in expanding the steel mill industry of the country.

Besides iron ore and limestone, charcoal has in the past been the other necessary raw material, but it is stated that recent improvements in the construction of these furnaces make them equally suitable for the use of coke in place of charcoal. The scarcity of charcoal in the United States is undoubtedly one of the reasons why this type of furnace has not been more extensively tried out in this country, and if it is true that coke is a satisfactory reducing agent, we shall undoubtedly soon find many of these furnaces installed here.

There are at present thirteen of these furnaces in operation in Sweden, and four under construction of capacities up to 6,000 kw. each. There are also seven under construction in other countries, several of which are said to be for using coke as a reducing agent. The productive capacity varies from three to four tons of pig iron per kw.-yr., depending on the quality of the iron produced.

The following article is of considerable interest in that it deals with a number of investigations which were made on existing furnaces in order to determine the best arrangement of electrodes, leads, etc. In one case, for instance, the power consumption was reduced from 474 kw. to 282.5 kw., or 40 per cent, simply by changing the connections from transformer leads to electrodes; moreover, the power factor was raised from 0.7 to 0.91. It also explains the intimate relation between the electrical and metallurgical phenomena within the furnace, and how the operation of the furnace can be controlled for the highest output by a close observation of the electrical measuring instruments.

Investigations of Furnace Operation

The Helfenstein Furnace.—The investigations were begun with furnace 3 at Domnarfvet Steel Works. This furnace was built by Helfenstein and showed the poorest results, both as far as operation and power consumption per ton pig iron were concerned. The heat had a tendency to rise higher and higher in the stack and the heat losses were considerable. The electrode potential could not be brought up to the desired value, and it was thought that this was due to too short a path of the current. To overcome this, water-cooled bridges were provided between the electrodes in the furnace dome in order to force the current to pass through the bath. The energy losses in the leads between the transformers and the electrodes were measured by the three-voltmeter method and found to be not less than 17.5 per cent of the total capacity.

The above changes and numerous other tests and trials failed to improve the results, and similar investigations were started at the Soderfors Steel Works.

The Soderfors Furnace.—This furnace, which is of the "electrometal" type, had shown much better operating results than the Helfenstein furnace at Domnarfvet, but on the other hand the power factor was lower than for furnace 2 at Domnarfvet, which also was of the electrometal type. Electrically, the principal difference in the arrangement was that with the former the transformers were installed in a separate room about six meters from the center of the furnace, while for the latter they were placed immediately near the furnace wall. The frequency in the former case was 50 and in the latter 60.

In these tests complete voltage diagrams were drawn by means of the three-voltmeter method, whereby the losses and the inductive voltage drop in the different leads could be determined. All the measuring instruments had before always been connected to the transformer terminals or near these, whereby the effect of the leads from the transformers to the electrodes was included. This, of course, was not the correct method, as what is most valuable for a study of the furnace operation is a knowledge of the current and voltage at the electrodes proper.

In the first test of the Soderfors furnace a relatively symmetrical voltage diagram, Fig. 1, was obtained, and the losses amounted to 474 kw., or to about 16 per cent of the total capacity. In the diagram the losses F are shown as the projection of the voltage drop on the current I. Points T represent the transformer terminals and E the electrodes. The diagram shows, however, that the furnace was not symmetrically connected, so that the six electrodes will not follow one another in the same sequence in the voltage diagram as in reality.

With currents up to 20,000 amp. or more, which are common with these furnaces, the magnetic fields set up about the conductors become very strong if not compensated for. In this installation, which is three-phase at 50 cycles, the direction of current will change 100 times for each second and the three currents will be

*Abstracted and translated from the *Transactions* of the Swedish Iron Institute by E. A. Lof.

displaced with respect to each other one-third period. If now the same current is carried forth and back through two adjacent conductors (one going and one return conductor), then the electromagnetic fields set up by the two conductors will be equal but opposite. The conductors will therefore compensate each other, and there will, practically speaking, be no electromagnetic field. If, however, a conductor is placed adjacent to

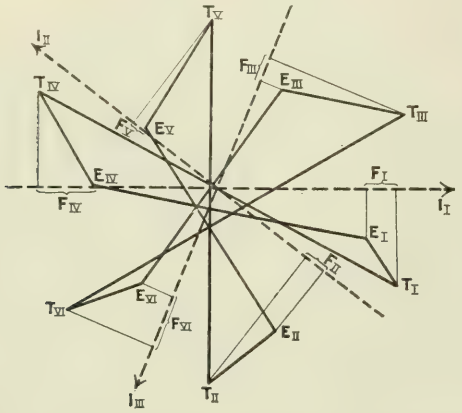


FIG. 1. CURRENT AND VOLTAGE RELATIONS IN SODERFORS FURNACE

another, and one carries a different current, or current of a different phase than the other, then the electromagnetic field will be greater or less, depending on how the fields set up by the two currents will combine vectorially.

In the diagram, Fig. 2, are shown the results from the first test of the Soderfors furnace. The strength and phase-displacements of the currents are drawn to scale, and represent also the electromagnetic fields set up. Besides this, there is shown in the smaller diagram the leads around the furnace and the direction of the currents therein. The directions of the arrows thus correspond to one another in the two diagrams. We see therefore in the smaller diagram how the arrows of the conductors between electrodes *I* and *II* have the same direction, while between the other electrodes this is not the case. The resultant of the two currents, therefore, gives a field proportional to $R_{1,2}$. The two others will, on the other hand, be respectively $R_{5,6}$ and $R_{3,4}$. The electromagnetic fields which thus surround the conductors will be increased by adjacent iron structures which will lower the magnetic reluctance. Such structures are the furnace casing, iron pillars, etc. In these iron parts eddy currents are now in turn set up, which are converted into heat. The less compensated the leads, the greater will be the iron losses thus created. The fields will besides set up electromotive forces in the conductors themselves, which may cause a drop and even a rise in the voltage.

Losses Reduced by Interchange Electrode Leads

The terminals of the transformers for electrodes *III* and *IV* were then changed so that the direction of the current in the circuit was reversed. The result was measured and is shown in Fig. 3. At a first glance it would seem as if the first connection would have been the correct one on account of the symmetrical and otherwise clear vector relations. The unsymmetrical diagram depends, however, on inherent conditions in the furnace which will be dealt with later.

From the diagram it follows that certain losses ($F_{2,\ 4,\ 6}$) have become negative, that is, that a power increase has taken place instead of a loss. This is readily explained. On account of the above-mentioned mutual induction a certain amount of power has been transformed from one lead to the other, in that the former has acted as the primary winding in a transformer and the latter conductor as the secondary. The adjacent iron structure has served as the necessary "transformer" core. If we consider the fields which could have been formed around the conductors, we find (Fig. 4) that in the latter case these have become much smaller, which must result in lower additional losses. This proved to be the case, as the losses went down to about 375 kw.

The low power factor caused by the relatively large inductive voltage drops (represented in Fig. 1 by the lines at right angles to the currents) could not, as expected, be improved by this reconnection, and it was then suggested that the transformers should be connected to adjacent electrodes instead of to opposite ones as had been done before. Investigations involving the inherent electrical conditions of the furnace were made and it was found that this suggestion was practicable.

If we assume that an electrode of circular cross-section with radius r cm. is lowered to a depth of h cm. in a conducting homogeneous mass with a specific conductivity c, then the resistance which the current has

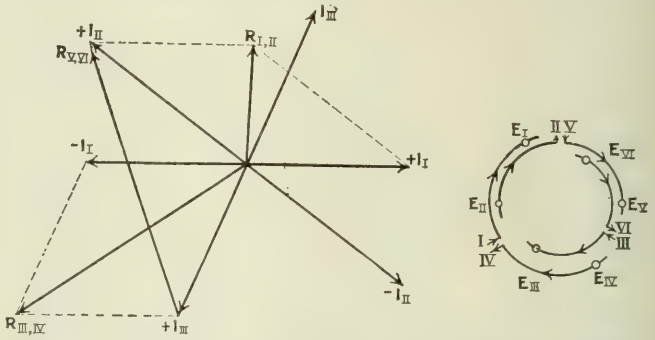


FIG. 2. MAGNETIC FIELDS AND ELECTRODE CONNECTIONS FOR FIRST TEST

to overcome in its travel from the electrode to a concentric cylinder area with the radius R cm.:

$$M = r\int \frac{Rdx}{x} \cdot \frac{c}{2\pi h} = \frac{c}{2\pi h} \log_e \frac{R}{r} \text{ ohms.}$$

From this we get the voltage

$$E = \frac{Ic}{2\pi h} \log_e \frac{R}{r}.$$

The energy production per unit volume will therefore be

$$\frac{dU}{dx} = \frac{1}{x^2} \cdot I^2 \frac{c}{2\pi h} - \text{const.} \frac{I^2}{x^2}$$

and will therefore drop rapidly the farther the distance from the electrode.

The zone nearest the electrodes may be considered as consisting of a number of parallel arcs, where the resistance and the voltage drop presumably follow other laws. Oscillograph tests of the applied current and voltage have shown that these have a practically sinusoidal wave shape. Whether this was due to impossibility of connecting the oscillograph sufficiently near the arc itself, to the heat capacity of the arcs, or to other causes, could not be determined. This resistance may depend, however, upon the current density, the

temperature, the composition of the charge, and the distance between the electrode and the bath. Besides this, the gas currents and finally the electromagnetic field may have their influence.

Distinction Between Working Resistance and Conductor Resistance

It is in this zone presumably the principal direct energy generation takes place. Outside of the zone the above laws may hold, excepting that the resistance will increase with a falling temperature. The energy generation drops therefore less rapidly than the formula would indicate. In the former zone we thus have the real "working resistance" and in the latter the "conductor resistance" to the next working zone.

There is no doubt that the "working resistance" preponderates, but it is not quite clear what rôle the "conductor resistance" to the next working zone plays.

This electrical condition with two such zones is known by the term "free" electrodes, and represents a normal operating condition. If no arc zone exists, we say that the electrodes are "frozen." This occurs when the potential required for maintaining the arc cannot for

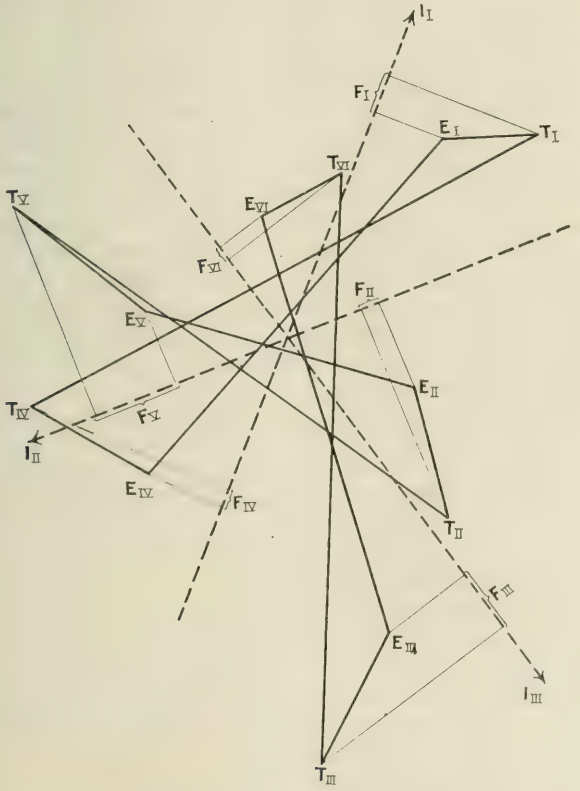


FIG. 3. DIAGRAM WITH LEADS TO III AND IV (FIG. 2) REVERSED

some reason or other be produced. The condition appears as a lowered "working resistance" (consequently increasing current), rising temperature in this part of the hearth and reduced production.

Regarding the effect which the "conductor resistance" in the mass itself may have and its effect on the heat development in the furnace, it may be of interest to determine how the different currents proceed through the crucible.

Fig. 5 represents the progress of the currents within the furnace when complete symmetry exists, that is, when the currents in the three phases are equal, the furnace connections symmetrical and non-inductive and when the currents enter and leave the crucible through opposite electrodes. We find that the currents entering will divide according to the parallelogram law into components such that the current between either of the electrodes will be equal to the current entering.

In connection with the first investigations of the

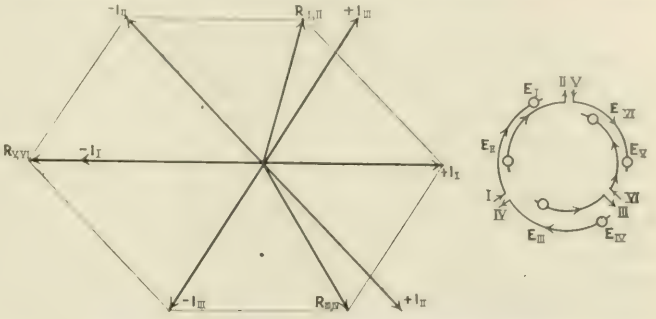


FIG. 4. REDUCED MAGNETIC FIELDS WITH LEADS TO III AND IV REVERSED

Soderfors furnace it was found after the shut-down that the lining was more corroded between certain electrodes than others and it may be assumed that the greatest effect in the mass took place there. It is, however, difficult to say whether this really had anything to do with the two conditions referred to or was just a circumstance.

It has not been possible to determine the effects of the unsymmetrical condition and the different currents passing through the charge, but from the voltage diagrams it is fairly evident that even the "conductor resistance" of the mass is a factor which must not be lost sight of in considering the heat distribution in the furnace. The diagrams thus show that there is far from a common neutral point, for which reason it must be assumed that work has also been done by the currents in the mass. Cold spots between certain electrodes were thus found in the Soderfors furnace. There is some uncertainty as to the magnitude of the work done in the mass itself between the electrodes and its effect on the thermal procedure within the furnace.

Best Results by Connecting Transformer Leads to Adjacent Electrodes

Regardless of how the effects are distributed on the arc zones and in the mass itself, we see therefore that the current paths will not be any longer if the transformer terminals are connected to two opposite electrodes than if they are connected to two adjacent electrodes. It was therefore decided to change the connections so that each phase was connected to two adjacent electrodes. The result was, as expected, a considerable reduction of the losses in the conductors, which went down from 375 to 282.5 kw. with the same operating condition of the furnace. The power factor, furthermore, was improved to such an extent that from a power consumption of 4,420 kva. now only 3,395 were required, or a saving of not less than 23 per cent in kva., resulting only from the rearrangement of the leads. The power factor improved from 0.7 to an average of 0.91.

Electrometal Furnace 4 at Domnarfvet.—This furnace showed, to begin with, the same trouble as the Soderfors furnace before the leads were rearranged. Furnace 4 has eight electrodes arranged with a double "Scott" connection, and is therefore equivalent to a doubling of the set at Trollhattan.

The power factor was found to be low, hangings occurred and the operation was for this reason uneven at the different electrodes. The leads were arranged as for the Soderfors furnace, that is, the terminals of the respective transformers were connected to diametrically opposite electrodes. Very thorough investigations were made on the furnace.

In Fig. 6 is shown a complete vector diagram of the connections in which the magnitude and direction of the currents and voltages are marked. As there is no real neutral within the furnace, that shown in the diagram will be regarded as fictitious. The great difference, both in magnitude and direction, between the voltages at the transformer terminals and at the electrodes, is at once apparent. For electrode 6, for example, the voltage between the corresponding transformer terminal and neutral is about 41 v., while between the electrode itself and the neutral it was found to be only about 15 v. The phase-displacement with reference to the fictitious neutral was in the former case only about 0.16 and in the latter about 0.8. It is therefore apparent what little help we have from instruments connected to the transformer terminals, as a guide for operating the furnace.

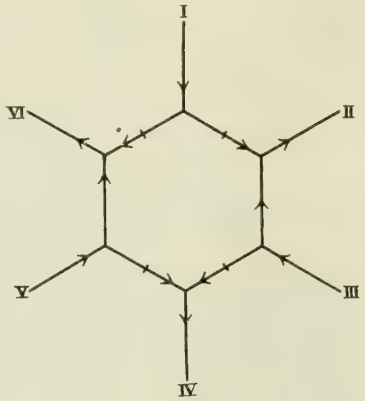


FIG. 5. CURRENTS IN THE FURNACE FOR BALANCED CONDITION

Analysis of Losses

From this diagram it was now possible to approximately determine the distribution of the losses in the different parts of the conductors, and the values so obtained have been combined in Fig. 7. This shows still more clearly the faulty interpretation one may get from the instruments as regards the load on the different electrodes. So, for example, the wattmeter indicated a load of 1,020 kw. for electrodes 4 and 8, while in reality the electrodes received only 637 kw. Still more peculiar is the result at electrodes 2-6, where the meter indicated 744 kw., while in reality the electrodes received not less than 1,019 kw. This big difference can be explained by an insufficient interlacing of the conductors and the fields thus set up, besides the transformation of work from one conductor to the other.

At the test in question a total of 3,942 kw. was applied, of which only 3,392 kw. were useful in the furnace, leaving a 603-kw. loss in the 80 m. leads between the transformers and the furnace. These were segregated as follows:

Losses in the contact terminals:	kw.
At the electrodes	122.2
In the leads themselves	164.2
In surrounding iron structures	316.6
Total	603.0

From one set of conductors to another there was transformed no less than 544.4 kw. With a rearrangement of the leads to correspond to that at Soderfors, it was estimated that the losses could be cut in two. Regarding the furnace leads, the following rules can therefore be laid down:

The low tension conductors should be so arranged that adjacent electrodes are connected to two opposite transformer terminals, and that these + and — circuits are carried the shortest distance and in such an interleaved manner that the magnetic fields will be neutralized.

The measurements give a clear picture of the electrical properties up to the electrodes and teach us the best method in which to arrange the leads. Inside the furnace we know that the resistance can be divided in a "working resistance" in which the principal energy is developed, and a "conductor resistance" between the electrodes. It has been shown how the currents pass through this conductor resistance, but it has not as yet been possible to determine the relative magnitude of the two resistances, which undoubtedly has an intimate relation to the operation and the furnace temperature.

It can safely be assumed that unequal heat supply also was the cause of the irregular operation which was noticed both in furnace 4 at Domnarfvet as well as in the Soderfors furnace before the connections were changed, while the performance of furnace 2 at Domnerfvet was decidedly better from the beginning. As seen from Fig. 8, the leads did not here cause the same disturbing effect on the instrument readings. Regardless of how the furnace leads are arranged, the instruments must always be connected as close to the electrodes as the heat radiation from the furnace will permit. With a perfect arrangement of the leads, then, this is of course not so important, as confirmed by Fig. 9, which represents a voltage diagram of the Soderfors furnace after the leads had been changed. This diagram should therefore be compared with diagrams Figs. 1 and 3, but above all with Fig. 6.

From the preceding there is good reason to believe that there exists a certain reciprocal action between the electrical and metallurgical phenomena of utmost importance inside the furnace.

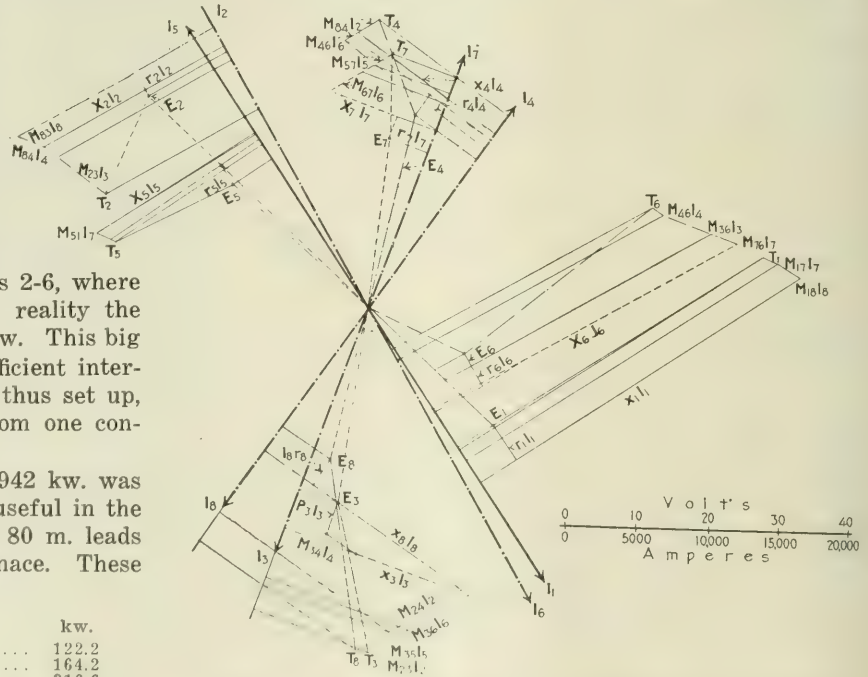


FIG. 6. COMPLETE VECTOR DIAGRAM FOR FURNACE 4 AT DOMNARFVET

Earlier investigators have already dealt with the equilibrium of electric-furnace operation in that with a surplus of coal the operation will readily become "hot," meaning that the furnace temperature would be above normal, while with a surplus of ore it will become "cold," meaning that the furnace temperature would be below normal. The former condition is characterized by a tendency of the current to rise, that is, the resistance in the furnace drops and the temperature rises with reduced operation. Referring back to the previously mentioned division of the resistance inside the furnace, we find in the first place that the "working resistance" drops, which undoubtedly depends on the reduced operation.

It may be possible that this takes place in the following manner in that in the active arc zone the reduced iron drops down into the bath below the electrodes, and the carbon monoxide escapes the easiest way along the electrodes up to the stack, whereby the section nearest these will be exposed to an unusually severe heat.

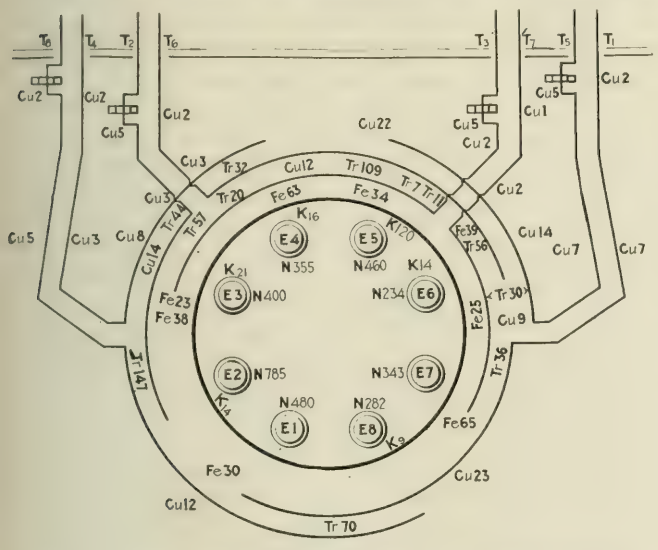


FIG. 7. LOAD DISTRIBUTION TEST OF DOMNARFVET FURNACE 4

The gas blast will cool the mass and the arch between the electrodes, whereby at least the upper part of the mass between the electrodes will have a relatively low temperature and a correspondingly higher resistance.

If now there is a reduction in the operation on account of a surplus of carbon, then the real smelting zone, which therefore practically contains iron drops and rising carbon monoxide, will be thinner and thinner, and the working resistance will drop. The surrounding zone, which practically consists of conducting carbon, will be forced more and more toward the electrode, until if finally sticks to the same, and the "working resistance" ceases more or less to exist. The resistance between the electrode and the mass is thus exceedingly small and the current rises considerably. As the reaction $FeO + C = Fe + CO$ is strongly endothermic, and as any cold charge is prevented from descending into the bath, the reduced operation will always mean an increased heat supply to the mass surrounding the electrode, which also in turn lowers the resistance in the mass between the electrodes. If in the charge, when it enters the hearth, there is a certain surplus of carbon in proportion to the available oxygen for formation of CO, then there is, of course, no possibility for this to oxidize, as, contrary to ordinary blast furnaces, the mass is not passed through by any gas with an oxygen surplus. An accumulation of carbon will then take place which will more and more prevent the charge from descending and a reduced operation will result. Such carbon accumulations are especially apt to take place when coke is used on account of its compact nature and its tendency to graphitize.

The "cold" operation, on the other hand, is characterized by the fact that with a rich easy reducible ore there will be a too large arc zone around the electrode with accompanying high "working resistance." On account of the increased operating condition, the surrounding mass will not be sufficiently supplied with heat, but will solidify. The arcs between the electrode and the mass will finally go out and the operation will stop.

Unbalanced Operation Between Electrodes

As has been pointed out above, the heat supply has often proved to be very irregular at the different electrodes. On the other hand, it seems to be true that the arc zone, which is desirable for a successful and regular operation of the furnace, has a certain relation to the operating conditions of the electrode in question. As soon as the charge around the electrode reaches an unsuitable composition (surplus of coal or ore) it has been found that the operating condition becomes bad, either due to electrical heat supply with accompanying disturbance of the electrical phenomena (during "hot" operation) or because the electrical phenomena have been disturbed with an accompanying checking of the electrical heat supply (during "cold" operation). In the former case an increased ore supply is resorted to and in the latter a reduced supply.

That the heat in electric furnaces is very unevenly distributed cannot be disputed, and that an uneven energy supply through the electrodes will still further increase this condition is self-evident. The result of this has also often shown itself during tappings, in that the iron then often shows a changing temperature.

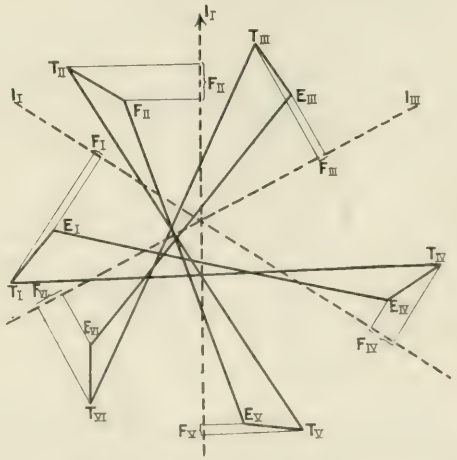


FIG. 8. TEST OF FURNACE 2 AT DOMNARFVET

It even sometimes happens that at tappings iron and slag will be poured in alternating successions.

It shows therefore that there has been an irregular metallurgical condition at the different electrodes, depending partly on the uneven energy supply and partly on a different composition of the charge at the different electrodes. At one electrode the furnace may thus show typically "hot" operation with a low effect, while the operation at the other electrode may be entirely

normal. The uneven successive tapping of iron and slag can naturally also be due to the fact that under each electrode there has been formed an individual iron bath with accompanying slag cover, which confirms the unequal heat distribution within the furnace.

Electrodes Should Be Controlled Individually

It seems therefore that the crucible of an electric furnace can be considered as consisting of a number of furnaces equal to the number of electrodes. When the operation of an electrode tends to get "hot" it should therefore be possible to prevent this by cutting off the current from this electrode for such a length of time that the surplus of carbon may be removed in some manner. As an increased ore supply through the stack affects all the electrodes, it would seem that in order to obtain a steady operation of the furnace the electrodes should be controlled individually. With "hot" operation, ore should therefore be supplied through special holes in the dome to the respective electrodes if such holes will not unduly weaken the furnace construction.

The uneven distribution of coal and ore in the charge, which is liable to cause a "hot" operation, should therefore be avoided by a careful mixing before the charging. If ore and coal are supplied to the furnace in the ordinary way in form of alternate layers, it is possible that the profile of the stack may influence the charge at the electrodes. If we follow the layers down through the stack, we find that the sinking will be more rapid in the center of the stack on account of the friction against the walls, Fig. 10. It is therefore possible that the occasional surplus of coal is due to the fact that a layer of coal, or a part thereof, during its progress through the bosh, will take up a position parallel to the

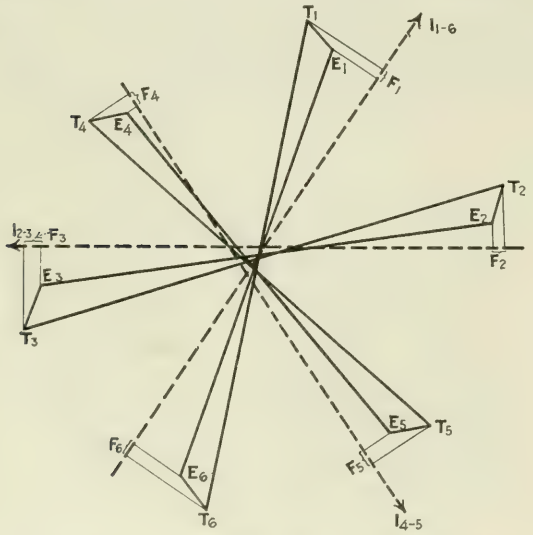


FIG. 9. VOLTAGE DIAGRAM FOR FURNACE WITH CORRECT ARRANGEMENT OF LEADS

electrodes, and finally surround the same in the form of a mantle and thus prevent the operation with a resulting over-heating.

Another kind of "hot" run is also possible, namely, when the electrode is unable to burn itself free and form an arc, regardless of the fact that the charge does not contain any local or general surplus of carbon. This may depend on the special nature of the electric-furnace process, in that the furnace can be supplied with only a sufficient quantity of electrical energy required by the process on the supposition that this is produced in arcs. By simply conducting the circuit through the charge it is not possible to produce the required energy and heat for the furnace, on account of the limited low value of the resistances. Why a reaction corresponding to this energy does not take place in the mass so heated and thus cause reduced operation, is difficult to explain. Instead we obtain a surplus of heat in the furnace. It may possibly be caused by the fact that the smelting process ceases and that therefore the reduced material is not removed as rapidly as necessary.

Causes of Operation With "Frozen" Electrodes

This corresponds to what was found with the Helfenstein furnace. A low electrode voltage could not be used on account of the inside resistance of the furnace. The operating capacity was very small and the operation very "hot," the heat rising further and further in the bosh and stack. As soon as a higher voltage could occasionally be noticed at any of the electrodes an increased capacity was also observed. The electrode has then very likely burnt itself free, while the Helfenstein furnace thus "normally" ran with frozen electrodes. The reason for this might have been that the contact surface between the electrode and the mass, due to the furnace construction, was too great, so that the energy required for burning the electrode free was greater than could be produced with the arrangements of the leads, etc.

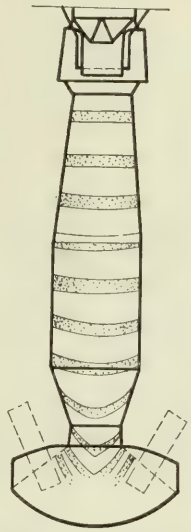


FIG. 10. PROGRESS OF CHARGE THROUGH THE FURNACE

"Hot" operation due to the same cause was also noticed in the Soderfors furnace before its reconstruction. The great distance to the bottom of the furnace made it often necessary, especially with hangings, to push the electrode far down in order to get any current to pass. When then the charge fell, the reaction surface became too great and the electrode was unable to burn itself free. On account of the great free length of the electrodes within the crucible and their slope with respect to the "falling-down" angle of the mass, they were often broken. The remaining stump was then quickly pushed down to prevent burning of the roof, and contact with the broken-off part was established, with the result that the reaction surface became still greater and a burning-free was impossible. Since the height of the crucible has been considerably reduced, any "hot" runs from this cause have not been observed.

Reducing Losses by Rebuilding the Crucible

As a result of the rebuilding of the crucible, it may be noted that with a suitable electrode surface in the mass, the current became relatively low, which, of course, was of greatest importance as far as the secondary transformer windings and the low-tension leads were concerned. It was furthermore possible to keep the voltage high without unduly overheating and damage to the furnace lining. The low current had an especially favorable effect on the losses in the conductors, as these were reduced to only about 180 kw. from 282.5. The inside resistance of the furnace was increased from 1,250 microhns per electrode to not less than 2,700 michrons, and it is, of course, desirable to keep this

resistance as high as possible. The upper limitation is the risk of "cold" operation with a rich charge and irregular operation on the whole due to the tendency of the arcs to go out, besides the silica reduction.

From the above it is apparent that it is very important to use electrical measuring instruments for obtaining a knowledge of the metallurgical progress inside the furnace. The operation is closely related to the load for the same charge, and it is necessary to gain a knowledge of the resistance which is obtained in the furnace for different compositions of the charge, in order to determine on the best operating method therefor. With a charge rich in ore and thus low resistance, for example, it is not permissible to wait with the lowering of the electrode until the same voltage is reached as with a poorer charge with a relatively high resistance.

Points of Consideration in Planning New Electric Furnaces

Frequency. Some of the furnaces with the original arrangement of the connections, that is, with the transformers connected to opposite electrodes, operate with 25 cycle power and a good power factor. There are also several furnaces with the new arrangement of connecting the transformer to adjacent electrodes in operation on 50 cycle power, with good power factor results and low losses in the conductors. If the leads, therefore, are correctly arranged it may be stated that electrical furnaces can be satisfactorily operated with any of the standard frequencies now in use.

Electrodes. There are two ways in which the capacity and thus the production of a furnace may be increased. One is by increasing the electrode diameter with the number of electrodes remaining the same, and the other by increasing the number of electrodes, keeping the diameter the same. Both these arrangements necessitate an increase of the current supply. An increase of the voltage is, however, not permissible on account of the irregular operations which would result therefrom and the effect which the voltage has on the furnace process in reducing the silica. Of the two first named arrangements, an increase in the size of the electrode will surely result in an increased operation on account of the larger smelting zone which is thus obtained, but the difficulties with the current supply will also grow in that the "useful" area of the electrodes, due to the skin-effect, will not increase in the same proportion to the actual area. Besides this there will be increased difficulties in connection with the leads for carrying the large currents. It seems, therefore, as if more can be gained by the second alternative, that is, by increasing the number of the electrodes. At present there are furnaces with 4, 6 and 8 electrodes, and from the electrical point of view there is no reason why the number cannot be increased to 9. The "neutral" column of the charge is, however, likely to be larger and larger, and it may be questioned whether it would not be advisable from an operating standpoint to raise the bottom of the crucible in the center when the diameter has reached a certain dimension, provided that this would not cause an increased pressure of the charge against the electrodes.

Electrode Terminals. This is generally one of the weak points in electric-furnace installations, and every effort should be made to improve the same. A good contact is essential, as about 30 to 40 per cent of the losses from the transformers to the electrodes are to be found here. Arrangements should also be made to facilitate a quick change of electrodes and an easy raising or lowering.

Leads. As has already been explained, the tests and investigations have shown conclusively that the leads must be arranged in a manner which will reduce the resultant electromagnetic fields to a minimum. Conductors which carry the same current but in opposite direction should be placed together as close as possible. This led to the suggestion of connecting adjacent electrodes to the same transformer phase, whereby a much better power factor is obtained and also shorter connections and lower losses therein. The form of the conductors is also of great importance with alternating currents when large currents have to be handled, on account of the influence which the electromagnetic field around the conductor has on the current distribution within the conductor, reducing the useful area. It has also been proved that with uncompensated conductors very little is gained regarding the current distribution therein whether these consist of multiple or solid bars. Better radiation is, of course, obtained and therefore a lower direct current resistance, but the current within the conductors will nevertheless be distributed as if the conductor had been solid. Where the conductor run is uncompensated, that is, where it is impossible to interleave + and — bars, it is advisable to arrange the conductor in the form of a pipe, two half pipes or eventually as four bars arranged to form a square. At 50 cycles it will be possible in this manner to bring down the losses to less than one-half of that with parallel bars. In other words, only one-half the amount of copper need be used in these portions of the leads.

As far as the compensated part of the leads is concerned, much has been done to reduce the surrounding electromagnetic fields by interleaving the + and — bars. For the same area the resistance will also be lower if the thickness of the two outside bars is made only one-half of the inside ones. Where the individual bars are of different lengths the longest ones should be placed outside so as to obtain as low field as possible around the same. Each bar should preferably be connected to an individual transformer winding, and in such case the forward and the return conductors should be bunched and interleaved. They should also be arranged so that the voltage drop in the conductors to the individual transformer windings will be as nearly alike as possible, in order to assure an equal distribution of the load among the different windings. When pipes are used for the leads the amount of copper can be reduced by water cooling. The losses will, however, be higher. Such water-cooled pipe conductors are often used in the leads nearest the electrodes where the heat from the furnace is excessive.

Electrical Arrangement. From what has been said in the above it is evident that the shorter the leads the better will the operation be from the electrical point of view. This was fully demonstrated in furnace 2 at Domnarfvet, where the transformers were placed immediately adjacent to the furnace, and where the operation was the best from the beginning. From the general operating standpoint, however, this arrangement has many disadvantages, in that it takes away much of the space nearest the furnace which is essential for the operation otherwise, and besides this the transformers are directly exposed to the heat from the furnace. This

arrangement has therefore not been followed in the later installations, where the transformers have been placed in a common room separated from the rest of the installation. This transformer room has in different installations been located at different elevations with respect to the control platform, but the leads have generally been carried along the ceiling above this platform and from there down to the electrodes. It would seem advisable, however, to install the transformers at such a height that their terminals would be at the same elevation as the electrode terminals; in other words, the leads should, if possible, be installed in a single horizontal plane.

Furnace Operation From the Electrical Point of View

In the preceding it has often been pointed out that in the electric-furnace process the metallurgical and electrical phenomena have an intimate relation to one another, and from this it follows that the operation must be with this in view.

The problem is to produce the greatest quantity which the limitations of the installation will permit, and this with due consideration of the quality of the product. When such a furnace can produce up to 10,000 tons of pig iron per year and possibly more, the importance of keeping the operation uniform and at near maximum is obvious. All interruptions, etc., should be localized to include as small a part of the installation as possible.

On account of the connections to the transformers, there has so far always been a mutual electrical relation between two electrodes. But inasmuch as the operation has been found to be somewhat independent at the different electrodes, the question arises whether it would not be advisable to make an arrangement whereby each electrode could really be independent of the other. This could most easily be done by means of a bottom electrode connected to the transformer neutral. Whether this would meet with any practical difficulties, however, must first be investigated. Another advantage of this would be that in case of repairs or when changing electrodes, only one electrode need be disconnected. With a surplus of coal at one electrode the current could be shut off temporarily from this electrode to prevent "hot" operation. A closer and more frequent regulation of the electrodes would then also be possible, thus permitting the highest voltage to be maintained more uniformly.

Electrical Instruments as Guides to the Operator

The electrical instruments serve as a good guide to the operator provided they are connected so that the leads to the furnace have no disturbing influence. Individual measurements at the different electrodes are preferable, and for this reason the instruments should be connected either to the bottom electrode if there is one, or otherwise to some suitable conducting point in the bottom of the furnace. Besides a voltmeter which should be able to be connected between the neutral and the respective electrodes, there should always be a wattmeter for each pair of electrodes, the potential coil of which can be interchanged to different electrodes. By thus carefully following the size of the "working resistance," it would at least be possible to discover in time when there is a tendency for "hot" or "cold" operation and thus make it possible to take the necessary precautions against it. A knowledge of the load on each individual electrode should also give an indication of the limitations as far as the furnace lining is concerned, and it would be highly desirable to have pyrometers installed in the roof near the electrodes if this could be done from a practical point of view. It would then be easy to determine when the electrode should be lowered.

Conclusion

1. The low-voltage leads are of utmost importance as far as the losses and power factor are concerned, and their arrangement should be carefully planned in new installations.

2. The electrical measuring instruments should be arranged so that they will really indicate the electrical conditions at the electrodes.

3. There is an intimate connection between the electrical and metallurgical phenomena at the different electrodes, and an individual control of the electrodes is desirable. It seems that the electrical measurements should be a good guide in determining the metallurgical progress, and for this reason we should endeavor to obtain a deeper knowledge of the relation between the electrical measurements and the metallurgical phenomena. An intimate collaboration between the metallurgist and the electrical engineer is essential in this study of the same, as in the study of the physical character of the arc zone.

Crucible or Electric Steel for High-Speed Tool Steel?

According to the writer of an article in *The Edgar Allen News*, entitled "Crucible or Electric Steel?" electric steel, owing to its purity and comparative cheapness, is admirably suited for many purposes such as constructional parts of motor cars and aëroplanes, miners' drills, blacksmiths' tools, etc., but when it is used solely for producing steel of the highest quality, such as high-speed tool steel, the final word has yet to be said which would place electrical steel in the same class with that of the tried and proved product of the crucible.

Many plausible reasons are given by electric steelmakers for the alleged superiority of high-speed steel made by their process. They claim, for instance, that, as each cast of electric steel is a large one, greater uniformity can be guaranteed than with the crucible process, in which twenty-four crucibles full of steel may be required to make the same weight of steel. But the crucible steelmaker may justly reply that high-speed steel is a very complex alloy; that each constituent, carbon, tungsten, vanadium, chrome, manganese, etc., must be present in exactly the right proportion, or the steel will not be up to the mark; and that in this respect the crucible process is vastly more under control than the electric. Each ingredient being carefully weighed and the crucible sealed, only an accident could alter the composition, and should an ingot be altered in this way it would be readily detected.

Moreover, while one wrong ingot out of twenty-four would not worry the crucible steelmaker, a whole cast of electric steel which went wrong would be a serious business for the electrical maker. If it were only slightly wrong, there would be a great temptation to finish the steel and risk the errors being discovered by the user.

Exaggerated claims of advantages for electric steel should, therefore, according to the writer, not be taken too seriously.

Cooling Liquids in Spray Systems and Cooling Towers

A Description of the Principles Involved in Cooling Liquids—Factors Governing the Capacity of the Cooling System Employed—Data Obtained in Testing the Ceco Spray System—Possible Application of Spray Cooling for Crystallizing Work in Chemical Industries

BY EDWIN M. BAKER

IN MANY industries it is frequently necessary to cool hot liquids, either clear solutions or solutions containing suspended solids. Also where a large supply of cooling water for condensers and similar usage is not available, it has become practice to cool the condenser water by some form of spray system or cooling tower, so as to permit using the cooling water over and over again.

The various spray systems and cooling towers all work on the same principle: i.e., they aim to bring the water to be cooled in contact with air, and to effect a cooling of the water (1) by exchange of sensible heat, the water being cooled and the air heated, and (2) by saturating the air with water vapor to cause evaporation of part of the water, thus removing some heat as latent heat. In general, it may be said that the bulk of the cooling is due to the latter effect, but the exact distribution of the cooling may be found only if the entering and exit temperatures of the air and water, and the relative humidity or saturation of the entering and exit air, are known. In any system, if there be no radiation of heat, or if this is so small that it may be neglected, it is evident that the total heat entering in the air and water must equal the total heat leaving in the air and water.

In the following discussion let

t_1 = temperature in deg. F. of entering air.
t_2 = temperature in deg. F. of exit air.
t_3 = temperature in deg. F. of entering water.
t_4 = temperature in deg. F. of exit water.
L_1 = latent heat of steam at the temperature t_1.
L_2 = latent heat of steam at the temperature t_2.
a = lb. of water vapor per lb. dry air carried by entering air, as obtained from wet and dry bulb readings.
b = lb. of water vapor per lb. dry air carried by exit air, as obtained from wet and dry bulb readings.
c = mean specific heat of dry air at constant pressure, in B.t.u. per lb. air per deg. F., taken as 0.2373.
W = lb. dry air entering per minute.
Q = lb. hot water entering per minute.
V = lb. cooled water leaving per minute.

The total heat entering will be the sum of the heat in the water and in the air. The heat above 0 deg. F. carried by the air will be composed of three parts: first, the sensible heat of the dry air, equal to Wt_1c; second, the sensible heat in the water vapor carried by W lb. dry air $= Wat_1$, and third, the latent heat in the water vapor carried by W lb. of dry air $= WaL_1$. The heat carried by the entering water will be sensible heat only, and will equal Qt_3. Therefore the total heat in B.t.u. above 0 deg. F. entering equals $Qt_3 + Wt_1c + Wat_1 + WaL_1$. The heat leaving is likewise, first, sensible heat in dry air $= Wct_2$, second, sensible heat in the water vapor carried by W lb. of dry air $= Wbt_2$, and third, latent heat in water vapor carried by W lb. of dry air $= WbL_2$. The heat leaving by the exit water is Vt_4. Therefore the total heat leaving is $Wct_2 + Wbt_2 + WbL_2 + Vt_4$. Equating these two, we get $Qt_3 + Wt_1c + Wat_1 + WaL_1 = Vt_4 + Wct_2 + Wbt_2 + WbL_2$.

The amount of water entering as liquid equals the amount leaving as liquid plus the amount evaporated, or $Q = V + (b - a)W$. Substituting this value for Q and collecting terms, we get

$$W = \frac{V(t_4 - t_3)}{C(t_2 - t_1) - (b - a)t_2 - aL_1 + bL_2} \quad (1)$$

The amount of cooling due to the sensible heat of the air with the water vapor it carries is $Wc(t_2 - t_1) + Wa(t_2 - t_1 + L_2 - L_1) = W[a(L_2 - L_1) + (t_2 - t_1)(c + a)]$; and the amount due to evaporation and carrying away of sensible heat in this water vapor is $W(b - a)L_2 + W(b - a)(t_3 - t_2) = W(b - a)(L_2 + t_3 - t_2)$.

Therefore the per cent of cooling due to evaporation in terms of the total cooling is

$$W(b - a)(L_2 + t_3 - t_2) \div \{W(b - a)(L_2 + t_3 - t_2) + W[a(L_2 - L_1) + (t_2 - t_1)(c + a)]\}$$

or per cent cooling due to evaporation $=$

$$\frac{(b - a)(L_2 + t_3 - t_2)}{(b - a)(L_2 + t_3 - t_2) + a(L_2 - L_1) + (t_2 - t_1)(c + a)} \quad (2)$$

Substitution in equation (2) the values found in practice will show in general over 90 per cent of the cooling obtained is due to evaporation of part of the water. Since this is so, it is at once evident that the amount of cooling is practically determined by the evaporation.

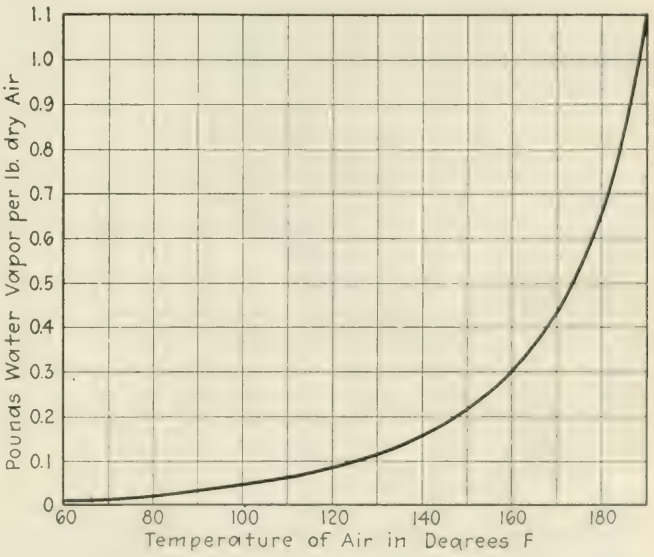
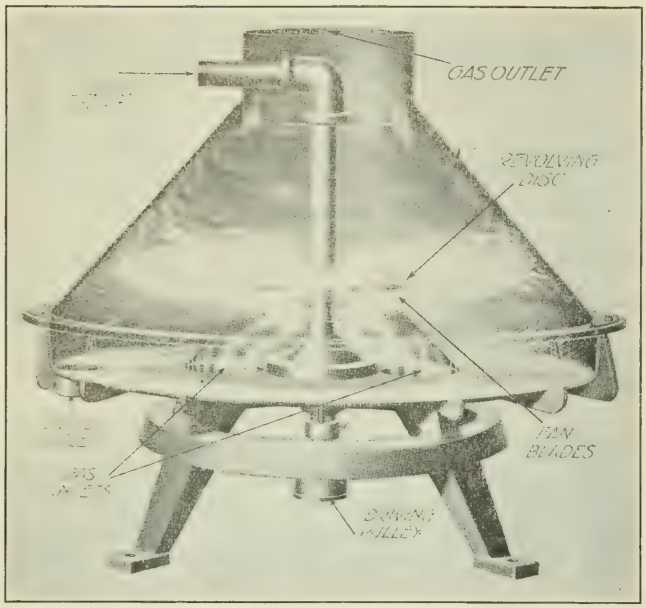


FIG. 1. WATER VAPOR IN SATURATED AIR AT 30 INCHES BAROMETRIC PRESSURE

The term "loss by evaporation," as frequently used in referring to cooling systems, is, to say the least, misleading. The amount of liquid actually vaporized is properly a measure of the cooling capacity of the system. In reality the only way that water can be actually lost in a spray system or cooling tower is by being carried away mechanically as entrainment or spray.



PHANTOM VIEW OF CECO SPRAY SYSTEM IN OPERATION

If the amount of water passing through the system per unit of time is known in addition to the above data, the volume of air handled may be readily computed. The above formula (1) gives the weight in lb. of dry air, and this may be converted to cubic feet at the temperature t_1 and particular barometric pressure existing. This air will carry with it Wa lb. of water vapor. From steam tables the specific volume of water vapor (steam) at the same temperature and pressure may be found. The product of Wa times this specific volume will give the corresponding cubic feet of water vapor. The sum of the volumes of dry air and water vapor so obtained will give the volume of atmospheric air entering the system. Or, if the air is saturated, the specific volume of the mixture may be obtained from published tables, and the product of $W + Wa$ times this specific volume will give the cubic feet of air.

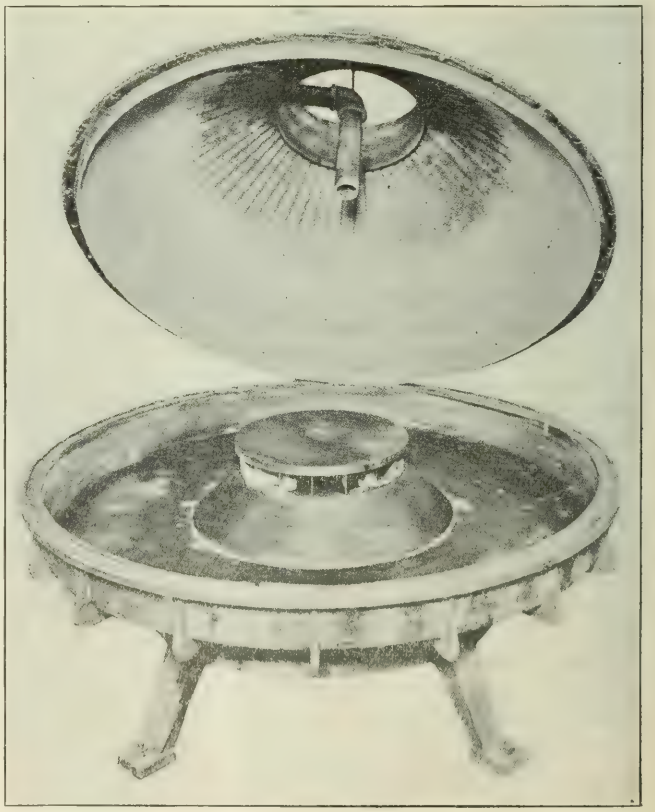
Factors Governing Capacity

The capacity of any cooling system working on air of given temperature and humidity will be dependent on the design of apparatus, the temperature of the exit air, and the amount of air handled.

The design of the apparatus should aim to give complete saturation of the exit air, and to discharge this air at as high a temperature as possible. That is, the counter current principle should be employed, and the intimacy and time of contact between the water and air should be sufficient to cause the maximum possible evaporation.

The temperature of the exit air is of prime importance, as this determines the amount of evaporation that can take place per unit of air handled. Fig. 1 shows the pounds of water vapor carried by 1 lb. of dry air when saturated at different temperatures. The amount of water vapor which can be held by the air at a given temperature is such that the partial pressure of the water vapor in the air just equals the vapor pressure of the water. If less water vapor than this is carried by the air, it is present in it as superheated steam, since it is present at a higher temperature than saturated steam would be at that particular pressure, i.e., the partial pressure of the water vapor. Ordinarily we think of this as merely unsaturated air, or air of a certain per cent humidity. It is not possible for the air to carry more water vapor than that indicated. That is, the exit air cannot be supersaturated unless the temperature is high enough so that the water would boil freely at the absolute pressure existing in the apparatus. For complete saturation of the exit air the amount of evaporation, and hence the cooling effect, will depend on the temperature of the exit air, and will increase very rapidly with increase in temperature. If the exit air is only partially saturated, then it is equally true that the higher the exit temperature of the air, the greater will be the cooling effect.

The cooling effect will always be increased by increasing the amount of air handled, but the increase will be directly proportional to the increased amount of air handled if, and only if, the degree of saturation and temperature of the exit air are maintained constant. However, for a given installation, doubling the volume of air handled will not double the cooling effect, for increasing the amount of air will increase the cooling, and hence the exit air will leave at a lower temperature. So that even if saturated, the air at the lower temperature will carry less water vapor per unit of air, and hence will have caused less evaporation or cooling effect per unit of air handled. It will not be unusual to find that doubling the volume of air will cause an increase in the cooling effect of only 50 per cent instead of the 100 per cent that might have been expected. This may be offset by increasing the flow of water so as to maintain the same high temperature of exit air. In general, the cooling capacity of any system may be increased (as measured by B.t.u. extracted and not by the temperature of the exit water) by increasing the flow of water so as to raise the temperature of the exit air. So, while it would appear contradictory, it is true that



TWELVE-INCH CECO SPRAY WITH COVER RAISED

greater cooling capacity will be obtained with higher temperature of exit water.

Tests on the Ceco Spray System

The writer has had occasion to run some tests on a new type of spray system manufactured by the Chemical Equipment Co. The accompanying cuts show the construction quite well. This spray system tested consists essentially of a revolving disk, carrying radial fan blades on its under side, and housed in a metal cone. The disk is rotated at approximately 1,800 r.p.m., from 2 to 3 hp. being required according to volume of water handled.

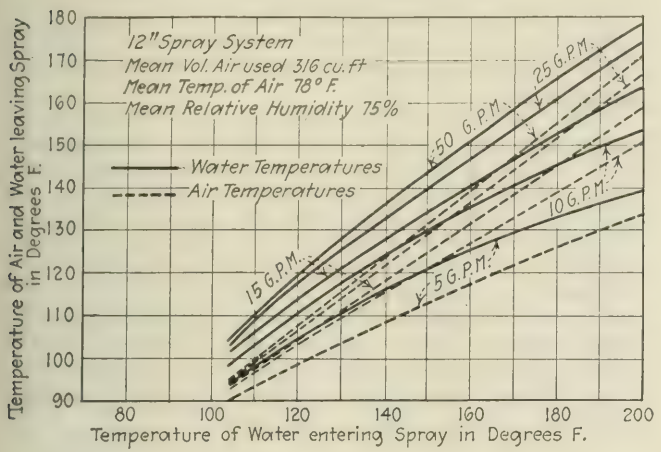


FIG. 2. RELATION BETWEEN TEMPERATURE OF ENTERING WATER AND TEMPERATURES OF EXIT WATER AND AIR

Water, or other liquid to be cooled, is brought upon the center of the disk through a fluid inlet pipe. The liquid is distributed evenly over the surface of the disk, but cannot travel at quite the rate of speed of the disk itself and consequently the liquid is broken up into small drops, each one of which is set spinning about its own axis. These drops, when leaving the disk, also tend to travel about the disk axle, and the combination of the two motions combines to give a planetary motion to each drop. A drop, as it proceeds outward from the disk, will subdivide into finer drops, to each of which is likewise imparted the planetary motion. The finer drops again subdivide, and so on. Thus a liquid curtain is built up in the spray system, thin, but dense near the edge of the disk, and becoming thicker and less dense at the cone wall.

Air is drawn in through the bottom of the spray system and discharged from the fan blades at a velocity slightly less than that of the liquid. The air is so directioned that it and the liquid curtain meet at a small angle, and due to the greater velocity and density of the liquid curtain, the direction of the air is changed without the possibility of its tearing holes in the liquid curtain, and it thoroughly intermingles with the liquid until the cone wall is reached. At this point the liquid is deflected downward, and the air upward. Due to the rotation of all particles about the disk axis, the air in its travel upward takes the path of a long spiral, and because of the centrifugal action, all entrainment is thrown out by the time the air exit is reached. The air is thus discharged from the top of the cone, whose function is to separate out any drops of liquid and so prevent entrainment; while the cooled liquid is discharged from a large connection below the cone.

The spray system was set up in the laboratory so as to permit measuring the volume of water used, the temperature of entering and exit water, and wet and dry bulb temperatures of the entering and exit air. Calibrated thermometers were used. Several sets of cooling tests were made, using a constant flow of water for each set, and varying the initial temperature of the water. Each test lasted about 11 min., ten readings of all thermometers being taken at even time intervals. These readings were averaged, and the proper thermometer corrections applied to get the true readings. From these data and the gallons of water cooled per minute, the volume of air handled and the cooling effect in B.t.u. or deg. F. could be obtained.

Temperature Changes With Varying Flow of Solution

Fig. 2 is interesting in that it shows the actual capacity of a commercial machine with a given volume of air, and as an illustration of the fundamental principles involved. If it were desired to cool large amounts of water for condenser or other work, the most economical operation would be to use a high rate of water flow and several machines in series, each discharging its saturated air separately into the atmosphere. But if it were desired, as in some chemical industries, to cool a small amount of liquid very quickly, a small flow of liquid should be used to give the desired effect, at the sacrifice of capacity. These statements in a qualitative way are general, and applicable to any type of spray or tower system.

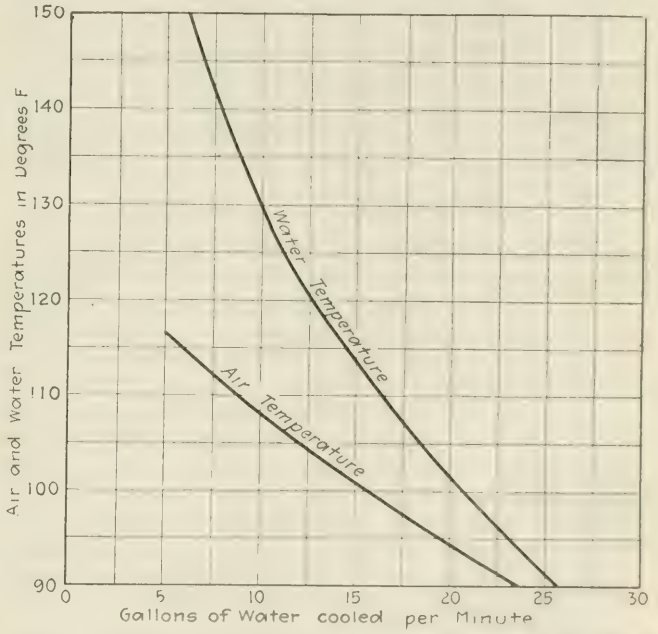


FIG. 3. MINIMUM INITIAL TEMPERATURE AND VOLUME OF WATER REQUIRED TO GIVE COMPLETE SATURATION OF EXIT AIR

Fig. 3 shows the minimum initial temperature and volume of entering water that give complete saturation of exit air. The corresponding temperatures of exit air are also plotted on this curve. For smaller volumes or lower initial temperature of entering water, the air will escape without causing maximum possible evaporation or cooling per unit of air used. To obtain maximum capacity of the machine it should be operated so as to give a saturated exit air, that is, if the initial temperature of the entering water is plotted against the water flow, the point should fall in the area to the right of the curve as drawn. There may be cases, however,

where the maximum capacity is not the main objective, and where for special reasons it would be desirable to operate to the left of the curve, that is, with the exit air not completely saturated.

Effect of Variation of Volume of Air

Fig. 4 shows the effect of increasing the volume of air handled. This was done in these experiments with the aid of a booster fan. The effect is exactly what could be predicted from fundamental considerations.

Another interesting feature brought out by the tests was the resistance of the liquid curtain to passage of the air. It was expected that just as increasing the liquid flow in a tower system increases the resistance to the passage of air, so increasing the water flow would have the same effect with the system under test. The reverse was found true. Increasing the flow from zero up to 60 gal. of water per min. caused a Pitot tube in the air inlet duct to show a marked increase in the volume of air handled. The water undoubtedly exerts a pumping or fan effect on the air—a very interesting characteristic. The tests also showed that there was no liquid entrainment in the exit air for any rates of flow of water and air used.

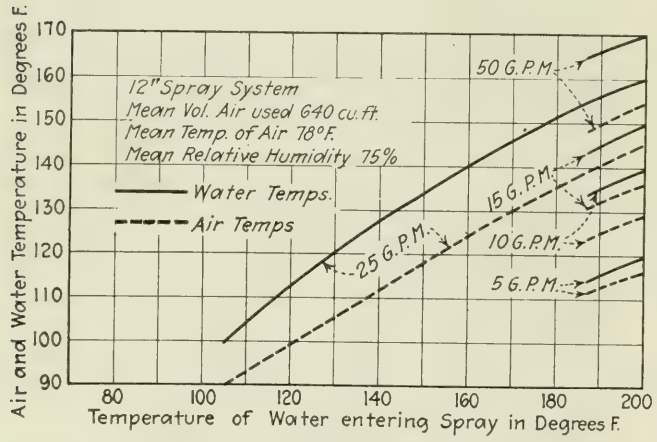


FIG. 4. RELATION BETWEEN TEMPERATURE OF ENTERING WATER AND TEMPERATURES OF EXIT WATER AND AIR, WITH INCREASED AIR VOLUME

The writer is particularly interested in the possible applications of the spray system in the chemical industries for crystallizing work. In many cases, hot solutions are run out into vats to cool slowly, the object being to form large uniform crystals. Large vats are required, and crystals of uniform size are difficult to obtain. Now, if such a solution could be run through a spray system (of a non-clogging type such as the one under test) and rapidly cooled to just the temperature of initial crystallization, and if this were accompanied by violent agitation (as obtained in this case), a large number of very small seed crystals could be started. If this liquid just starting to crystallize and containing many fine seed crystals were run to a vat to stand, the seed crystal should grow with reasonable uniformity, giving a well-graded product of large crystals. The saving in vat capacity, due to the much lessened time required for cooling the liquid with such a system, would be enormous. Moreover, concentration in the particular evaporators used would not have to be carried quite so far, as the evaporation in the spray system would remove a certain amount of water.

Chemical Engineering Laboratories,
University of Michigan.

Some Metallurgical Features of the Liberty Engine

By R. S. Archer

THE development and manufacture of the Liberty engine has afforded a most unusual opportunity for the study and correlation of knowledge concerning the materials of engineering construction as applied to gas engines. The design and materials specifications of the Liberty engine were based to a large extent upon the best modern practice, and the building of the engine was undertaken by some of the best manufacturers of this country. This applies not only to the principal contractors who turned out the finished engines, but also to the many manufacturers of parts and accessories.

While most of the metallurgical work connected with the Liberty engine was concerned with parts made of steel, the experience gained with these parts and the general principles regarding the suitability of various materials for definite uses should be of value to those engaged in the production of any material for the building of gas engines. Time is too short to cover any great proportion of the many interesting metallurgical questions that arose during the Liberty program. I shall try to point out what seem to me to be outstanding principles of a general nature, and to cite examples in illustration of these principles.

Specifications and Difficulties in Their Fulfillment

The design and materials specifications of the engine were drawn up with a sort of slogan that the best was not good enough. This was due quite largely to the insistence by many people, both in Europe and in this country, that American manufacturers were not capable of building quality engines. The high standards set up were also influenced by the strictness of the foreign specifications and inspection.

It was not long until experience showed that this rule would have to have exceptions if any quantity of engines was to be produced. One of the first difficulties encountered was the machining of the cylinders. It was necessary to remove about ½ in. of metal from the cylinder wall and the Brinell hardness limits specified were 350 to 400. This made the cylinders almost non-machinable. A similar difficulty was encountered in the case of the connecting rods, the hardness of which was about 300 Brinell, and was even worse than in the case of the cylinders, because this was milling machine work instead of a lathe job.

Lowering of Specified Brinell Hardness

One of the first concessions to the necessities of manufacturing was in the case of the cylinders. A little consideration showed that in the operation of welding the intake and exhaust elbows onto the cylinders, which was done after the cylinders had been finish heat-treated, the top of the cylinders would probably be heated up sufficiently to draw the hardness below the specified minimum of 350. A casual inspection of the welding room was enough to show that at least some of the cylinders were being heated to a temperature which would certainly reduce the hardness in places below 350. In order to test the mechanical strength of the finished cylinders, some of them were fitted with a piston in a tensile testing machine and filled with

soft soap. The bursting load found by this means gave ample assurance that the hardness could safely be reduced. The hardness limits finally established were 217-255. The chief factor governing the hardness was machinability rather than strength.

The next step of importance was the lowering of the hardness of the connecting rods. This change encountered considerably more opposition than the change in the cylinders, both because the manufacturing necessity was not so great and also because the connecting rod was considered a more highly stressed part. The situation as regards machining was rather acute, however, because the number of milling machines required for milling the channels in the connecting rods was rather larger than was easy to obtain at the time.

Some tests were run on soft connecting rods by equipping Liberty engines entirely with soft rods. One set of the usual rods was used which had not received final heat treatment and had a Brinell hardness of only 187. No failures occurred. Another engine was equipped with a set of straight carbon steel rods having a hardness of 250. This engine was also run successfully without any failures. As a result of these tests and of the obvious advantage from the standpoint of production the specified Brinell hardness was lowered from 286-321 to 241-277. This meant a change in the minimum elastic limit from 130,000 to 105,000 lb. per sq.in. No subsequent trouble was experienced as a result of this change.

Changes in Originally Specified Screw Machine Parts

Another change of the same nature, but by far the most difficult of all changes to get past the conservatism at Washington, was the substitution of screw stock for the high grade low-carbon steel which had been specified for screw machine parts. It should be explained that the term "screw stock" usually signifies a low-carbon steel of rather high phosphorus and sulphur content. This high sulphur and phosphorus confer upon the steel the property of cutting freely, although the Brinell hardness is actually higher, and steel of this type is almost universally used for screw machine products. The designers of the Liberty engine did not consider that this material was sufficiently reliable for their purposes and consequently specified a first-class open-hearth low-carbon steel with the phosphorus and sulphur limited to 0.045 per cent. At the same time the limits specified on threads were extremely close. It was found practically impossible to produce large quantities of screw machine parts with the required accuracy of thread from the low-sulphur low-phosphorus steel. Such threads could be produced from this steel if new dies were always available, but the die-producing capacity of the country was limited and very hard pressed, so that it became practically necessary to secure a free-cutting steel. In the face of much opposition the specification was finally changed on a large number of lightly stressed screw machine parts to permit the use of low-carbon steel having a sulphur content of 0.06 to 0.09 per cent, and the situation was greatly relieved.

The changes just noted were probably the most important made and were typical of a number of other changes of a similar nature. These changes were all an expression of the general tendency to specify a material which could be manufactured into the necessary parts, rather than one which would be ideal if it could be manufactured.

As time went on and the cry for increased production of engines became more insistent, further changes in material were made to facilitate manufacture, although they were not of so urgent a nature as the above changes. The time had been reached when such changes could be safely made, because the engine was much better understood, and the original factors of safety which had been employed, which were largely factors of ignorance, could be reduced. Two changes in materials of this type were the substitution of chrome-vanadium steel for chrome-nickel steel for connecting rods, and the substitution of a steel of reduced nickel and chromium contents for the crankshaft. The high chrome-nickel steel originally used for the connecting rods is particularly difficult to handle, especially in the forging and heat-treating operations. This is due to a large extent to the fact that nickel decreases the welding power of steel, thereby causing cracks once formed to remain open, and to the semi-air hardening properties of the steel which cause it to stiffen up severely if allowed to cool to too low a temperature during the forging operation. The connecting rod problem became so serious that in May, 1918, connecting rods had become the proverbial "neck of the bottle." At least this was said to be the case, and at a conference of the American Drop Forgers' Association it was decided to substitute a chrome-vanadium steel. This was done by most of the manufacturers. The result of this change was a faling off within six weeks of the average forging scrap on connecting rods from about 55 per cent to less than 10 per cent.

A change of the same nature was the substitution of S. A. E. steel 3240 for X3335 for crankshafts, because of the greater ease in forging and heat treating and the greater freedom from defects arising from the original steel ingot.

Tendency of Specification Changes

The tendency exemplified by these changes in material and lowering of the physical properties required seems to be characteristic of modern engineering thought and may be summed up in this way:

First, there is no use in specifying a material for production work which cannot be produced with the manufacturing facilities available.

Second, and rather more important because less obvious, is the tendency to prefer uniformity and reliability of product to a less uniform and less reliable product, which may have superior properties when it is at its best.

Significance of Manufacturing "Scrap"

There has been a rather inadequate appreciation of the engineering significance of manufacturing "scrap." It has pretty generally been considered that a high percentage of scrap simply means high cost and occasionally insufficient production. The evils of scrap material go much further. Scrap is material containing defects which have been found. A high percentage of scrap means a high percentage of detectable defects, and *implies* a high percentage of defects which are not detected. This may be illustrated by a consideration of the Liberty connecting rod. Most connecting rods were first made of S. A. E. steel, X3335 or X3340. These are steels containing approximately 3 per cent nickel, 0.80 per cent chromium with 0.35 and 0.40 per cent carbon. As mentioned before, this steel is difficult to handle in every step of its manufacture.

This includes the melting, casting, rolling, forging and heat treating. The defects arising from the difficulties encountered in the steel mill are typified by the snowflakes and hairline seams found in the finished stock. In forging, the steel is very sensitive to burning if it is slightly overheated. It also cracks quite easily and has the property of not welding shut on further application of work. These properties result in the production of a high percentage of scrap forgings, meaning forgings in which the defects are visible. The same causes which produce these visible defects also produce a correspondingly high percentage of invisible defects which are difficult to detect. In order to detect overheating it was required that small lugs be forged on the side and end of each connecting rod and that these be broken off after the final heat treatment in order to test for the coarse grain characteristic of overheated steel. These lugs could not, however, vouch for the quality of the entire rod, especially of the thin section in the channel, which was very apt to be overheated in the operation of heating up the big end of the rod. Similarly, the minute cracks formed occasionally in forging were sometimes completely hidden and there was no way of finding them in the finished connecting rod. When the change was made to chrome-vanadium steel, in spite of the fact that chrome-vanadium steel at its best is inferior to chrome-nickel steel at its best, it is very probable that the percentage of inferior rods which passed the final inspection and went into engines was less than when the chrome-nickel steel was used.

This is merely one example of a principle which applies to any manufactured article; that is, the greater the percentage of apparently perfect material that can be produced, the greater will be the percentage of truly perfect material and the less will be the probability of hidden defects.

Uses and Abuses of Alloy Steels in the Art of Producing Engineering Materials

This principle is not as yet widely accepted by the engineering profession, but that its acceptance is growing is shown by an increasing tendency to specify straight carbon steels where alloy steels were formerly used, not in order to cheapen the product, but to improve its quality. It is still true that alloy steels, some of them of a very fancy composition and with very extravagant claims made for their properties, constitute a strong selling point for the steel salesman, but I believe the tendency is against these products in favor of a product which can be made with greater uniformity and certainty. This does not mean that it is advisable to avoid alloy steels or other materials of a superior quality simply because the methods of fabricating them have not been fully developed. Such an idea would of course stifle advances in the art of producing engineering materials, nevertheless there are some materials which are inherently more difficult to produce satisfactorily than others. For example, I do not see how any advance in the art of manufacturing alloy steels can overcome the fact that nickel steel is difficult to weld and that cracks once formed in a forging will remain open; or, to go even farther back than this, that cracks formed in the ingot will also remain open and be found in the finished product as snowflakes or other defects. The alloy steels must by all means be used where material of the very highest properties is necessary. There are also cases where economy requires the use of alloy steels because of the wider range of heat-treating temperatures, and the greater ease of machining.

Strength of Materials

Let us consider briefly the steps in engineering design, as applied to the strength of materials. First, the maximum working stresses of the part in question are calculated; a factor of safety is assigned and a material chosen whose properties are expected to give the required factor of safety when the part is made of the proper dimensions. This method, which is followed so largely in structural engineering, does not hold to such an extent in automotive design. In building automobile engines and especially airplane engines, the practice has been to start with a part of sufficient size and made of a material of sufficient strength to give considerable assurance of safety, then to gradually reduce the dimensions of the part or the physical properties of the material to the lowest point which experience shows to be safe. I have been told that one of our foremost designers of airplane engines determined the limiting sizes of his important parts by running destruction tests on engines containing parts of successively smaller dimensions. When the dimensions had been reduced to such an extent that the part in question failed in service, it was known that the dimensions had to be increased or a better material used. In other words, the engineering of automobile and airplane engines has been largely a cut-and-try proposition.

Factors of Safety

The factor of safety which is used in engineering design is largely a factor of ignorance; ignorance as to the actual stresses developed in service, and ignorance concerning the true physical properties that will be obtained in the fabricated part. The nature and extent of the working stresses developed are investigated by the process of cut and try to which I have referred. By this process there is obtained a fairly exact idea of the limiting dimensions of the part, assuming definite physical properties in the material to be used. These minimum dimensions must then be increased in proportion to the uncertainty regarding the physical properties which actually will be obtained. This uncertainty, and consequently the dimensions and weight of the part in question, can be reduced by using a material which is more certain to yield uniform properties and less likely to develop flaws which are hard to detect in inspection. It is not the average physical properties of the material of a given piece of mechanism that determine the quality of the machine, so much as it is the maximum deviation from the average. For example, it may be better engineering practice from the standpoint of quality alone to use a straight carbon steel with an average elastic limit of 90,000 lb. per sq.in., in preference to a chrome-nickel steel having an average elastic limit of 125,000 lb. per sq.in., if the conditions of manufacture are such that the percentage of parts made of the straight carbon steel which fall dangerously low is less than the percentage of the chrome-nickel steel parts which fall dangerously low.

Conclusion

To sum up the foregoing observations, the effect of the Liberty engine program upon the selection of engineering materials has been to emphasize the importance of uniformity of product and ease of manufacture.

Loss Due to Carbon in Furnace Refuse*

By C. H. Berry

IT IS common to treat as pure carbon the combustible which passes through the grates or over the dump plates together with the ash. The losses resulting from the failure to burn this lost coke depend upon two factors—the percentage of ash in the original coal and the percentage of carbon in the furnace refuse. Both of these quantities are determined by laboratory analysis of samples of the coal and refuse respectively. Knowing these values, the heat loss may be computed from the following equations:

$$\textit{Per cent ash in refuse} = 100 - \textit{per cent carbon in refuse.}$$

$$\textit{Lb. refuse per lb. coal} = \frac{\textit{per cent ash in coal}}{\textit{per cent ash in refuse}}$$

The weight of carbon lost is then

$$\textit{lb. refuse per lb. coal} \times \frac{\textit{per cent carbon in refuse}}{100}$$

$$= \frac{\textit{per cent ash in coal}}{\textit{per cent ash in refuse}} \times \frac{\textit{per cent carbon in refuse}}{100}$$

This may be written:

$$\textit{Lb. carbon lost per lb. coal fired} = \frac{\textit{per cent ash in coal}}{100} \times \frac{\textit{per cent carbon in refuse}}{100 - \textit{per cent carbon in refuse}}$$

Since 1 lb. carbon has a heating value of 14,600 B.t.u.,

$$\textit{Lb. carbon lost per lb. coal fired} \times 14{,}600 = \textit{B.t.u. lost per lb. coal fired.}$$

The percentage heat lost will be

$$\frac{\textit{B.t.u. lost per lb. coal fired}}{\textit{Heating value of coal as fired}} \times 100.$$

These formulas have been combined in the accompanying alignment chart, in which the left half gives the pounds of carbon lost per pound of coal and the B.t.u. lost per pound of coal, for given values of the percentage of ash in the coal and the percentage of carbon in the refuse. The right half of the chart gives the per cent of heat loss from the known result found from the left half of the chart together with the known heating value of the coal.

An examination of the chart will indicate that the extent of this heat loss may be considerable. For example, if we fire a coal containing 12.5 per cent of ash, and if the resulting furnace refuse contains 38.7 per cent of carbon, the weight of carbon thus lost will be 0.079 lb. of carbon per pound of coal fired. This results in a loss of 1160 B.t.u. per pound of coal fired. If the heat value of the coal is 12,700 B.t.u. per lb. this heat loss will be 9.2 per cent of the heat value of the coal, which is the basis used for figuring all the heat losses in the furnace, boiler and setting. It can readily be seen that for higher percentages of carbon in the refuse this loss may be an even larger proportion of the heating value of the coal. It should also be noted that a higher ash content of the coal, with the same percentage of carbon in the refuse, will also give a larger heat loss. This is one reason, though a minor one, why high-ash coals do not permit as high boiler efficiencies as obtainable with higher grades of fuel.

The extent to which this loss may be reduced depends upon many things, but it seems that under fair operating condtions it is reasonable to expect not more than 20 per cent. of carbon in the refuse, and under good conditions not exceeding 10 per cent. The corresponding heat losses will then be less than 5 per cent and may be as low as 1 per cent under favorable conditions. A series of 77 tests conducted at the St. Louis plant of the United States Geological Survey showed an average heat loss a little under 5 per cent, and these tests were made under oprating conditions, using coals of a wide range of quality.

Practical suggestions for reducing this loss include: Avoidance of unnecessary barring and raking of fires, an ample (but not too vigorous) supply of air at the dump plate, and the use of clinker grinders.

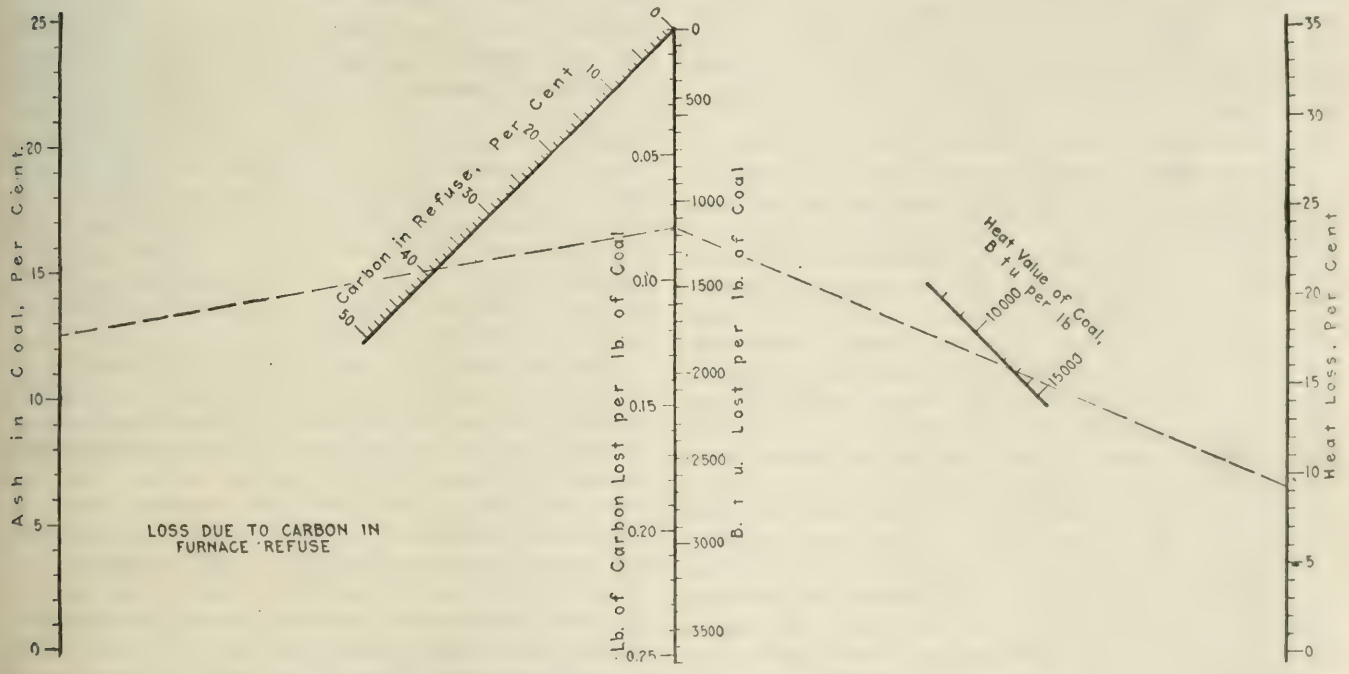

Ash in Coal, Per Cent.
Carbon in Refuse, Per Cent
Lb. of Carbon Lost per lb. of Coal
B. t. u. Lost per lb. of Coal
Heat Value of B t u per lb Coal
10000
15000
Heat Loss, Per Cent
LOSS DUE TO CARBON IN FURNACE REFUSE

CHART FOR FINDING LOSS DUE TO CARBON IN FURNACE REFUSE

*Abstracted from *Power*, Sept. 23, 1919, p. 500.

Legal Notes

By Wellington Gustin

Unfair Competition by Use of Trade Mark—Extent of the Use of Trade Mark

THE rights of one to adopt and use names in the prosecution of one's business is very broad, but must be limited when such use injures the business of others. Especially when the use of a word offers unfair competition with another who has a prior right to its use the courts will interfere to protect the latter's interests. But the right to exclusive use of a trade mark is not unlimited. In a recent case at special term the Supreme Court of New York County enunciated several rules affecting these principles. (177 N. Y. S., 713.)

The plaintiff in the case is a trading corporation organized in 1907, at that time succeeding to the business of a partnership formed in 1900. It is chiefly engaged in trade with foreign countries, dealing in a great variety of merchandise, paper products appearing to be its chief lines. It seems to be rapidly extending its lines and business and is the owner of a trade mark, consisting of the word "Caravel" with the picture of a sailing vessel of the ancient type. This word was originally used only on paper, but as the business was expanded the trade mark was more widely used, so that it has been affixed to inks, ink-making materials, and various other goods. Other goods have been shipped and to them the word has been applied as a designation of a brand in the invoices. Goods of many other descriptions have been shipped, and many other shipments of similar goods have been made without the use of either the name or the mark.

Name Complained Of Chosen Innocently

Now, in 1916 the defendants in this case formed a partnership and began doing business under the trade name "Caravel Company." The firm name was chosen innocently. At first the firm business was confined to dyestuffs, but later it dealt also in drugs and chemicals. Its business also was largely done with foreign countries. In 1918 the defendant corporation was formed and the firm name was adopted as the corporate name. The business of the firm was transferred to the corporation and the firm dissolved. The partners became officers of the corporation, which continued the business in dyestuffs, drugs, and chemicals. It also extended its dealings to general merchandise. It has used a label upon which its corporate name is printed, together with a representation of a sailing vessel of the caravel type. The catalogs, advertising matter, and stationery bear the same name and drawing. Its label has been affixed to certain classes of goods which plaintiff has been accustomed to ship without its trade mark. It was shown to have attempted to do business in paper and in other classes of merchandise which plaintiff had dealt in previously under its trade mark. Prior to the organization of the corporation, but after the formation had been decided on, plaintiff notified the firm that it was the owner of the Caravel trade mark and requested the firm to discontinue the use of the word "Caravel," both in its firm name and otherwise, in connection with the sale of its goods. At this the firm had a search made of the records of the Patent Office. This search showed the particular classes of merchandise for which plaintiff's trade mark had been registered, and also that trade marks consisting of the word "Caravel," both with and without the representation of a sailing vessel, had been registered by other persons for goods of various descriptions. The defendants refused to abandon the use of the name "Caravel Company" or the use of their labels, and plaintiff asked for an injunction against them.

The essence of the wrong complained of is unfair competition, said the court. The general principles applicable were stated as follows: "A trade mark is acquired by adoption and use as such. It must be affixed to the goods. The right of user is in its very nature an exclusive right. Unauthorized use or imitation by a competitor may be restrained. The right to exclusive use of the trade mark is not unlimited. Its use upon one or more commodities does not give the right to use it upon all. But neither is the right confined to the precise species of goods to which the mark has been affixed. It extends to other goods of the same class; and where the general uses or characteristics of the articles are similar or analogous they are within the same class. A trade mark used by a manufacturer of picks and hoes may not be used by a competitor upon shovels; . . . nor may a manufacturer of tooth brushes appropriate the mark used by another on hairbrushes.

Test of Legal Trade Mark

"Prior appropriation to the species prevents a subsequent competitive use upon a class in which the species is included. The test is whether an intending purchaser would be likely to mistake the origin of the goods. The purpose is to prevent the palming off of the products of one trader as that of another; and where the danger of confusion and deception is manifest, it is unnecessary to prove that either has in fact occurred. The principles thus stated as applicable to trade marks apply equally to marks which are not technical trade marks and to trade names. So the use of a corporate name may be enjoined, if confusion or deception is likely to result from its use by a dealer in competitive goods."

Applying these principles the court concluded:

First—The plaintiff has acquired the exclusive right to use the Caravel trade mark on the various classes of goods upon which it or its predecessor was the first to affix and use that mark.

Second—The plaintiff did not acquire any exclusive right to the use of the name or mark by the mere use of the name "Caravel" in its invoices.

Third—The use of the trade mark upon certain classes of goods cannot upon any theory of extension of user give to plaintiff the exclusive right to use it upon all the varied classes of general merchandise in which it has dealt, or in which it may hereafter choose to deal.

Fourth—Though the use of a corporate name may be restricted and enjoined in a proper case, there is no ground upon which the defendant company can properly be required to discontinue the use of its corporate name.

Whether the defendant corporation should be allowed to do business in its corporate name in those classes of goods upon which plaintiff has the exclusive right to use the Caravel trade mark was an important question in the case. The court said that if

the business of the defendant corporation was confined solely to such goods, it would be restrained from doing business under the name "Caravel Company." But the defendant corporation deals in goods of a very diversified character. Hence the court held that defendants should be restrained from dealing in or advertising, under the name "Caravel Company" or any other similar name, those goods as to which plaintiff has established the exclusive right to use the Caravel trade mark. So judgment was given accordingly.

Injuries to Workmen From Noxious Dust and Gases —Employer's Duties Set Forth

Compensation acts are disposing of much of the negligence cases formerly arising under the common law. However, exceptions and conditions still permit of many cases. In Indiana, which has such an act, comes a case wherein an employee brings an action against his former employer to recover damages for injuries to his eyes and health through the employer's negligence in permitting the escape of noxious dust and gases from its mixing room into the room where the employee was working. (Brunson vs. Macbeth-Evans Glass Co., 122 N. E., 438.)

From the facts it appears that the employment extended over several years and the injuries were a general resulting condition some time after the employment. In this complaint the plaintiff charged that he first worked for defendant as a gatherer of molten glass and later as a glass blower, working in the blowing room; that adjacent to the blowing room defendant maintained a room known as a mixing room, where it mixed products used in the manufacture of glass in large troughs; that among the poisonous substances thus mixed were suboxide of copper, oxide of tin, white sand, pearl ash, saltpeter, arsenic, magnesia, soda ash, lime, carbonate of soda, niter, charcoal, and lead, which said substances were at all times mixed dry; that all of these substances were injurious to human beings who came in contact with them, and were especially injurious to the eyes of such persons. The plaintiff further charged that from the mixing of these poisonous substances in a dry and powdery state, there arose a cloud of dust, which, if not confined and prevented from blowing from the mixing room into the other rooms of the factory, would permeate the air of these parts and injure the eyes and eyesight of the workers there; that during the time of his working in the blowing room his eyes and eyesight became affected and injured from this dust, though at the time he did not know that they were, or would become, injured from it.

The defendant was charged with knowledge, or by the exercise of proper care should have known, of the injurious and deleterious effect of this dust upon the eyes of human beings. It was charged with negligence in that there were doors in the mixing room for the purpose of keeping it closed, but defendant permitted the doors to be open and the dust to escape through these doors into the blowing room, where plaintiff worked; that defendant negligently suffered the partition shutting off the mixing room to be loose and insecure and allowed large cracks and openings to remain in the same so that dust and gases from the mixing troughs and poisonous chemicals escaped into the blowing room and into the plaintiff's eyes and face. All of which injured plaintiff's general health and his eyes and caused cataracts to form over them, permanently impairing his eyesight.

In another count of the complaint negligence was charged in that the employer did not instruct the employee as to the danger to his eyes when they were, as during the course of the employment, exposed to intense radiated heat.

Another count was the alleged negligence of defendant in causing plaintiff to work exposed to great heat, when run down physically.

Plaintiff obtained a verdict and judgment for damages upon the trial. On appeal the higher court held the complaint stated a good cause of action, but granted defendant a new trial on an erroneous instruction regarding defendant's allowing plaintiff to work where his eyes were being subjected to radiated heat while in a run-down physical condition.

It should be valuable to employers to know what the court said regarding the first cause of the complaint. The duty of the employer in protecting his workmen is put into a statute that is more than declaratory of the common law. This statute provides as follows:

Statute Defines Employer's Duties

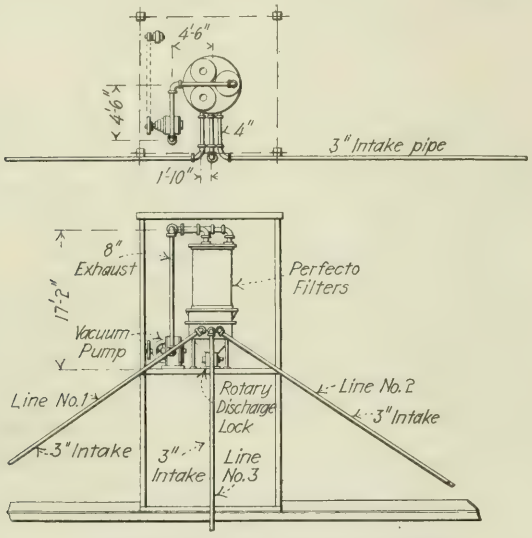
"It is hereby made the duty of all owners, . . . corporations, agents or persons whatsoever, engaged in the care, operation, management, . . . of any shop, factory or business of whatsoever kind, . . . and generally it shall be the duty of all owners, managers, operators, contractors, . . . and all other persons having charge of, or responsible for, any work, mechanism, machinery, appliance, building, factory, plants, means, employment, or business of whatsoever nature, involving risk or danger to employees, . . . to use every device, care and precaution which it is practicable and possible to use for the protection and safety of life, limb and health, limited only by the necessity for preserving the reasonable efficiency of such structure, ways, work, plant, building, factory, . . . appliances, apparatus, or other devices or materials, without regard to additional cost of suitable materials or safety appliances, or safe conditions or operations, the first concern being safety to life, limb and health."

In view of this statute the court asked: Did the defendant "know that the continued breathing of the dust and fumes as complained of was injurious to the workmen? If it did not so know, could it, by the exercise of reasonable care and caution in the premises, have so known? If it did know of the poisonous nature and deleterious effect of these gases and dust on workmen, and permitted their continued exposure thereto, it was negligent, as a matter of law. . . . If it did not have actual knowledge of the foregoing facts, but by the exercise of reasonable care in the premises could have so known, and yet permitted the continuation of such dangerous condition, as to which condition the jury were told in said instruction that they must find as a fact 'that said partition was allowed by defendant to become in disrepair, and was not properly constructed, and that doors and windows were left open so that dust was allowed to arise and blow through said crevices and cracks and said doors and windows in said partition, into and upon the workmen and the plaintiff, at work in said blowing room,' then, this fact being found against defendant, it was guilty of negligence in not so ascertaining that fact, and in permitting further unnecessary exposure of its employees thereto."

Dracco System at Armour Fertilizer Co.

The accompanying illustration shows the operation of a Dracco nozzle directed by a single workman in removing dry blood, tankage, and other materials used in the manufacture of fertilizers at the Jacksonville plant of the Armour Fertilizer Co. Formerly cars were unloaded by hand and material lifted by bucket elevators, a process most tedious and unsanitary and at the same time expensive.

Three ascending intake pipes terminate at the lower end in flexible steel hose, and intake nozzles make it possible to unload three cars without switching. These steel pipes lead upward to and are connected with a receiver where all the coarse particles are settled, this



OPERATION OF A DRACCO NOZZLE

settlement being accomplished by a reduction in the air velocity.

The extremely fine dust passes upward into filter units of the Perfecto type, placed directly on top of the receiver. This settling and filtration collects all the material and it is carefully discharged through an especially designed rotary lock as fast as unloaded. The air which has been entirely cleaned by its passage through the filters is sucked through a high-efficiency vacuum pump. Operation depends upon a high vacuum, which may be anywhere from 5 in. to 25 in. of mercury according to distances, material, capacity, and other local conditions.

Scoop Conveyors for Coal Storage

A portable conveyor developed by the Portable Machinery Co., Passaic, N. J., shown in Fig. 1, has become quite popular as a means of handling bulk materials from car to wagon or stock pile, or vice versa.

A great advantage of using the scoop conveyor to

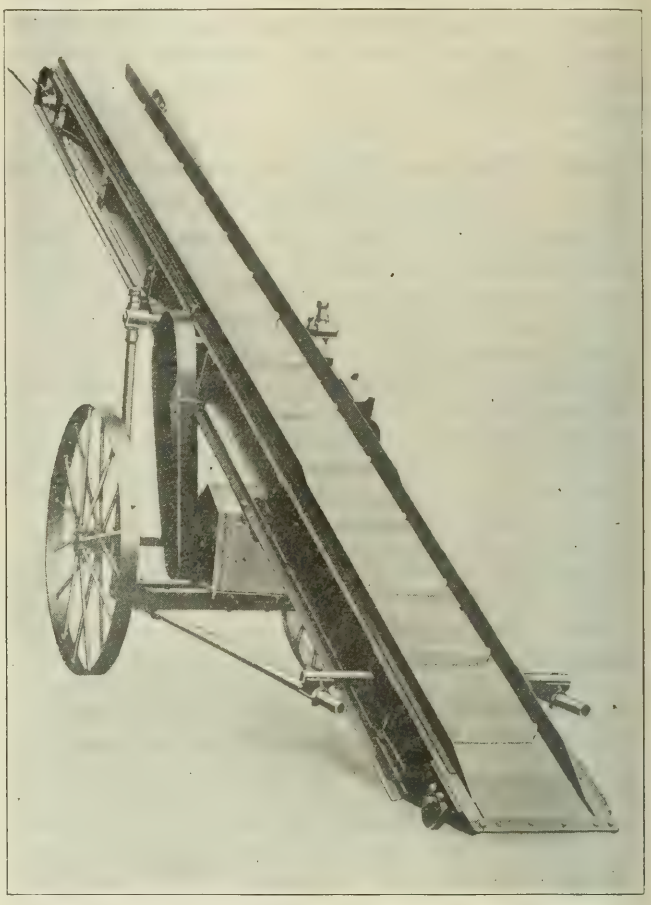


FIG. 1. SCOOP CONVEYOR FITTED WITH HIGH-FLIGHT BELT

unload hopper-bottom cars is the fact that no track hopper or pit is necessary. This makes it possible to unload cars at any point along the track. To unload a car, the feed end of the machine is placed near or under the car hopper, which is then released and the belt on the conveyor carries the material away as fast as it flows through the hopper opening.

FIG. 2. UNLOADING COAL A DISTANCE OF 150 FT. WITH FIVE SCOOP CONVEYORS

An interesting application for storing coal is shown in Fig. 2, illustrating five individual machines electrically driven being used to unload coal from hopper-bottom cars direct to storage pile. This provides a convenient, efficient and flexible arrangement. The first

FIG. 3. LOADING COAL HOPPER ON A HUNT ELECTRIC STORAGE BATTERY TRUCK WITH A SCOOP CONVEYOR

machine is practically self-feeding from the hopper doors of the car, and the four others may be swung around at any angle to cover a wide storage area, and can be operated by one or two men. They can also be used to reverse the operation and convey the coal direct from storage pile into boiler room, or singly to load as shown in Fig. 3.

Synopsis of Recent Chemical and Metallurgical Literature

The Solubility of Gold in Cyanide Solutions.—A paper on this subject, by A. H. WHITE, was published in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa for July, 1919, of which the following is an abstract:

The relative rate of solubility of gold and zinc by cyanide solution is proportional to their equivalent weights; thus

$$2Au : Zn = 394.4 : 65.37 = 6.03$$

Maclaurin has also found the relative rate of solubility of Au and Ag is proportional to their atomic weights.

The speed of the reaction depends entirely upon the rate of diffusion of the cyanide and oxygen in the solution in practice, of which the latter is the more important. The final effect of the reaction is given by the equation

$$2Au + 4KCN + O + H_2O = 2KAu(CN)_2 + 2KOH$$

394.4	260.44	16.0
1.000	0.6603	0.04057
1.5145	1.000	0.06144
24.648	16.276	1.000

Therefore 10 mg. oxygen per liter is equivalent to 0.0163 per cent KCN, 7 mg. to 0.0114 per cent KCN and 6 mg. equivalent to 0.0098 per cent KCN in solution. Since the average concentration in this district is 6 mg. of oxygen per liter, other things being equal, there is no advantage in maintaining the cyanide strength of the working solution in excess of 0.01 per cent KCN. It was found by experiment, however, that with about 6 mg. of oxygen per liter, the greatest speed of the reaction was with solutions containing between 0.02 and 0.03 per cent of KCN; sodium cyanide of equivalent strength being used, and the gold being free from electrolytic contact. Maclaurin found the maximum speed to take place at 0.25 per cent KCN; these results are only one-tenth this strength, but are confirmed by the fact that a similar degree of concentration, namely, 0.02 to 0.03 per cent, was found to give maximum speed of reaction for zinc, pure gold and for battery bullion in a solution made up with sodium zinc cyanide, the "total" cyanide strength being taken. There seems, therefore, to be no adequate reason for maintaining higher strengths of solution in contact with sand under treatment where the last portions to yield a profit have chiefly to be considered, and these may well be assumed to be in contact with quartz only. Adequate oxygen concentration is always of an advantage, especially in case of working solutions where side reactions are effective competitors for this oxygen.

The paper contains details of the experiments from which these deductions are drawn, together with tables and curves showing results.

Powdered Coal in the Chemical and Allied Industries.—The *Catalyst* of December contains the following abstract of an address delivered by W. H. FITCH before the Delaware Section, American Chemical Society.[1]

The steel and cement industries are the greatest users of powdered coal as a fuel. Altogether about 2,000,000 tons of powdered coal are used annually. In the steel industry open-hearth furnaces are the greatest users of coal, and there are about eighty-five furnaces thus equipped. About 75 to 80 per cent of the cement produced in the United States is made in the Lehigh Valley, and in this valley nearly all of the kilns are equipped to burn powdered coal. Most of these powdered coal plants have been put in during the last four years. Any kind of coal may be used, from lignites to anthracites. Even anthracites containing as high as 40 per cent non-combustible matter can be thus burned. Lignites must be dried to a water content of 4 or 5 per cent, bituminous coals and anthracites to less than 1 per cent. This drying is necessary to get economical grinding.

When powdered coal was first introduced everybody was afraid that great explosion risks would result therefrom. This has been demonstrated not to be the case, and the bugbear of those unfamiliar with powdered coal is now the ash problem. In regenerative furnaces this really constitutes a problem because the ash deposits in the brick checker-work. With a properly designed furnace, however, this is not serious. In a steam plant burning powdered coal about 10 per cent of the ash known to be in the coal deposits in a molten condition in the bottom of the combustion chamber. Beyond the bridge-wall a further small deposit is found, and in the rest of the setting no more than would be the case when firing coal with a mechanical stoker. The remainder, about 90 per cent, goes up the stack in a finely divided condition.

This is not surprising considering that the coal is ground so fine that 95 or 96 per cent goes through a 100-mesh sieve, 85 per cent through a 200-mesh sieve, and 72 to 75 per cent through a 300-mesh sieve. Powdered coal delivers from 25 to 30 per cent more of the heat value of the coal than gas producers and the installation and operating cost are about half as great as for gas producers. At the present time the total cost of delivering one ton of coal from the railroad

[1]The *Catalyst*, vol. 4, No. 10, p. 4, December, 1919.

siding, grinding it, and preparing it for burning in the pulverized form is about 60c.

Effect of Inclusions on Stress Distribution.—Considerable study has been given to stress distribution in non-uniform sections, notably to the effects of circular holes in tension members. Such variations were experimentally determined by Wilson and Gore using perforated rubber sheets, by Andrew McCance (*Trans.*, Inst. of Eng. and Shipbuilders in Scotland, vol. 62), plotting lines of equal hardness in permanently deformed metal, by E. G. Coker, *Trans.*, Inst. of Naval Architects, 1911; *Proc. Phys. Soc.*, London, vol. 25; *Proc.*, Inst. of Automobile Engineers, November, 1917, and *Trans.*, Inst. of Eng. and Shipbuilders in Scotland (December, 1919), studying interference figures by polarized light on transparent nitrocellulose sheets. McCance also suggests that since a piece is cooled when tension is applied, modern pyrometry, capable of measuring accurately within 0.001 deg., could be used to map lines of equal stress. C. E. Inglis has worked out a purely mathematical solution for both circular and elliptical holes in plates of infinite width (*Trans.*, Inst. of Naval Architects, 1913).

These researches show the surprising result that the dimunition of the section of a bar by a center hole is accompanied by a dimunition of stress at the outer edge of the perforated bar, owing to the great concentration of stress at the boundary of the hole. Stress at the latter point varies widely, from a value practically equal to 3 times the average on the transverse diameter, diminishing to zero at 60 deg. and to a maximum compression at the axial diameter. Intensity of these stresses at the inner edge of the hole is independent of the size of the hole, and the area surrounding subjected to higher stresses than the average is shaped like a two-bladed propeller, with a greatest width extending at right angles to the direction of stress of about 4 times the diameter of the hole.

McCance, in discussing Coker's latest paper in the *Transactions* of the Institution of Engineers and Shipbuilders in Scotland, December, 1919, points out the metallurgical applications of these results. Steel, no matter how well made, always containes non-metallic inclusions, and it has been found by experience that when fracture takes place its path nearly always favors segregated areas. But so long as the impurities are small and uniformly distributed, they do not seem to affect the steel, but when they are large or in clusters or segregates, they are dangerous, causing test pieces to break with low contraction and elongation. Apparently, if the particles are separated from one another by more than four times their diameter, the zones of overstrain caused by their presence (internal notching) do not overlap, and are consequently not so objectionable as when closer together, when their stress effects are mutually superimposed. If close enough, the stress in metal separating them may approach six times the average, and easily pass its elastic limit or ultimate strength. The larger the size of each particle, the greater the chance that another will be found enclosed within the overstressed boundary. Such ideas explain well the fact often encountered that when examining steel, cracks appear between two very small inclusions close together, but nearby single ones much larger have no cracks in their vicinity.

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Process of Treating Copper Ores by Lixiviation With SO_2 Solution.—Niels C. Christensen of Salt Lake City improves the process for the extraction of copper from ores by lixiviation with a sulphur dioxide solution. The leaching solution is kept free from sulphates by the exclusion of air and the formation of copper sulphates is prevented during the leaching and subsequent operations by the addition of metallic copper. Copper is recovered from solution by boiling off SO_2, this latter being used again. The accumulation of iron in the mill solution is prevented by the addition of lime or limestone. (1,316,351; Sept. 16, 1919; assigned to the Metallurgic Improvement Corp.)

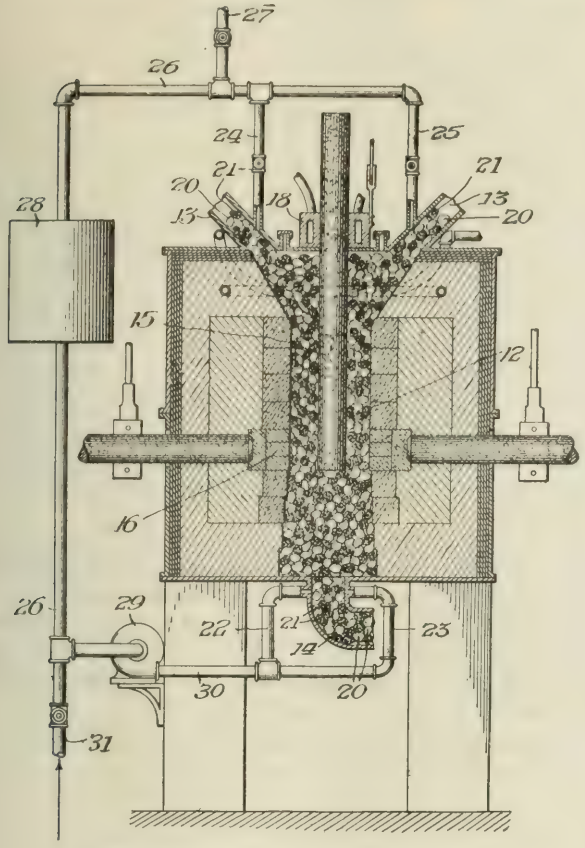
Tungsten Crucible.—Frederick G. Keyes of Hoboken, N. J., produces a tungsten crucible as follows: A form in the shape of a crucible is made by molding pure tungsten powder (sometimes mixed with ½ per cent NiO or with 20 per cent MoO). This form is filled with W_2O_5 or WO_2 and heated in a resistor furnace. This furnace is provided with a means of introducing carbon monoxide. As the tungsten oxides melt they are absorbed by the tungsten powder crucible form and then are reduced by the CO to metal. A homogeneous vessel of pure tungsten results. (1,318,452; Oct. 14, 1919; assigned to the Cooper Hewitt Electric Co.)

Ferro-Alloys.—Two patents have been issued to the estate of the late J. E. Johnson, Jr., on methods of producing ferro-alloys. In the first it is proposed to charge a high-temperature furnace with the usual ingredients for making ferrosilicon, with the exception that a feldspathic mineral is used as the source of silicon. At the high temperature needed to reduce the silica, the feldspar is decomposed and volatile alkaline metals driven off as oxides or carbonates, practically free from mineral acids and easily purified into salts of much value chemically. The fuel on heat consumption of the furnace is not materially greater than when using quartzite in the mix. In the second it is noted that low-carbon alloys can be made in ordinary furnaces (preferably a small blast furnace with enriched oxygen blast) if sufficient temperature is produced to reduce a considerable quantity of silicon from the charge. It appears that silicon has the important quality of excluding carbon from the alloys to a progressive extent as its quantity is increased. This undesirable silicon is then removed on tapping the alloy from the furnace by mixing with a molten reagent, made of iron oxide, lime and a little fluorspar. Silicon then replaces the iron in the reagent, and is fluxed as a lime silicate. (1,318,763 and 1,318,764; Oct. 14, 1919.)

Polyphase Electric Furnace.—Mark Shoeld of Chicago, Ill., provides for the uniform distribution of current flow in polyphase electric furnaces and therefore obtains uniform distribution of heat throughout the material to be treated. This is accomplished by mixing the material in the form of briquets with infusible heat-conducting resistor-elements of a

greater specific conductivity than the briquets. The current tends to flow through the resistor-elements, the material thereby being heated by conduction preventing the fusion of this material. The spacing of the electrodes and their distance from the furnace are important. (1,317,328; Sept. 30, 1919.)

This principle is applied in furnace shown in the illustration. In case aluminum nitride is to be produced the briquets 20 are composed of comminuted carbon, alumina and a suitable binder. The resistor-elements 21 may be composed of carbon. These are fed through chute 13, pass through furnace chamber 12 and are discharged at 14. The furnace has a central electrode 15 and a ring electrode 16. Nitrogen gas is caused to flow up through the furnace charge entering through pipes 22 and 23. This cool gas reduces the temperature of the treated charge and is itself heated, the hot gases after passing the heating zone pass through the incoming charge, heat being transferred to the charge from the gases which pass out through pipes 24 and 25. This gas may be carried by pipe 26 to the scrubber 28 and thence through blower 29 and pipe 30, completing the circuit, or a portion of the gas may be exhausted through pipe 27, in which case the supply is made up by the admission of gas through pipe 31. (1,317,327; Sept. 30, 1919. Both patents assigned to the Armour Fertilizer Works of Chicago, Ill.)



POLYPHASE ELECTRIC FURNACE

Removing Scale From Steel.—QUINTIN MARINS of Hendon, England, proposes the use of 25 deg. Bé. solution of alkaline sulphates and fluids, in proportions of 3 to 1. A carbon or lead anode, a current density of 20 amperes per sq.ft., and a temperature of 75 deg. C. are recommended. (1,324,317; Dec. 9, 1919.)

Book Reviews

CREATIVE CHEMISTRY. By *Edwin E. Slosson, Ph.D.* With an Introduction by Julius Stieglitz. 311 pp., illustrated. New York: The Century Co.

This is an excellent book on popular chemistry, designed to explain the application of the science to industry and daily life to the lay public. Although made up in chief part from a series of papers that appeared in the *Independent*, of which Dr. Slosson is literary editor, it is carefully planned and well put together. It is also richly illustrated. The text is by a man who writes with great ease and experience in the art of expression, and it makes pleasant reading to that part of the public that does not require tam-tams for its ragtime thought. The chapters, which number fourteen, consist of a short historical introduction, Nitrogen, Feeding the Soil, Coal-Tar Colors, Synthetic Perfumes and Flavors, Cellulose, Synthetic Plastics, The Race for Rubber, The Rival Sugars, What Comes From Corn, Solidified Sunshine (referring more particularly to vegetable oils and fats), Fighting With Fumes (or Gas Warfare), Products of the Electric Furnace, and Metals Old and New. These are followed by a well-selected bibliography for extended reading arranged according to subjects, and a good index. Of course, every subject treated is important enough to cover many volumes, but it is fair to say that Dr. Slosson has crowded an unusual amount of information into each chapter. ELLWOOD HENDRICK.

* * *

QUANTITATIVE ANALYSIS BY ELECTROLYSIS. By *Alexander Classen.* Revised, rearranged and enlarged English edition by William T. Hall. xiv + 346 pages. New York: John Wiley & Sons, Inc.

The revision and enlargement of this well-known book is chiefly in the introduction, which comprises about a third of the volume. The application of theory to the procedure in analytical methods tends to clarify the details in the mind of the student. A thorough comprehension of the principles and the application of the electronic theory is therefore essential to the successful use of electrolytic methods of analysis. The discussion in the introduction is well presented from this point of view. The brief historical review of the development of the science of electrochemical analysis is more extensive than in the previous edition. The remainder of the book has been rearranged, the sequence in which the determinations are discussed constituting a more logical presentation of the subject matter. Data consisting of the atomic weight, electrochemical equivalent, electrolytic potential and the overvoltage of hydrogen are given under each element. The revision has added to the value of the book and is sufficient to warrant the presentation of the new edition. L. W. CHAPMAN.

* * *

PROBLEMS OF LABOR AND INDUSTRY IN GREAT BRITAIN, FRANCE AND ITALY. 406 pages. A report of the European Commission of the National Industrial Conference Board, 15 Beacon St., Boston, Mass.

This report by a special commission of industrialists is the result of first-hand observation of conditions in Great Britain, France and Italy during the period immediately following the armistice. The report was prepared in the belief that it would be of assistance to American industry in solving its own problems of industrial readjustment. The report includes investigations into the efficiency of production and methods of stimulating the interest of the worker in increased output; the role of management in its relation to capital and labor; types of organizations of employers and employees; the development of unionism in Great Britain and the attitude of British employers toward it; the system of shop stewards and works committees; the 8-hr. day and the minimum wage; unemployment and housing; types of co-operative schemes and examples of welfare work; a review of the political labor situation in European countries and schemes for nationalizing various British

industries. The commission summarizes its findings in twelve closely printed pages. The widespread discontent among the laboring classes is ascribed mainly to the long strain of the war and the industrial and economic disturbances incident thereto. Fallacious economic teachings, particularly with respect to restricted output, are held responsible for the low efficiency of production. Trade unionism has increased greatly in recent years in all countries visited, but especially in Great Britain, where there is a tendency toward consolidation and unity. This has resulted in forcing British employers to organize among themselves for dealing with trade and labor problems. Shop stewards are seen as a menace, but works committees are considered to be a fair means for bringing employers and workmen together. The movement to establish an 8-hr. day and minimum wage has progressed rapidly in all the countries visited and laws have been passed establishing these principles. The commission found the labor situation "shot through and through with political influence," labor organizations and the socialist parties overlapping to a great extent in membership. Attention was directed to the fact that there has been no organized effort to combat the effect of teachings of socialism, and the commission is of the opinion that "some elementary teaching is needed to show that capital is as essential to industry as labor, and that capital is the one factor of production which assumes practically all the risks and uncertainty and loss."

H. C. PARMELEE.

Personal

Dr. P. G. AGNEW, physicist in the electrical division of the Bureau of Standards, has resigned to become secretary of the American Engineering Standards Committee, with headquarters at the Engineering Societies Building, 29 West 39th St., New York City.

H. C. BARNES has joined the Allegheny Gear Works at Pittsburgh as superintendent of laboratory and metallurgical work. Mr. Barnes is a technical graduate, having been for more than ten years in complete charge of heat treatment for one of the largest gear manufacturers and supervising similar work at one of the large steel mills.

Dr. WALTER H. EDDY, of Teachers College, Columbia University, associate in physiological chemistry, has been appointed assistant professor of physiological chemistry. Dr. Eddy has recently returned from France, where he served fifteen months with the A. E. F. as major in the Sanitary Corps.

H. LIPSON HANCOCK, general manager, Wallaroo & Moonta Mining & Smelting Co., South Australia, is making a visit to the principal copper mining and smelting centers of the United States. He expects to sail from San Francisco some time in March.

ARTHUR G. HENRY, metallurgist for the Illinois Tool Works and secretary of the American Steel Treaters' Society, has resigned to become Chicago representative of the Vanadium Alloys Steel Co.

IRVING H. JONES is now associated with Joseph R. Ryerson & Son in the machinery department, specializing in sales engineering work in the Chicago district.

ROBERT M. KEENEY, consulting engineer of the York Ferro-Alloys Co., will be at York, Pa., for several weeks.

Dr. ARTHUR LACHMAN, a well-known chemist of San Francisco, formerly professor in the University of Oregon, was last seen on the street at noon on Dec. 11, 1919. Since then his family and friends have been unable to obtain any clue or any trace of his whereabouts. It seems probable that he had an attack of amnesia with loss of identity and wandered away. Anyone having information in regard to him is requested to communicate with his family or with Dr. Felix Langfeld, 272 Post St., San Francisco, Cal.

P. E. LANDOLT has been appointed manager of the commercial department of the Research Corp., New York City. Mr. Landolt has been connected with the corporation from its inception.

D. J. LEWIS, JR., formerly with and secretary of W. J. Wayte, Inc., has severed his connection with that company and is now sales agent for the Cresson-Morris Co. and the Kestner Evaporator Co., with headquarters at 277 Broadway, New York City.

W. A. LEDDELL has been appointed manager of the engineering department of the Mine & Smelter Supply Co. with headquarters at Denver, Col.

R. S. MCBRIDE, who has been engineer-chemist of the National Bureau of Standards, resigned on Jan. 15 to join the McGraw-Hill Co. staff in Washington, D. C., as an engineering representative. Mr. McBride was educated at the University of Minnesota, where he received the degree of B.S. in 1908, and at the University of Wisconsin, where he did one year's graduate work and obtained the M.A. degree in 1909. He has been in charge of the gas engineering investigations of the Bureau of Standards for over ten years, specializing in problems of gas supply, gas testing, fuel utilization, byproduct recovery, and the related public utility work of the Bureau. Mr. McBride has been the author or has directed the preparation of over fifty printed articles on various parts of the work as well as had charge of the field studies which have resulted in the preparation of about the same number of engineering and chemical reports not published thus far. As department editor of the *Journal of Industrial and Engineering Chemistry*, a contributor in charge of the Patents and Abstracts sections of the *Gas Record*, and as grand editor of his national fraternity quarterly, the *Hexagon* of Alpha Chi Sigma, Mr. McBride has also had considerable editorial experience.

Dr. FRITZ PANETH, director of the chemical department of the German technical high schools at Prague, has been appointed professor of chemistry at the University of Hamburg, Germany.

L. DUANE SIMPKINS has severed his connection with the Peters Cartridge Co. as metallurgist and chemist, to accept the position of metallurgist with the National Lead Co., Brooklyn, N. Y., in the research laboratory.

LEWIS B. SKINNER, consulting engineer, of Denver, Col., is in New York on business.

PAUL C. SKINNER has been recently made general manager of the General Chemical Co.'s plant at Denver, Col. Mr. Skinner, who has been for years connected with the plant under management of the Western Chemical Co., has worked up through all the departments of the business to the present position under the new management. He has been spending considerable time at the Chicago headquarters recently making arrangements for extensions of plant and business.

Dr. S. A. SOCHOCKY, general technical director of the Radium Luminous Materials Co. of New York, was recently elected president of the company.

WILLIAM A. THOMAS has resigned as president of the Brier Hill Steel Co., Youngstown, Ohio, having been president since 1912. JAMES H. GROSE, formerly general superintendent in the Youngstown district for the Carnegie Steel Co., has been elected to succeed Mr. Thomas.

Dr. WILLIAM H. WALKER, head of the department of applied chemistry at the Massachusetts Institute of Technology, Cambridge, Mass., has been appointed head of the new division of industrial co-operation and research.

Obituary

E. FRED WOOD, formerly vice-president of the International Nickel Co., died suddenly at New York City on Jan. 5, in the sixty-second year of his age. Mr. Wood was born in Milwaukee on Aug. 28, 1858. He was educated in the public schools of his native city and later entered the University of Michigan, where he was a brilliant student and was graduated with distinction. After leaving college Mr. Wood devoted himself assiduously to the study of metallurgy and in connection with his studies made extensive trips through the various mining camps of the

West and lived for a year at Leadville and in other mining towns, where he pursued his studies and obtained his practical experience. He later entered the employ of the Carnegie Steel Co. and rapidly rose to the position of assistant general superintendent of the Homestead plant, which position he filled for a number of years. During the period of the big strike at the plant, when Mr. Frick was shot, Mr. Wood was in entire charge of the plant. He was looked upon by Mr. Carnegie and his associates as one of the valuable men of the organization and was one of the so-called "Carnegie Veteran Associates."

Because of the great reputation that he had achieved he was invited to join the International Nickel Co. upon its organization, becoming first vice-president of the company and a member of the board of directors and of its executive committee, and he was an important factor in developing the mining, smelting and refining business of the company, so that from a small and unimportant undertaking it developed into the largest business of its kind in the world.

When the United States entered the World War, Mr. Wood resigned his official connection with the International Nickel Co. to devote himself to public work, and became a member of the Committee on Production of the War Industries Board, of which committee Samuel Vauclain, president of the Baltimore Locomotive Works, was chairman. Mr. Wood served continuously on this board during the entire period of the war, without compensation. His work on this board was conspicuously fine and of inestimable value and won the admiration and commendation of those who were brought into contact with it. It was the kind of work for which his talents were especially fitted and in which he took particular interest.

Mr. Wood was a man of great learning in his profession and of a wonderful memory, which enabled him to have on tap, ready for use, the result of his many years of study, observation and experience. He was keenly interested in travelling; he visited almost every country on the globe and had the unique distinction of having travelled around the world twice in one year. He was a member of the University of Michigan Club, the Automobile Club, the New York Athletic Club, the Society for Electrochemical Engineers and of the Railroad Club.

Current Market Reports

The Non-Ferrous Metal Market

New York, Jan. 26, 1920—Tin advanced ½c. in the last week. The copper market has been quiet, with price unchanged. The other metals have changed slightly in price in a very few instances.

	Cents per Lb.
Copper, electrolytic	19.50
Aluminum, 98 to 99 per cent	32 @ 33
Antimony, wholesale lots	11.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	63.25
Lead, New York, spot	8.62½
Lead, E. St. Louis, spot	8.30
Zinc, spot, New York	9.52½
Zinc, spot, E. St. Louis	9.20
Silver (Dollars per oz.)	1.31⅞

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250 00
Palladium	oz.	150 00
Mercury .75 lb.		93.00

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23½ @ 24½
Aluminum, sheet scrap	22½ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp.	14½ @ 14½
Copper, heavy and wire	13½ @ 14
Copper, light and bottoms	12½ @ 12½
Copper, heavy cut and crucible	15½ @ 16
Brass, heavy	7½ @ 8½
Brass, casting	10½ @ 10½
Brass, light	5½ @ 6½
No. 1 clean brass turnings	8½ @ 8½
No. 1 comp. turnings	12 @ 12½
Lead, tea	5½ @ 5½
Lead, heavy	6½ @ 7
Zinc, scrap	4½ @ 4½

The Iron and Steel Market

Pittsburgh, January 23, 1920.

Increasing production of steel, with concurrent increase in the anxiety of buyers to cover for forward deliveries, indicates that there is either a large increase in the actual consumption requirements, present and prospective, or a great increase in the nervousness of buyers. It is not always the case in the steel market that the anxiety of consumers to buy is in precise proportion to their requirements. Sometimes they buy less than they will need and sometimes they have bought more.

The unwillingness of many of the producers in the past few weeks to cover their customers, regular and occasional, has undoubtedly produced some of the anxiety now so apparent. In the case of a number of large producers this conservative policy in the matter of selling has been due to an unwillingness to sell at the March 21 or Industrial Board prices, to which the United States Steel Corporation steadfastly adheres, and at the same time an unwillingness to make formal and regular advances over that schedule. In many cases producers have promised to take care of regular customers' requirements in the second quarter, at prices to be named later, and thus the time has been rapidly approaching at which definite price action must be taken.

Predictions as to the Course of Prices

There are many predictions being made as to the course of prices named by the independents. One possibility, regarded almost everywhere as an unfortunate one, is that there will be a runaway market, prices advancing until the whole structure becomes topheavy, with the natural and inevitable outcome. A prediction that seems reasonable from several aspects is that the larger independents will advance prices of most commodities to the level that obtained between Dec. 12, 1918, when the post-armistice reductions were made, and March 21, 1919, when the Industrial Board reductions went into effect. The December reductions were $4 to $8 per net ton on most finished steel products, with no reductions at all on wire products, while the March reductions were $7 a net ton on all important rolled steel products, with $5 reduction on wire products, including nails, grooved skelp being reduced $5, while universal and sheared were reduced $7. The prediction mentioned, therefore, is that prices will go back to the level of January and February of last year, equivalent to an advance from present basis prices, largely nominal, averaging a little less than $7 a net ton. If this prediction as to finished steel is verified, however, it is unlikely that unfinished steel would advance only by the $5 a gross ton by which it was reduced in March. That would put sheet bars at $47, whereas it seems more probable that they will advance to about $50, and indeed some sales have lately been made to regular consumers at that figure. Sheet consumers, buying for the purpose of having the steel rolled into sheets under contract, would in some cases pay $55 or $60, and some business of this description has been done.

Operating Rates

It may be estimated that the steel mills as a whole are now operating at between 85 and 90 per cent, this comparing with a rate of about 80 per cent at the beginning of the month and an average of not over 60 per cent during the last three months of the old year. The most important restrictive influence now is transportation, this replacing

labor as the chief factor. In point of numbers labor supplies are now practically adequate at most plants. Efficiency and morale of men in employment have increased, but there is still some distance to travel in these respects.

Car shortages are experienced at many plants in the matter of shipping finished products, but not to an extent to cause material to back up against production. Shortages of cars in the Connellsville region for loading coke and at various mines shipping coal to byproduct ovens are a serious limiting factor, and while conditions have been improving somewhat in the past week, the demand for coke keeps well ahead of the supply. More pig iron is being made than at the beginning of the month, but there are still some idle furnaces, awaiting a coke supply, and a number of furnaces are operating with reduced blast pressures to conserve their coke supplies.

Prospects of Demand

There are very conflicting statements as to the prospects of demand for steel for building purposes. In some quarters it is insisted that, labor and material costs as they are, few investors will take hold at present, while in other quarters there are assertions that a very large amount of construction work is in immediate prospect. The requirements of ordinary manufacturing consumers have proved heavier than could be expected. A year ago there was no thought that demand for steel, as a whole, could be as heavy as it has been with the amount of new construction as small as in the past year, and with so little steel passing to the railroads, yet a relatively large quantity of steel has gone somewhere.

As to the railroads, much is being said as to the needs of the railroads, while little is being said, except by railroad officials, as to the ability of the roads to finance purchases, and what the railroad officials say is that they cannot finance purchases unless conditions are made distinctly favorable. The rail requirements are covered very largely either by actual purchases or by reservations, while as to other purchases there may be delays greater than have lately been expected. It is possible that many buyers of steel have deluded themselves in the expctation that the railroads will be heavier buyers in the next few months than will actually prove to be the case, and the course of events will bear careful scritiny from this viewpoint.

The Chemical Market

New York, January 23, 1920.

There has been no change in the general conditions of the market during the past week, prices remaining at the same level. Domestic consumers have not shown a tendency to invest in large stocks at present quotations, preferring instead to contract on future delivery. Manufacturers are sold ahead on contract, and several large factors in the chemical market say they will have nothing to offer until late in 1920.

Heavy Chemicals:—The demand on all grades of *alum* continues strong, but there has not been a large enough demand to warrant an increase in price. The market in *barium* products has been active, with an increase in quotation from $80@$85 per ton for barium chloride to $90@$100 per ton. The continued coal scarcity has hampered producers of *aqua ammonia,* which is being offered at 8¾c. per lb. on spot and 8½c. on contract in drums. *Caustic potash* is steady in demand, export business being about the same as last week, and quotations remain the same at 28@32c. per lb. The demand on *caustic soda* is still very heavy, especially for export. There was a shipment of 450 tons reported during the last week, but this lot about cleans out producers for the time being. The price on the above-mentioned shipment was $4.25 per cwt., but the price quoted by second hands, who at present control the market on this item, is $4.50 per cwt. and up, and it is the opinion of some that this item will reach 5c. per lb. shortly. *Sodium nitrite* continues steady in demand, and it is hoped that with the arrival of a large consignment to one of the manufacturers there will be a drop in this product, which at present is quoted at 15@17c. per lb. according to the quantity desired. There have been no new developments in the *alcohol* situation, demand on *ethyl* continuing heavy, while *methyl* is unobtainable. Dealers in the *wood* grade refuse to quote, there being none to be had on spot and contracts have been made so far ahead in some cases that the output will be taken up for several months to come. The scarcity in *formaldehyde,* reported last week, still prevails, this item being practically off the market at present. There has been no change in the producers' quotations of $12 per cwt. on *acetic acid,* glacial 99½ per cent, during the past week. *Oxalic,* crystals, remains firm at 31@35c. per lb. A bill is now before the House of Representatives to levy a tariff on this item of 5c. per lb. in order to restrict the price on this item.

Coal-Tar Products:—The market still continues scarce in supply, especially in raw materials, and prices are quoted at the same general level. Export inquiry has been heavy, with difficulty on the part of the producer in meeting this demand. *Aniline oil* and *salt* continue firm, prices holding from last week, 34@36c. per lb. on the former and 45@50c per lb. on the latter. *Toluol* is easier at 28c. per gal. in tanks and 29c. in drums, with a somewhat larger supply on hand. One large producer of H acid has stopped quotations on this item, as he is contracted up to June, with all available spot material in second hands.

Waxes:—This branch of the market during the past week has continued firm, any action in price being caused by an actual scarcity of spot material on hand. There has been a noticable stiffening in all lines of the paraffine grade, of ¼c. to ½c. on each item. Japan continued active at 19½@20c. per lb. for the usual requirements, but no large orders have been placed.

Flotation Oils:—Considerable activity in demand has been the feature of this market during the past week. A general increase in price of all items has been caused by an increased demand combined with a natural scarcity of crude materials. *Pine oil,* steam distilled, sp.gr. 0.930-0.940, jumped from $1.38 to $1.45 per gal., while pine tar oil, crude, sp.gr. 1.025-1.035, tank cars, f.o.b. Jacksonville, Fla., jumped from 35c. to 48c. per gal. *Crude turpentine,* in sympathy with the spirits and under heavy demand at present, has had a rise from $1.40 to $1.60 per gal.

Naval Stores:—Spirits of turpentine remains the center of attraction in this market, quotations remaining $1.97@ $2 per gal. There has been no relief in the London market, and demand still continues brisk, with a threatened upward price. The situation will be relieved only by the dropping out of the bullish element of the market. Demands, both export and domestic, have been heavy on the New York market for *turpentine* and *rosin,* Grade B, which is quoted at $19.50 per 280 lb.

Vegetable Oils:—Linseed Oil has shown a slight indication of coming back during the past week, though the amount of actual business recorded has been small. No immediate large demand is expected by dealers, but it is expected that the coming season will bring a larger demand by consumers than was placed last year. Most of the present output is used to fill contracts made last year for future deliveries. The quotation still remains $1.72 per gal. Stocks of *soya bean* and *peanut oil* are diminishing, while no large stocks of *cocoanut oil* are to be found on spot in the market. There has been a general strengthening during the past week in this market, prices remaining steady, but buyers are somewhat wary of existing prices.

St. Louis, January 21, 1920.

The good demand for heavy chemicals which has been manifested since the first of the year continues in St. Louis. The demand for *sulphuric acid,* which slumped last month, has stiffened in the last two weeks. There is very little spot buying; the reason being small stocks, not few inquiries. Contract buyers are having no trouble in filling their requirements, however. Local men look for this condition to continue on account of the absorption of surplus stocks. A slight rise in prices is predicted.

Sulphuric Acid:—The demand for this chemical is picking up due to the fact that conditions in the coal business are getting back to normal and there has been an easing up of the phosphate rock situation. It is almost back to normal at

present and as soon as operations in the oil fields are in full swing once more this chemical will be in heavy demand. Prices have started to rise now over what they were two weeks ago. The 60 deg. grade is quoted at $14@$15 a ton, where two weeks ago it was at $12@$14, according to quantity. The 66 deg. grade has gone from $18 to $20 a ton, though oleum is still quoted at $25 a ton, as it was two weeks ago.

Muriatic Acid:—There is a normal movement in this chemical, it having recovered from the slight slump it was in two weeks ago. There have been a number of inquiries and producers report several sales. It is quoted at $22 a ton for the 18 deg. grade.

Sodium Sulphate:—There is a fair inquiry for this chemical, though not many sales have been reported in the last week, none of them being over $20 and the average being $19.50.

Sodium Bisulphate:—The movement in this chemical is better than at the beginning of the month, though there has been no change in price. Several large contracts have been closed during the past week, all of them at the low price prevailing the first of the year, $2.50. On account of the fact that these large contracts will remove part of the supply from the market, producers look for the price to rise in the near future.

Nitric Acid:—There is little demand for this acid and the market remains at 10@10½c. per lb. for 38 deg.

Zinc Chloride:—There is a greatly increased demand for this, due to the fact that the manufacturers of creosoting oils have resumed operations in full swing. This may be attributed to the fact that when the railroads are turned back to the hands of the private owners there will be a big demand for railroad ties, many of the roads having been neglected in that respect by the Railroad Administration.

Zinc Oxide:—Advices have been received here that Eastern manufacturers have raised prices ½c. a lb. on bbl. shipments for all grades except the high-leaded zinc oxide, 20 and 30 grades, which have been raised ¾c. a lb. on bbl. shipments. No advances have been made yet by local makers. The demand is strong and many orders are on the books for immediate shipment and plants are working to their capacity to keep pace with the orders. It has been necessary during the past week to make advances in labor wages, and all things indicate prices will advance later on.

Phenol:—This is in very good demand for domestic consumption, practically all on the market being Government material, which a St. Louis chemical concern has contracted to market. In 15-ton lots, f.o.b. St. Louis, Philadelphia or New York, it is bringing 12c. per lb., with smaller quantities at slightly higher prices. There is a shortage of this item for export purposes.

Chicago, January 21, 1920.

Remarkable steadiness is shown in all lines this month, with the general tendency upward. Steady domestic demand, increasingly heavy exports of certain items and greater producing costs have combined to produce the present strong market, and the fact that many producers are under contract for their full output for some time will tend to prolong present conditions. A comment heard among manufacturers is that it seems impossible to procure as heavy production today as was the case in the past with the same plant and force of men, seeming to indicate that the lessened efficiency of labor, so often noted in other lines, is now felt in the production of chemicals.

Heavy Chemicals:—Exports of *granulated caustic soda* to Europe and the Orient continue heavy and the price remains firm as last quoted—$4.50 per cwt., in carloads, f.o.b. works. The solid is firm at $4. So much of the future output of caustic is under contract at these figures that spot stock buyers will probably be asked even more for some months to come. *Bleaching powder* and *soda ash* are also in heavy demand for export, considerable quantities being put under contract for shipment to the Far East. *Bleaching powder* in carlots is bringing $2.50@$2.60 per cwt. for immediate shipment, with producers showing no anxiety for long-term contracts. *Soda ash* is worth $1.75 per cwt. on contracts for future delivery, and $2.10 is asked in cars f.o.b. works for spot shipment. *Sodium bicarbonate* is also in good tone, with $2.75 per cwt. asked for spot delivery in less than carlots, $2.40 in cars, f.o.b. factory. *Niter cake* (sodium bisulphate) is in fair demand at $7@$7.50 per ton in large quantities.

Sodium bichromate, which was completely out of hand in the local market a month ago, is back again at 20c. in bbl. lots and indications are that this figure will hold good for some time. *Formaldehyde* presents the most spectacular advance of the month. It is much in demand, is very scarce, and 50c. per lb. is asked for the limited quantities available. *Alcohol*, also, is in good demand, with *ethyl* quoted in less than carloads at from $5.30@$5.50 per gal. *Methyl* is even stronger, available spots going freely at $1.80 in reasonable quantities. *Oxalic acid*, under heavy demand from the dyestuffs, manufacturers, is high and short in supply, 40c. a lb. now being quoted in barrels.

Roll sulphur (brimstone) has developed a very strong tone, price from factory being about $3.80 per cwt. in cars. This item is quoted by jobbers as high as 5c. per lb. in bbl. lots. Acids, except for oxalic as mentioned above, remain quiet, the demand still being somewhat below normal, with 66 deg. sulphuric quoted at $20 a ton in quantities, and 20 deg. hydrochloric (muriatic) at $2.25 per cwt. in less than carloads. With the gradual straightening out of the steel industry the acid market should show considerably more strength, as with consumption in full swing manufacturers will be hard pressed to supply the needed quantity.

Coal-Tar Products:—Very severe shortage of *benzol* has forced the price even higher than it was at the end of the coal strike, the current price being 33c. *Toluol*, being in slightly better supply, is selling at 27c. in tanks, with deliveries fairly prompt. Continued short supply of *anilines* has forced the *oil* up to 35c. and *salts* to 45c. These prices are for small quantities only, no large supplies being available. Very little business for future delivery is reported.

Benzoic acid is slightly firmer, 95c. being current quotation for U.S.P. and 78c. for technical in wholesale quantities. *Picric acid* shows no change from the former quotation of 20c., but excess stocks are dwindling and an advance is looked forward to shortly. *Salicylic*, under moderate demand, remains at 44c. per lb. for the technical grade.

Vegetable Oils:—This entire line shows considerable strength, except in *corn oil*, which is being freely offered at 17½c. in sellers' tanks, and *cottonseed oil*, which shows only fair demand at 19½c. for crude and 24c. for prime summer yellow in barrels. *Cocoanut oil* is in excellent demand, 18½c. per lb. ruling for Manila grade in sellers' tanks, f.o.b. Pacific coast. Similar grade in barrels is bringing 19½c. in Chicago. *Soya bean oil* is also much wanted, the market being strong at 17½c. in barrels.

Flotation Oils; Naval Stores:—Having thoroughly recovered from the slackening in demand occasioned by the fuel strike, *pine tar products* are developing such heavy demand as to guarantee a strong market for some time. Distilled pine tar oil, .933 pure, is easily sold at the current quotation of $1.50 and a rapid increase in price is expected. The *destructively distilled* grade carries the same price and is even harder to get. *Turpentine*, in cars, is quoted at $2 @$2.05 per gal. f.o.b. Chicago, and the jobbers' price in barrels is $2.16. Actual needs in the various industries are in excess of supply and it is hard to tell how high the market may climb before the new crop comes in March.

Rosin, likewise, is scarce and high priced. It is noted that the first exportation of rosin to Germany since 1914 occurred last week, when 1,500 bbl. left Savannah, and inquiries are being received in the local markets from Bavarian consumers. Ruling prices are, for F grade, $20.20 per cwt. in barrels, delivered, and for WW grade, $24.50@$25. Fluctuation is so rapid that these quotations may be considered nominal.

Fertilizers:—With stocks still suffering from the depletion which occurred during the fuel shortage and with both domestic and foreign demand strong, prices are on the up grade. Ground blood at $7.85 and unground blood at $7.65 have scored higher than at any time last year.

Tankage is also in strong demand, high-grade ground being quoted at $7.50 and bone meal, raw, is now sold at $44.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..... –	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	2.50 –	2.60 – 2.75
Hydrofluoric, 52 deg.	lb.	.12 –	.14 – .....
Lactic, 44 per cent tech.	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.	..... –	4.00 – 4.25
Nitric, 40 deg.	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg.	lb.	.06½ – .07	.08 – .....
Oxalic, crystals	lb.	.31 – .32	.32 – .35
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	..... – .....
Sulphuric, 60 deg., drums	ton	..... – 30.00	..... – .....
Sulphuric, 60 deg., carboys	ton	..... –	..... – .....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	..... – .....
Sulphuric, 66 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	25.00 –	30.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P.	lb.	..... –	1.35 – 1.45
Tannic (tech.)	lb.	..... –	.42 – .55
Tartaric, crystals	lb.	..... –	.69 – .74
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	..... –	.76 – .78
*Alcohol, denatured, 190 proof	gal.	..... –	.71 – .73
Alum, ammonia lump	lb.	.04½ – .05	.04½ – .04¾
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	..... –	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½ – .14	.13½ – .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	..... – .....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	..... –	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..... – .....
Barium chloride	ton	80.00 – 85.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.09½ – .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03¾ – .04
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.90 – .95	..... – .....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	..... –	.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	..... –	2.50 – 3.75
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .80
Calcium sulphate, pure	lb.	..... –	.25 – .30
Carbon bisulphide	lb.	.05½ –	.06 – .09
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..... –	.75 – .....
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Cobalt oxide	lb.	..... –	1.50 – 1.55
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	..... –	.28 – .31
Copper cyanide	lb.	..... –	.65 – .70
Copper sulphate, crystals	lb.	.07¾ – .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	2.30 – 2.50
Formaldehyde, 40 per cent	lb.	..... –	.51 – .52
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.24½ – .26
Iodine, resublimed	lb.	..... –	4.10 – 4.30
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.75
Lead acetate, normal	lb.	..... –	.20 – .23
Lead arsenate (paste)	lb.	..... –	.13 – .17
Lead nitrate, crystals	lb.	..... –	.30 – .35
Litharge	lb.	..... –	.09½ – .10½
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	..... –	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	..... –	.75 – .90
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	..... –	.56 – .60
Potassium bromide, granular	lb.	..... –	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.23 – .32	.35 – .42
Potassium iodide	lb.	..... –	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	..... –	.65 – .95
Potassium prussiate, red	lb.	..... –	1.10 – 1.20
Potassium prussiate, yellow	lb.	..... –	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	..... – .....
Rochelle salt (see sodium potas. tartrate)		..... –	..... – .....
Sal ammoniac (see ammonium chloride)		..... –	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake (sodium sulphate)	ton	18.00 – 21.00	..... – .....
Silver cyanide	oz.	..... –	1.25 – .....
Silver nitrate	oz.	..... –	.81½ – .82½
Soda ash, light	100 lb.	2.05 –	2.25 – .....
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.20 – .21	.22 – .25
Sodium bisulphate (nitre cake)	ton	6.00 – 8.00	10.00 – .....
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	..... – .08	.08½ – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..... –	4.30 – 4.50
Sodium hyposulphite	lb.	..... –	.03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salt)	lb.	..... –	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.03½ – .04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.43 –	.60 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran.	lb.	.12½ –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.09 – .11	.11 – .14
Zinc oxide, dry American	lb.	..... –	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.36
Aniline oil, drums extra	lb.	.34 —	.36
Aniline salts	lb.	.45 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.30
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.75 —	.80
Cresylic acid, 95-97%, dark, in drums	gal.	.72 —	.75
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.60 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12¾ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.55 —	.60
Salicylic acid, U.S.P.	lb.	.42 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white, pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl.	280 lb.	$17.00 —	$17.50
Rosin E-I	280 lb.	17.85 —	18.40
Rosin K-N	280 lb.	19.75 —	22.50
Rosin W. G.-W. W.	280 lb.	22.50 —	24.25
Wood rosin, bbl.	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	.... —	1.97
Wood turpentine, steam dist.	gal.	.... —	1.70
Wood turpentine, dest. dist.	gal.	1.64 —	....
Pine tar pitch, bbl.	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl (500 lb.)	bbl.	15.00 —	15.25
Rosin oil, first run	gal.	.... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	.... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.47½ —	$0.48½
Upriver coarse	lb.	.34 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.52 —	.54½
Ribbed smoked sheets	lb.	.51¾ —	....
Brown crepe, thin, clean	lb.	.48 —	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls.	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls.	lb.	.21 —	.23
China wood oil, in bbls.	lb.	.23¾ —	.24½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.20 —	.20¾
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½ —	.23
Corn oil, crude, in bbls.	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined in bbls.	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls.	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17¾ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	$ .04½ —	$ .06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00 —	45.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C.	lb.	.... —	....
Shellac, V. S. O.	lb.	.... —	....
Shellac, Diamond I.	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	80-90 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-90 at Chester, Penn.
Silica brick	1,000	41-45 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	140.00 —	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25 —	1.40
Ferro-uranium, 35-50% of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluorspar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

* Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.80
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	16.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	48.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	50.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	40.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	70.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	63.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		2.25
Roofings, slate-finished shingles, 100 sq. ft. carlots		6.00
Linseed oil, raw in barrels	gal.	1.75
Linseed oil, 5 gal. cans	gal.	1.90
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.15½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

CHANDLER—The Bd. Educ. will receive bids until Feb. 14 for the construction of a high school, including a science building. Estimated cost, $150,000. Allison & Allison, 1405 Hibernian Bldg., Los Angeles, Cal., archts.

California

EL SEGUNDO—The Standard Oil Co., 200 Bush St., San Francisco, has awarded the contract for the construction of additions and improvements to its refinery, to the Foundation Co., Holbrook Bldg., San Francisco. Estimated cost, $2,000,000.

Connecticut

WINDSOR—The General Electric Co., Lynn, Mass., will soon award the contract for the construction of a 3-story, 67x200-ft. manufacturing building.

Maryland

BALTIMORE—The Mutual Chemical Co. of America, Block and Wills Sts., has awarded the contract for the construction of a 2-story, 100x200-ft. addition to its chemical plant at 1348 Block St., to Morrow Bros., 1201 Fidelity Bldg. Estimated cost, $60,000.

Massachusetts

PITTSFIELD—The General Electric Co., Morningside, will build a 1-story, 80x400-ft. enameling building addition. Work will be done by day labor.

WEST MEDFORD (Boston P. O.)—The Warner & Childs Paper Co. has awarded the contract for the construction of a 4-story, 100x225-ft. factory on Boston Ave., to W. M. Bailey Co., 88 Broad St., Boston.

Michigan

DETROIT—The Butt Welding & Mfg. Co., Bellevue and Warren Aves., plans to build a 20x100-ft. building. F. W. Biederman, mgr.

DETROIT—The Detroit Grey Iron Fdry. Co., Wight St., has awarded the contract for the construction of a 2-story, 135x150-ft. foundry, to J. L. Kolley, 3563 Jefferson Ave.

GRAND RAPIDS—The Bd. Educ. plans to construct a 3-story, 225x250-ft. school, to be known as the North Junior High School, on Plainfield Ave. Chemical laboratory equipment will be installed in same. H. H. Turner, 234 Division Ave., N., archt.

Minnesota

MESABA—D. C. Jackling and Hayden & Stone, 25 Broad St., New York City, plan to construct 10 concentration plants on various points on Mesaba Range. The first unit will cost $3,000,000, ultimate cost $30,000,000. Dwight E. Woodbridge and Walter G. Swart, 808 Sellwood Bldg., Duluth, engrs.

Missouri

ST. LOUIS—D. A. Blanton Co., 2nd and Spruce Sts., has awarded the contract for the construction of a 2-story, 73x151-ft. oleomargarine factory at 319-23 South 1st St. and 101-11 Spruce St., to the Kellerman Constr. Co., International Life Bldg. Estimated cost, $50,000.

ST. LOUIS—The Emerson Electric Co., 2100 Washington St., has awarded the contract for the construction of an 8-story, 129x150-ft. factory at 2012-20 Washington St. and 2011-19 St. Charles St., to the Murch Bros. Constr. Co., Ry. Exch. Bldg. Estimated cost, $400,000.

ST. LOUIS—James D. Howe, 5811 De Giverville St., has purchased a site on the Natl. Bridge Rd., and plans to construct a 3-story, 117x250-ft. factory for the manufacture of patent medicines. Estimated cost, $20,000.

New Hampshire

NORTH STRATFORD—The Warner Sugar Refining Co., 79 Wall St., New York City, plans to build a sugar refinery. Estimated cost, $1,000,000.

New Jersey

TRENTON—The Mercer Motor Co., Whitehead Rd., will soon award the contract for the construction of a 1-story, 80x400-ft. paint shop addition to its plant. Estimated cost, $50,000.

VERONA (Montclair P. O.)—The Eagle Rock Mfg. Co. is having plans prepared for the construction of a 2-story, 40x350-ft. factory for the manufacture of moving picture films. Estimated cost, $250,000. Lockwood, Green & Co., 101 Park Ave., New York City, archts. and engrs.

New York

OGDENSBURG—Williams & Johnson, archts., are preparing plans for the construction of a factory for the manufacture of electrical fixtures, plumbers' supplies and brass articles, on the Wright property in the East End of city, for Cooper's Brass Wks., Inc. Estimated cost, $100,000. Address R. J. Donahue, Ogdensburg, or Abraham Cooper, 16 Nassau St., Brooklyn.

WATERTOWN—The Bagley & Sewall Co., mfr. of paper-making machinery, has purchased a site in the vicinity of its plant on East Moulton St., and plans to build a plant for the manufacture of pulp screens. The company recently acquired the equipment and good will of the Harmon Machine Co., manufacturer of the "Harmon Inclined Pulp Screens."

Ohio

CINCINNATI—The Rapid Electrotype Co., Canal, Race and Elm Sts., has awarded the contract for the construction of a 2-story, 100x215-ft. factory on McMicken, Race and Elm Sts., to L. Schrieber & Sons, Ivanhoe Ave.

CLEVELAND—The National Carbon Co. has awarded the contract for the construction of a 1-story, 120x180-ft. furnace building on West 117th St. and Madison Ave., to the Crowell, Lundorff, Little, Bicknell Co., 5716 Euclid Ave. Estimated cost, $200,000.

WARREN—The Goheen Mfg. Co. has awarded the contract for the construction of a 5-story, 50x125-ft. paint factory, to the Craig-Curtis Co., 1031 Guardian Bldg., Cleveland. Estimated cost, $200,000.

Oklahoma

WILBERTON—The city is having preliminary plans prepared for the construction of a 6 to 12 in. pipe sewer, sewage disposal plant, and 13,000 ft. of flow line and main extensions. An Imhoff tank will be installed in same. Estimated cost, $100,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, engr.

Oregon

ASTORIA—W. H. Goodnough and associates plan to construct a 2- or 3-story, 50-ton daily capacity, pulp and paper plant and have asked the Port of Astoria Comn. to investigate a site for same. Estimated cost, $500,000.

Pennsylvania

FRANKFORT (Philadelphia P. O.)—The Belmont Packing & Rubber Co., 133 North 2nd St., Philadelphia, plans to build a 2 story, 120x120-ft. factory. Estimated cost, $60,000. Carl P. Berger, South Pennsylvania Square Bldg., archt.

Wisconsin

MILWAUKEE—The Central Bd. of Purchases, City Hall, will soon award the contract for furnishing 35,000 lb. of liquid chlorine.

Ontario

CHATHAM—The city plans to construct a new water system, to include rapid sand filters, 250,000-gal. steel tank, etc. A by-law appropriating $300,000 for the project has been passed. E. A. James Co., Ltd., 36 Toronto St., Toronto, engr.

OWEN SOUND—The Aluminum Steel Products, Ltd., plans to build an extension to its plant. Estimated cost, $250,000.

SCARBORO—The town plans to construct two pumphouses to be equipped with rapid sand filters, chlorinating apparatus, etc. A bylaw appropriating $300,000 for this project has been passed. E. James Co., Ltd., 36 Toronto St., Toronto, engr.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a joint meeting with the American Chemical Society and the Society of Chemical Industry, Feb. 6, 1920. On Feb. 27 another meeting will be held, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is Peace Uses for War Products.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16 to 19.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W., 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION has found it necessary to change the date of its convention at the Waldorf-Astoria Hotel, New York City, from Jan. 29 and 30, to Feb. 26 and 27.

Industrial Notes

THE ROYAL GRAND OIL CO., El Paso, Tex., plans the addition of another unit of 1000-bbl. capacity to its El Paso refinery. This will give a total capacity of 2000 bbl. of crude oil daily.

THE CLIMAX MOLYBDENUM CO., which is associated with the American Metal Co., 61 Broadway, New York City, now has in press a 72-page book on molybdenum commercial steels. The book is the first of its kind to be published, and contains tables, colored charts, microphotographs and other illustrations. It will be sent upon request without charge.

THE NORVELL CHEMICAL CORP., of Perth Amboy, N. J., was incorporated Jan. 1, 1920, in the State of Delaware with an authorized capital of $1,000,000 of preferred stock, and with 20,000 shares of common stock, no par value. The company has taken over from McKesson & Robbins, Inc., the property near Perth Amboy, N. J., consisting of 350 acres of land and a number of factory buildings erected on the property, purchased last year by McKesson & Robbins, Inc., also additional works which have since been constructed on the property, and will operate the plant, supplying the medical profession and the drug trade with pharmaceutical chemicals and the industries with chemicals useful in the manufacture of a variety of products. The company has gathered a staff of highly trained chemists for research work and expects to develop new and useful processes for the manufacture of chemical products. At a stockholders' meeting held at the temporary New York office at 11 Cliff St., the following directors and officers were elected: President, Donald McKesson; vice-president and treasurer, Saunders Norvell; second vice-president, Francis J. McDonough; secretary, William S. Gray, Jr.; assistant treasurer and assistant secretary, James J. Crawford. George Simon was appointed general manager.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, February 4, 1920 — *Number* 5

Federation of Engineering Societies

FOR a decade or more those who have administered the affairs of our engineering societies, both national and local, have been aware of a growing sentiment in favor of some form of federation or aggregation that could represent the entire engineering profession of the country when united action was necessary. This tendency has found expression locally in the formation of clubs or joint societies, and nationally in the organization of Engineering Council, which represents its five constituent bodies in their varied relations with the Government and the public.

Subsequent to these developments the four founder societies of civil, electrical, mechanical, and mining and metallurgical engineers made a searching internal examination of their own aims and organizations, their relation to local sections and service to individual members. In addition to special reports submitted directly to some of the societies, a general report by a Joint Conference Committee was prepared for the consideration of all. Among other things it proposed a comprehensive federation of national, state and local engineering societies of the whole country. The proposed federation is on a more democratic basis than that underlying Engineering Council, membership in which is limited to national bodies.

It is significant of the drift in society affairs that at a recent meeting of the governing boards of its constituent bodies, called by Engineering Council, this report of the Joint Conference Committee was discussed and adopted in principle. By formal resolution the Joint Conference Committee was requested to "call without delay a conference of representatives of national, local, state and regional organizations to bring into existence the comprehensive organization proposed." This is without doubt the most important step yet taken toward the federation of all engineering societies and the unification of engineering interests. Since most of the dissatisfaction with previous engineering society activities has emanated from local sections of the national bodies or from independent local organizations, it follows that a successful federation must give close attention to the welfare of local bodies. By the same token, local societies must give a hearty response to the invitation of the Joint Conference Committee and realize that through the proposed federation they have for the first time an opportunity to voice their sentiments and exert an influence for the benefit of engineering as a whole. We will follow with the greatest interest the progress of the forthcoming conference, because it promises what has long been needed. Whether or not it will meet expectations depends wholly on the vision and constructive ability of its leaders.

Army Reorganization and the Chemical Warfare Service

THE other day a man came to us with a problem. He had his market and his sales organization planned, but he did not have his product in the form desired. What he wanted was, first, the thing itself with a new finish, and second, the technique of manufacture. So he proposed to "hire a chemist," rig up a laboratory, and set him to work. It was a problem in physical chemistry, although the promoter was not aware of the fact, and he thought any bright young fellow with a technical education should be able to crack the nut for him.

Now, any bright young fellow might succeed, but the chances are against it. As soon as complicated problems are attacked the factor of *esprit de corps* enters into research. A well-organized laboratory brings a number of minds to bear upon the solution of major problems. In it, invention becomes a habit, and contributions that lead to the complete answer are but incidents in the day's work. A research laboratory that gets results is like KIPLING'S Ship That Found Herself, and the co-operation of the staff is something more than a text for speeches. Co-operation becomes a veritable thing rather than a vague idea, and it generates energy.

The Chemical Warfare Service of the United States Army is still a thing, an organization, a body of men working together with the necessary *esprit de corps*. Its members co-operate. It is organized to get results. This is, however, almost a miracle, because it has been attacked from without and from within the Army. Two conflicting ideas are current about it, one of which was originally embodied in the House bill on the reorganization of the Army, and the other is that of the Senate. We understand from the latest reports which have come in that the sub-committee of the House has revised its proposal in this respect, but the danger still threatens. It was proposed that the Chemical Warfare Service be made a part of the Bureau of Ordnance. This reflects the opinion of many officers who did not get overseas during the war, and it may meet the approval of the Secretary of War. It conforms to the old traditions. Ordnance is an old department and it takes precedence. It makes sure of a West Point man in command; and to command is just what a West Point graduate is trained to do. An irreverent person undertook to imagine a battalion of chemical sergeants, corporals and privates at work in a laboratory as a certain exalted military authority in Washington would have it administered and according to such Laboratory Manual of Arms as his attitude toward the subject suggests.

The men stand in place, each one before his table with a test-tube. The commands follow: Grasp—Reagents!

Uncork—Bottles! Battalion—Pour! Agitate—Test-Tubes! Observe—Reaction! Titration Squad, Right—Face! Column of Twos, Forward—March! (They proceed to titration room and take places. Titrate—Solution! Titration—Halt!

That would provide a certain kind of *esprit de corps*, but not the kind that gets results. And it isn't done as far as we have observed in any of the laboratories that enjoy the habit of success. Men may be taught to obey commands, but chemical reactions are sometimes baffling and military "organization" cannot hope to train elements and compounds to perform at will.

The Senate sub-committee, on the other hand, recommends that the Chemical Warfare Service be made a separate department. This is as it should be. How can a body of chemists be made subject to the changing administration of officers in rotation, whether they be Ordnance officers or members of the Corps of Engineers? Of course it can be done, but it spoils the operation. It is born of the idea that a West Point man can do anything. We hate to deny cherished traditions, but we make bold to say that one West Point graduate differs from another in knowledge, ability, character and capacity. And we do not hesitate to add that the training in chemistry in the West Point Military Academy course is and must remain wholly inadequate to equip a good, modern research chemist. Chemistry is a profession. It is not a side line.

By making the Service part of the Ordnance Corps it will be elastic, they say, and it may be decreased to a minimum in time of peace and increased in time of war. In fact, as a kind of fifth wheel to the Ordnance Division it can be reduced to a nice round zero, which is just what is likely to happen. As part of the Ordnance Department it will also have to behave like a superfluous child and get out of the way. It is more likely to be regarded as a nuisance than as an arm of the service. Every chemist knows that a research department in chemistry must be a continuous and going concern, and that it cannot run by fits and starts and accomplish results. The whole proposition is as reasonable as if the General Electric Co. were to "reorganize" its research laboratory, discharge Dr. WHITNEY and the splendid corps of men who work with him, appoint a member of the finance committee as head of the laboratory organization, and then "recruit" young graduates to proceed with research. Obviously such disorganization would be disastrous.

We do not profess to know how to manage the War Department. On the other hand, we do claim to be somewhat familiar with chemical research and achievement. And experience teaches us that the highroad to failure is to take the spirit out of a department of research by putting it under the charge of first one and then another man who has no clearer grasp of chemistry and physics than the average graduate of a military academy. As a separate service it can remain under the men who have studied its requirements and know what is needed. As a separate service it will also invite other men of adequate military training to prepare themselves for a career in it. It will make the corps stand upon its own feet and be responsible for what it does. It will keep the Army up to date and make it ready to meet the enemy when he arrives in his might. In the name of common sense, is it not time to put aside the petty politics of rank and precedence, and to plan for results rather than for favor? Haven't we already suffered enough from this kind of quibbling?

Industrial Value of the Oxy-Acetylene Flame

MEN of the industry who are engaged in the actual operation of chemical plants have been quick to realize the value of the oxy-acetylene flame. When it is so necessary to keep the materials moving and the processes continuous, where there is a loss of precious time to tear out heavy castings for replacement, this tool in the hands of the trained welder has become invaluable.

And, incidentally, as a sidelight on the article appearing elsewhere in this issue, is to be noted the value of training the man to take pleasure in his work as an artisan. We have given too much thought to the creation of "foolproof" machinery and too little attention to the development of the imagination in the worker. Many thinkers are coming to realize that our future industrial growth must depend on the development of the human factor.

The Railway Administration And the Quest of Truth

THE assistant director of the United States Railway Administration decided that the meeting of the American Association for the Advancement of Science at St. Louis was not of a "religious, charitable, educational, fraternal or military character," and therefore the reduced rate of two cents a mile was not allowed. The plutocratic professors and teachers who attended had to pay the full rate of three cents a mile.

Perhaps the director had heard of the millions which the colleges were raising for endowment so that professors' salaries might be raised to the same level as those of window washers and day laborers. Or maybe the popular ouija board gave the answer, which suggests that the director moved in a mysterious way his wonders to perform. Anyhow, the problem was too knotty for officialdom to solve in a common sense manner.

In order to strike the heart of public servants rather than the heart of the people it might be advisable for the Association to change its name. Inasmuch as it has to do with science, it can hardly be classified as educational. There is too much, too great, too ponderous and too urgent authority against such a concept for the assistant director to rule otherwise than as he did. But if the Association were to re-name itself the Ancient and Honorable Fraternal Order of Cheiracanthi of the Scientific Sea, it might get by with it. That would make it fraternal—and worthy to the official eye.

What of The Breweries?

THE problem of converting a large brewing establishment to the manufacture of new products under the prohibition law offers a field of constantly increasing interest to the food chemist. Food chemist is said advisedly. Because of the large sales organizations in touch with wholesale grocers and food dispensers, and because of the factory personnel trained to work with cleanliness so necessary in brewing, the logical procedure calls for the manufacture of food products in these disused plants.

One fact seems evident. Large concerns because of their capacity cannot expect to convert their plants to the production of but one line, but must consider several. Candy, ice cream, maltose—that corn product

sweeter and more appetizing than glucose—malted milk, vegetable oils, and cereal beverages, are but specimens of related foods which may all be made in the same factory and marketed through the organized sales force of a modern brewery.

Exceptional opportunity for the food chemist thus exists today. When the research work now being carried on by these chemists becomes manifest in new industrial processes during the coming months one may again say, as many times heretofore, but alas! in a cup which somehow seems unfinished, "Here's to the chemist!"

Economics or Psychology

MARKET prices, including steel market prices, are made in various ways, and an interesting question now is whether prices in the nearby future are going to be made by economic or psychologic laws or influences. It may be granted that in the long run economic influences dictate prices; that is, they dictate the average of prices, but on the other hand it is obvious from any scrutiny of a typical market over a period of a few years that prices at individual moments cannot have been solely at the dictation of economic influences, for the economic influences could not change as facilely as prices have changed. Perhaps it is not far out to suggest as a rough generalization that the long swings are produced by economic influences and the fluctuations by psychologic influences.

The steel market at the present moment presents a very interesting case of economics and psychology. The United States Steel Corporation has been adhering rigidly to the "Industrial Board" price schedule, which means the war control prices minus the reductions that were made in December, 1918, and the further reductions that became effective March 21, 1919, as a result of an agreement between Secretary REDFIELD'S Industrial Board, which a few weeks later resigned, and representatives of the steel industry. The independents, on the other hand, have been advancing prices in rather irregular fashion and at the same time have been selling quite sparingly so that they have kept their order books relatively clear, obviously in the expectation that delaying sales will mean the realization of higher prices.

The Steel Corporation's position may be said to be held from economic considerations, the ground of the independents from psychological considerations. The Steel Corporation management evidently feels that over a period of years the general course of prices ought to be downward, and that any movement in the opposite direction, being contrary to economic laws, would eventually bring retribution.

The independents, on the other hand, evidently feel that buyers are willing, even anxious, to pay high prices for steel without having any definite limit beyond which they would be unwilling to go. Price advances make buyers more anxious to buy, and while sales are necessary in order that profits may be realized, to abstain from selling for a time is to bring greater profits, because later the material can be sold for more money.

The history of the steel market can be searched carefully without conclusive testimony being furnished as to whether economics or psychology has predominated in making the market. Usually there has been little theorizing by the leaders of the steel industry as to how the steel market is made, and what has been said has not always been illuminating. ANDREW CARNEGIE, for instance, who was quite a successful steel manufacturer as well as an excellent salesman, predicted late in 1898, on the eve of his departure for a trip in Egypt, that steel had a great tonnage future, for the reason that three pounds could be purchased for 2 cents, referring to $15 billets, saying also that a producer with bonded indebtedness could not expect to succeed, referring to his rival the Illinois Steel Company. Next year billets advanced above $40 and not long afterward Mr. CARNEGIE became the largest bondholder of a heavily bonded enterprise, the United States Steel Corporation. Then in 1908 Judge GARY, the astute head for nineteen years of the Steel Corporation, in connection with the "Gary dinner" or price maintenance movement, asserted, as to price reductions, that the volume of sales and purchases would not be increased or diminished, but whether he based this statement upon economic or psychological considerations is not known. Perhaps the idea was that from economic considerations the volume of purchases would be increased if the cost of the steel were less, but from psychological considerations buyers might be expected to be less disposed to buy through fear that one reduction merely indicated that another would follow, and thus the two influences, the economic and the psychological, might balance.

As to the actual market movements, which may be studied in the absence of any definite doctrine propounded by the authorities, one may possibly conclude that advancing movements in the market have been helped by psychological influences, while declines have been forced by the laws of economics. When prices begin advancing, buyers are moved to buy to avoid paying still higher prices, and as consumers buy, the sellers, becoming filled farther and farther ahead, are fortified to make additional price advances, all of which is psychological. Eventually the market is sold to a standstill, consumers find themselves with sufficient stocks and a free flow of material to them, adequate to their consumptive requirements, and the economic situation dictates that consumption can be stimulated only by waiting awhile and then beginning the process over again with attractively low prices.

Hence the interesting thing about the present situation is that, while in the past we have had psychology at one time and economics at another time in the steel market, now we have both at the same time.

The Woman And the Serpent

WE HAVE always welcomed the advent of women in science. They are supposed to be endowed by nature with a peculiar curiosity and that is one of the most needed attributes of those engaged in research. The curiosity of women is certain to differ from that of men, and by its very differences it should broaden the scope of the search for scientific truth. This is made manifest in a contribution to *Science* by Miss MABEL C. WILLIAMS of the State University of Iowa. With the aid of two assistants and suitable apparatus, which included a Deprez marker, a time indicator, a battery, some fine copper wire, a curved brass plate, etc., she determined the rapidity with which a rattlesnake wiggles its tail. The extremes ranged from 100 to 500 shakes per second.

Thus is science enriched with a bit of information quite as startling as the sound of the rattler itself.

Western Chemical and Metallurgical Field

Plant of the Olympic Portland Cement Co.

BY FAR the larger portion of the portland cement manufactured in this country is made by the well known "dry process," but what is termed the "wet process" is gaining in favor where the nature of the raw materials is such as to justify the use of this method. The wet process differs from the dry in that the raw materials are ground wet and the slurry thus produced is fed to specially constructed kilns; the treatment of the clinker is the same in both processes. The more obvious advantages of the wet process are two: first, the avoidance of dust both in that portion of the plant where the grinding and mixing of the raw materials are performed, also in the practical elimination of dust from the gaseous products of the kiln; and, second, the ease of obtaining a kiln feed of the required composition.

The first "wet process" mill to be built in this country is that of the Olympic Portland Cement Co., Ltd., at Bellingham, Wash. The plant was designed and constructed by the F. L. Smidth Co. for English capital, a fact that is obvious in the substantial construction of the buildings and equipment, particularly noticeable in the heavy concrete foundations for all machinery. The plant management claims that this expense is amply justified from the point of continuity of operation and few repairs. The present capacity of the plant is 2,000 bbl. per day; this can be doubled by the installation of additional equipment, a provision allowed for in the layout of the plant.

Raw Materials

The raw materials consist of a highly crystalline limestone and a glacial clay. The limerock is obtained from Balfour, Wash., the coarse-crushing plant being located at the quarry. The rock is crushed to pass a 3-in. ring and delivered to a 9,000-ton enclosed storage bin at the plant in standard bottom-dump, 50-ton steel cars. The clay is obtained from Brennan, Wash., being loaded into special 50-ton steel cars by a locomotive crane. At the plant the clay is excavated from these cars by a clamshell bucket-excavator operated from a traveling crane and delivered to a 7,000-ton storage basin. This same equipment is also used to transfer the clay from storage basin to the wash mill. The gypsum which is added in the final grinding operation is obtained from Montana.

The raw clay contains about 30 per cent moisture, and a further 30 per cent of water is added in the wash mill. This mill is a circular reinforced-concrete basin, 25 ft. in diameter by 6 ft. deep, in which the clay and water are added in batches and thoroughly mixed by revolving drags. The resulting slurry, when thoroughly incorporated, flows from the wash mill through a screened gate into either of two agitation basins, from which it is pumped by Smidth slurry pumps to receiving tanks located so as to feed by gravity two No. 85 Smidth Kominuters. The limerock is elevated to feed hoppers, also located above the Kominuters, by Link-Belt bucket elevators and a belt conveyor. The limerock is fed to the Kominuters at a constant rate, being controlled by an apron conveyor, the rate at which clay-slurry and water is fed to the Kominuters being controlled by gate valves; the desired proportion of clay, limerock and water is thus obtained. The excess of clay-slurry overflows from the receiving tanks and is returned to the agitation tanks. The feed to the Kominuters contains about 18 per cent dry weight clay, 82 per cent dry weight limerock and sufficient water to produce a 33 per cent slurry. The product of both Kominuters flows to a 22 x 7 ft. No. 20 Smidth tube mill containing 36,000 lb. beach pebbles. The product of the tube mill is elevated by concrete enclosed bucket elevators and fed to two 10 x 6 ft. No. 18 Smidth tube mills each containing 34,000 lb. "cylpebs." The product of these mills is elevated separately and after passing through Trix mills to screen out the oversize, which is returned to the Kominuters, flows by gravity to one of three 200-bbl. (dry weight) reinforced-concrete correction-basins provided with mechanical agitation, where the slurry is held until a laboratory analysis is obtained. The material is ground to 93 per cent through 200 mesh. The slurry flows from the correction basins to a 1,000-bbl. reinforced-concrete agitation basin and a check analysis obtained. It is then pumped by air lift pumps to either of the two 2,000-bbl. reinforced-concrete storage basins located in the kiln building.

The Kiln Building

The kiln building contains two 170-ft. Vulcan rotary kilns and the necessary auxiliary equipment. The kilns are specially designed for burning slurry, the first 30 ft. from the stack, or feed end, being fitted with "lifters" which elevate the slurry and drop it through the heated gases. The material after passing through the "lifting zone" contains about 10 per cent moisture. This operation effectively removes the cement dust from the gases passing through to the stacks, but does not retain all the ash from the coal dust which is used in firing the kilns. The first 130 ft. of the kiln from the stack end is 9 ft. in diameter, the remaining 40 ft., termed the combustion zone, being 10 ft. in diameter. The kilns are lined with 9-in. firebrick throughout and are connected through a dust chamber to reinforced concrete stacks, 175 ft. in height by 8 ft. in diameter. The slurry is fed to these kilns from supply tanks through gate valves, being pumped from the storage basin by Smidth slurry pumps; the excess overflows from the supply tank and is returned to the storage basins. The hot clinker from the kiln passes through a Smidth double-jacketed air-cooled clinker-cooler, the heated air being forced by a Buffalo Forge Co. slow-speed fan through the cooler and into the kiln, supplying the air necessary for the combustion of the coal dust. The cooled clinker is elevated by a Link-Belt bucket-elevator and delivered to a 180,000-bbl. enclosed clinker storage.

The coal is received from Nanaimo, B. C., on floats at the company's docks and unloaded by a 17-ton locomotive crane into 50-ton bottom dump cars and transferred to an enclosed storage bin. The coal is dried in a Cummer drier and pulverized to 97 per cent through 100 mesh by a Smidth Kominuter and No. 18 Smidth tube mill. The coal will contain about 20 per cent ash and runs about 11,000 B.t.u. per lb.

Finishing-Mill

The finishing-mill contains two No. 85 Smidth Kominuters and two No. 20 Smidth, 20 x 7 ft. tube mills, each containing a 15-ft. section of beach pebbles and a 5-ft. section of "cylpebs." The cement is ground to

pass 55 per cent through 100 mesh and 90 per cent through 20 mesh. About 3 per cent gypsum is added to the clinker entering the Kominuter, this being necessary to retard the setting time of the finished cement. The cement is transferred by belt conveyors to ten 1,000-bbl. reinforced concrete silos in the packing building. From these silos the cement is delivered through a hopper to an enclosed screw conveyor and bucket elevator to either of two four-bag Bates-valve packing machines; the bags are loaded direct into cars by a belt conveyor.

All operations involving the transfer of materials are performed mechanically, the quarry, clay-pit and plant being operated throughout by electricity, practically all equipment being fitted with individual motor drives. The present operating force is 103 men. The possibility of recovering potash was thoroughly investigated, but the amount contained in the clay proved to be too small to permit of economical recovery.

Company Reports

Burma Corporation, Ltd.—The annual report of the Burma Corporation for the year 1918, issued Oct. 31, 1919, contains information regarding the company's ore reserves, production and proposed metallurgical developments. Ore reserves at the end of 1918 were 4,404,000 tons assaying 24.1 oz. silver, 26.2 per cent lead and 18.4 per cent zinc; this includes 283,000 tons of copper ore assaying 21.6 oz. silver, 14.2 per cent lead, 8.7 per cent zinc and 10.2 per cent copper. The smelter production for 1918 was 18,641 tons of refined lead and 1,970,614 oz. refined silver. The development of the mines has been satisfactory, but the metallurgical problems have required a great deal of study and experimentation.

Lawrence Addicks is consulting engineer for the Burma Corporation and the following is abstracted from his report: The program for the coming year (1920) calls for the mining of 1,500 tons ore per day; beginning the operation of the mill on the "preliminary" flow sheet; erecting a standard type lead smelter near the mill, comprising crushing plant, roasters and blast furnaces fully equipped with bag-houses for 750 tons a day charge; erecting a modern Parkes process plant to refine 200 tons of lead bullion per day; erecting a 100-ton per day middling plant in England, provided tests show resulting zinc concentrates already produced are acceptable smelting product; proceeding with the erection of a 25,000-ton per annum zinc smelter at Jamshedpur, India, and developing copper metallurgy on an experimental basis. As the result of investigations and experiments carried out during the past year Mr. Addicks concludes "that it is extremely improbable that any of the many processes considered will ever be able to treat lead concentrates of the cleaner grade (that is, lead-zinc ratio of perhaps six to one) from the mill, and that a modern lead smelter (should) replace the plant now in use. The improved costs and higher recoveries resulting justify this replacement the moment we admit that no chemical process will render smelting obsolete. The question of relatively pure zinc concentrates has already been met in similar manner by the plant to be built at Jamshedpur." The conclusions are very interesting. In view of Mr. Addicks' familiarity with electrolytic methods, an electrolytic zinc plant and lead refinery would have been expected.

General Chemical Co. Buys Western Chemical Plant at Denver

It has been announced that the Western Chemical Manufacturing Co. of Denver, Col., has sold a controlling interest in its Denver works to the General Chemical Co.

The consideration has not been made public, but the physical valuation of the property is about $2,500,000. This plant has been in operation for many years, in the roasting of sulphide ores of the Colorado mining districts for the manufacture of sulphuric acid. The plant is especially adapted to making chemically pure nitric, sulphuric and hydrochloric acids and ammonia, and operates large acid chambers together with the contact acid plants. A zinc-lead smelter and electrolytic plant have also been recently constructed on the property for the recovery of the metals of the ores in the form of matte, paint basis, electrolytic zinc and cadmium.

With the largely increasing demand for acids in the Western district, there is little doubt that the present capacity of this plant will be increased by the new management.

Frank R. Ashley, president; L. B. Skinner, vice-president and general manager; A. K. McDaniel, assistant general manager, will withdraw from active part in the affairs of the plant, but will retain stock in the General Chemical Co. Paul C. Skinner, who has played an important part in the successful operation and growth of this property, is to continuue actively with the new management.

The General Chemical Co., under the arrangements made, will take a controlling interest in the local company's stock in exchange for its own.

St. Louis as a Steel Center

The United States steamboat H. S. Taber, with two of the new Federal steel barges built for upper river use, recently arrived in St. Louis with the initial shipment of Minnesota ore for St. Louis blast furnaces. Enthusiasts say this marks a new epoch in the steel industry in this district, where it is hoped that the combining of easy access of the ores from the Mesaba Range with Illinois coal will make it possible to produce steel fully as cheaply in St. Louis as in any other section of the United States.

In the Government fleet constructed for this purpose, there are nineteen barges and four towboats. The equipment has been leased by the Mississippi Valley Iron Co. of St. Louis, which will use it for the movement of Illinois coal into St. Paul and the Northwest. Returning, the boats will bring iron ore from the Minnesota mines.

These barges are 300 ft. long, 28 ft. wide and 10 ft. deep and will carry 3,000 tons on a 9-ft., 2,500 tons on an 8-ft. and 850 tons on a 4-ft. draft. During certain times of the year only may barges be loaded to full capacity. Seven of these barges have been completed and turned over to the Government. Five more are to be launched the first of the year. The towboats constructed for this use are 240 ft. long, all steel, of the stern wheel type and equipped with the latest machinery, having compound engines capable of developing 2,500 hp.

The unloading facilities in St. Louis are provided by the iron company, the ore being delivered directly at the plant. The trial trip has proved the equipment to be satisfactory in every respect.

Industrial Conference That Promises Results

At a meeting of the International Joint Conference Council in the printing industry, held in New York City recently, five cardinal points of labor policy were agreed upon. The Council is composed of representatives of the international unions of typographers, pressmen, bookbinders, and stereotypers and electrotypers, representing the employees; and of the Closed Shop Branch of the United Typothetæ of America, the Printers' League of America, and the International Association of Employing Stereotypers and Electrotypers, representing the employers. The adoption of these principles does not compel their acceptance either by the unions or the employers, but with these as a foundation the Council will outline a general policy which will be recommended to the members of the constituent organizations. They are incorporated in the scale just adopted for the magazine typographers of New York City.

The right of the workers or employers to organize, recognition of collective bargaining and the unrestricted right of the workers to select their representatives in wage conferences were not questioned. The cardinal points agreed to are as follows:

1. That the industry frankly recognizes the cost of living, as compared with 1914, as the basic factor in wage adjustments.
2. The industry to pay at least a reasonable living wage; scales below this to be adjusted in frank recognition of the basic principle involved.
3. That, when not in conflict with the existing laws of a constituent body, local contracts be for a period of not less than three years and include a clause providing for annual readjustments of wages based upon cost of living as determined by authorities jointly agreed upon, and upon the economic conditions of the industry at the time of readjustment.
4. That a uniform standard system of cost-keeping is considered fundamental to insure stability, permanence and prosperity to the industry, and to provide a basis for securing a greater degree of uniformity in conditions throughout the country; a clause to be included in local agreements providing that such a standard system as is recognized by the organizations represented in the Joint Conference Council be required.
5. That controversies over wages, hours and working conditions between employers and employees can and should be settled without resorting to lockouts or strikes, through voluntary agreements to refer disputes, where unable to settle through conciliation, to joint boards of arbitration composed of equal representation of employers and employees, provision being made for an impartial arbitrator if necessary.

It is evident that the employers as represented in the Council are willing to meet the employees half way. The international unions show a like spirit, and if the recommendations of the Council are adopted, and there is every reason to think they will be, and are followed in good faith by the members of the local unions, a repetition anywhere of the recent chaos in the printing industry in New York City will be impossible.

Also, while these principles doubtless would not be applicable to all industries, they might furnish suggestions for arriving at a better understanding between employer and employee and by providing for uninterrupted production during the adjustment of wage disputes bring nearer the time when economic conditions in the United States will again be normal.

Proposed Duty on Oxalic and Formic Acids

A duty of 5c. per lb. on oxalic acid and its salts is prescribed in a bill which has been introduced by Representative Wilson of Illinois. The bill also provides a duty of 3½c. per lb. on formic acid and its salts, including formate of soda.

Carnegie Corporation Aids National Academy of Sciences and National Research Council

The Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. It is understood that a portion of the money will be used to erect in Washington a home of suitable architectural dignity for the two beneficiary organizations. The remainder will be placed in the hands of the Academy, which enjoys a Federal charter, to be used as a permanent endowment for the National Research Council. This impressive gift is a fitting supplement to Mr. Carnegie's great contributions to science and industry.

The Council was organized in 1916 as a measure of national preparedness, and its efforts during the war were mostly confined to assisting the Government in the solution of pressing war-time problems involving scientific investigation. Reorganized since the war on a peace-time footing, it is now attempting to stimulate and promote scientific research in agriculture, medicine and industry and in every field of pure science. The war afforded a convincing demonstration of the dependence of modern nations upon scientific achievement, and nothing is more certain than that the United States will ultimately fall behind in its competition with the other great peoples of the world unless there be persistent and energetic effort expended to foster scientific discovery.

Better Service Demanded From Patent Office

A bill introduced by Representative Tilson of Connecticut calls upon the Secretary of the Interior to direct the Commissioner of Patents to transmit to the House the facts in his possession concerning delays in the consideration of and action upon applications for patents. The bill points out that the Patent Office is supported by fees from inventors, manufacturers and others transacting business with that office, that each year the Patent Office turns a surplus into the Treasury. Since the inventors and others pay the running expenses of the Patent Office, they are entitled to better service, Mr. Tilson says.

Ramsay Memorial Fund

The United States Committee on the Ramsay Memorial Fund has transmitted £3,500 which it has collected; £263 has been sent direct by contributors; approximately £100 yet remains in the hands of the treasurer, W. J. Matheson. Prof. Baskerville, the chairman, hopes that the total American contribution, which is £3,863, may be raised to £4,000, and then close the American subscriptions. The total fund now amounts to £51,274. This is a very gratifying tribute to the memory of Sir William Ramsay, who did so much for pure science as well as the cause of the Allies during the recent war.

Omaha Chemical Club Formed

Commercial chemists of Omaha, Neb., recently organized the Omaha Chemical Club at a banquet held on Jan. 13 at the Loyal Hotel. Dr. H. A. Senter and Dr. A. W. Peters were the principal speakers. Both emphasized the necessity of organization among Omaha chemists to advance the needs of the profession. Attention was called to the lack of sufficient number and variety of chemical books in the library to serve the rapidly growing industrial needs of the city.

Carnegie Research Fund of the Iron and Steel Institute

In connection with the announcement of the annual meeting of the Iron and Steel Institute, to be held May 6 and 7, members are reminded that in March the Council is prepared to consider applications for grants from the Carnegie Fund, in aid of research work, of such value as may appear expedient, but usually of the value of £100 in any one year. The awards are made irrespective of sex or nationality. Special forms, on which candidates should apply before the end of February, can be obtained from the secretary of the Institute. The research work must be on some subject of practical importance relating to the metallurgy of iron and steel, and allied subjects. The results of research work must be communicated to the Institute in the form of a report.

Theta Tau Fraternity for Engineering Students

The Fourth Biennial National Convention of Theta Tau Fraternity was held at its Delta Chapter House, Case School of Applied Science, Cleveland, Ohio, during the week of Dec. 29, 1919.

Theta Tau Fraternity was founded at the University of Minnesota, Oct. 15, 1904, as an honorary fraternity of mining engineers. After the first three chapters were established, members were chosen also from mechanical, electrical, civil and metallurgical engineering students. Due to the rapid growth of the various branches of engineering, the convention favored the selection of members from sophomore, junior and senior classes in all branches of engineering.

Although heretofore the fraternity has been exceedingly reserved, an extension policy has been adopted and chapters are to be established in many American institutions having engineering departments of high standing.

The next national convention will be held at the University of Kansas, Great Bend, Kan., in 1921.

Chemical Warfare Service

No predictions can be made with any degree of certainty as to the outcome of pending legislation which may change the status of the Chemical Warfare Service, the construction division of the Army and the other services which were given a separate identity during the war. Despite the fact that the House Military Affairs Committee has been working on the Army reorganization bill for nearly a year, the committee has not yet agreed upon the bill that it will bring out. A sub-committee has recommended that the Chemical Warfare Service become a part of the Bureau of Ordnance, but it is not at all certain that the whole committee will accept this recommendation.

On the other hand, unexpected progress is being made with the Army reorganization bill in the Senate Committee on Military Affairs and it is possible that the bill may be reported in a short time. The section of the bill referring to the Chemical Warfare Service, which is established as a separate service, as reported by the sub-committee to the full committee, reads as follows:

"The permanent personnel of the Chemical Warfare Service shall hereafter consist of one chief of Chemical Warfare, with the rank of Brigadier General, and 125 officers in grades from Second Lieutenant to Colonel, inclusive, and 1,200 enlisted men in their appropriate grades, all of whom shall be detailed or assigned from the permanent personnel under the provisions of this act. The reserve personnel of the Chemical Warfare Service shall consist of all reserve officers and reservists assigned thereto as provided for in this act."

Mohawk Valley Engineers Organize

About 125 engineers, architects and chemists met at dinner at the Hotel Utica, Utica, N. Y., on Wednesday evening, Jan. 7, and organized the Mohawk Valley Engineers' Club. The membership of the organization includes civil, chemical, electrical, mechanical, mining, textile, heating and ventilating, automotive and all technical engineers and architects. The territory embraced in the jurisdiction of the club lies within a radius of approximately forty miles from Utica and it is expected that the membership will ultimately reach the 200 mark. Regular meetings will be held on the first Tuesday of each month. The officers for the first year are: President, Byron E. White, engineer of the Utica Gas & Electric Co.; first vice-president, Hubert E. Collins, consulting engineer; second vice-president, Roy F. Hall, division engineer, State Highway Department; third vice-president, Horace B. Sweet, consulting engineer; secretary, Frederick E. Beck, engineer of the Consolidated Water Co.; treasurer, Clifford Lewis, Jr., civil engineer.

National Research Council Advises Baking Industry

The American Association of the Baking Industry has begun work in Minneapolis, Minn., under the direction of Dr. H. E. Barnard, assisted by an advisory committee of the National Research Council, and in cooperation with the Dunwoody Institute. Bread production is to become a science. It has been found that by furnishing the yeast with certain stimulants and special chemical foods a saving of some of both the flour and the sugar formerly consumed by yeast during its growth is made. The scientific aid of the specialist on food and nutrition, agriculture, chemistry and physics of the advisory committee of the National Research Council will give the bakers the advantage of science for the improvement of bread-baking methods.

Research Graduate Assistantships in Engineering at University of Illinois

To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains fourteen research graduate assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $500 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

An appointment to the position of research graduate assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of a research graduate assistant is re-

quired for the work assigned to him, the remaining time being available for graduate study.

The Engineering Experiment Station, an organization within the College of Engineering, was established in 1903 for the purpose of conducting investigations in the various branches of engineering, and for the study of problems of importance to engineers and to the manufacturing and industrial interests of the State of Illinois. Research work and graduate study may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil, electrical, mechanical, mining, and municipal and sanitary engineering, physics, railway engineering, and theoretical and applied mechanics.

Additional information may be obtained by addressing the Director, Engineering Experiment Station, University of Illinois, Urbana, Ill.

Disposal of Government Surplus Chemicals

Up to the end of 1919 the Government has disposed of surplus chemicals, acids and explosives to the extent of $31,954,010.57. The original cost of these supplies to the Government was $34,226,227.35.

British Chemical Industry

From our London Correspondent

London, January 7, 1920.

THE policy of amalgamation and understandings among chemical works continues and seems to be the natural consequence both of the experience gained during the war and of the trend of international competition to be expected in the future. As always, the end of the year was the signal for new issues and for increases in the capital of existing companies, rendered particularly desirable at the present time by the increasing amount of capital that has to remain tied up in stocks and material on hand of nominal value. There is continued activity and a general upward tendency in prices in all sections of the chemical trade, and considerable difficulty is experienced in obtaining prompt supplies of many products, buyers displaying anxiety to provide for their requirements for several months ahead. Competition from Germany does not seem to be feared for at least two years to come and the general opinion is that the coming year will be a busy and prosperous one, granted a reasonable absence of labor, fuel and transport difficulties.

The recent "pyrogallic acid" case has freed imports for the time being, but the position in regard to imports which were previously restricted will be somewhat risky, as the decision will either be reversed or legislation introduced to reimpose the restrictions.

Fuel Outlook Is Disturbing

The fuel outlook is still a disturbing factor, and as domestic supplies only were affected by the recent reduction in price, it is probable that a continuance at the very least of present prices must be faced by the chemical industry. As a result there is a general feeling that oil fuel must be resorted to in part, and the additional demand has already caused an increase in the price of fuel oil which can only be counteracted gradually as additional shipping becomes available for its transport. Considerable attention is also being devoted to the use of oil for auxiliary firing, especially in connection with low-grade coal, and to the possibilities of powdered coal and colloidal fuels. The possibilities of home-produced oil fuel are still treated with some scepticism, and development work is proceeding slowly. The experts' reports on the development of the Norfolk shale deposits owned by English Oilfields, Ltd., are considered ultra-optimistic and doubt is expressed as to the possibility of eliminating the large amount of sulphur usually found in such oils. The question of sulphur content is hardly mentioned in the report, which is calculated to give the impression that sulphur only occurs in isolated cases, an impression unlikely to be substantiated.

Nitrogen Products Committee Report

The final report of the Nitrogen Products Committee previously referred to[1] is to be published about Jan. 15, and owing to the inordinate delay, some of the figures and conclusions will be out of date. In general this country is less prompt and confident in disseminating knowledge acquired by government departments than the United States. The impressions and conclusions arrived at by a representative British mission sent to German chemical works by the Board of Trade and the Association of British Chemical Manufacturers were published for private circulation among members of the latter. Various items filtered through to the public in the form of addresses to local gatherings by members of the mission, but actually there is little in the report that could not have been published broadcast with advantage, particularly if done systematically as in the American technical press.

Chemists' Salaries and the Endowment of Science

The questions of chemists' salaries and the endowment of science at universities are again receiving attention, but in the latter case the sums asked for and forthcoming are minute in comparison with the munificent donations to American institutions. The future of the chemical industry is so closely bound up with these questions that those countries which take the lead quickly will reap the fullest advantage in the future. As regards the future of the British industry, a thoughtful contribution by E. F. Armstrong[2] sums up the position admirably.

Personal Notes

Sir Richard Redmayne has resigned his post of Chief Inspector of Mines in order to take up the work of chairman of the new Imperial Mineral Sources Bureau. The latter is the nucleus of an organization similar to the United States Bureau of Mines, and of course an institution of this kind should have been inaugurated many years ago in this country. David Gilmour, who as Director of the Factories Branch of the Ministry of Munitions controlled the erection and operation of some of the largest works in this country, has left for Canada to take up the appointment of president of the Standard Chemical Co., Ltd. Prof. Robinson, of Liverpool University, will be the new Director of Research of the British Dyestuffs Corp. Dr. J. E. Stead is the new president of the Iron & Steel Institute and Dr. C. H. Desch has been appointed to the chair of metallurgy at Sheffield University recently vacated by Dr. J. O. Arnold. Lever Bros., Ltd., is to build a large candle-making factory near Bath at a cost of about $5,000,000. It will be remembered that this firm recently acquired the business of Price's Patent Candle Co.

[1] See CHEM. & MET. ENG., Jan. 14, 1920, p. 56.
[2] *J. Soc. Chem. Ind.*, Dec. 15, pp. 448-450R.

Electrolytic Production of Hydrogen

Theoretical Principles Involved in Calculation of Cell Efficiency—Commercial Cells—Metal Diaphragm, Filter Press or Bi-Polar, Suspended Diaphragm Tank and Non-Porous Non-Conducting Diaphragm Types — Hydrogen as Byproduct From Chlorine Cells

By HARRY L. BARNITZ, Ph.G.

THE decomposition of water into its constituent elements, hydrogen and oxygen, had been a matter of experiment in the chemical laboratories for more than a century. It finally remained for the remarkable developments of electrochemistry in the past generation, stimulated by the commercial demand for these gases, to produce a commercially practical water electrolyzer (also termed electrolytic cell).

In an embryonic form, decomposition of water may be effected by passing an electric current between two metallic poles, or electrodes, immersed in water. As water has great power of resistance to electric current, it is necessary to lower the resistance to allow a large current of electricity to pass. This is accomplished by adding to the water either acid or alkali, forming an electrolyte. The electrolyte proportionally raises the gas production.

There are two classes of substances which act as conductors for the electric current. The first class includes metallic conductors, such as copper, aluminum, brass, iron, mercury and some solid non-metallic substances, of which carbon is the most important. The passage of a current through these conductors is not accompanied by any change in the conductor, other than the development of a certain amount of heat. Members of the second class of conductors known as electrolytes are water solutions of acids, bases and salts. Some melted compounds also act as electrolytes—these will not be considered here, as they are of no importance in the production of hydrogen and oxygen.

The passage of current through an electrolyte is accompanied by the liberation of two different substances. One of these appears at the terminal where the current enters the solution, known as the anode, or + electrode, and the other at the terminal at which the current leaves, called the cathode, or — electrode. For an illustration, if two electrodes made of platinum plates are placed in a strong aqueous solution of hydrochloric acid, the one electrode being connected to the positive pole of the battery and the other to the negative pole, decomposition of the liquid will take place—hydrogen will be given off at the negative electrode or cathode and chlorine at the positive anode. If the solution of hydrochloric acid is replaced by sodium chloride, chlorine is liberated at the anode and sodium hydroxide is found in the solution surrounding the cathode.

Now let the solution of hydrochloric acid and sodium chloride be replaced by a solution of sodium hydroxide. The solution of sodium hydroxide is split up by the current into oxygen, which is liberated at the anode, and sodium ions, which lose their charge at the cathode and become sodium atoms with the escape of hydrogen. Again, the solutions of hydrochloric acid and sodium chloride and sodium hydroxide are replaced by an aqueous solution of sulphuric acid. In this instance, hydrogen will be liberated at the cathode and the SO_4 group at the anode, which immediately reacts with the water and forms a new molecule of sulphuric acid.

Copyrighted, 1920, by Harry L. Barnitz.

Electrolytic Dissociation Theory

Before attempting to explain this result it will be necessary to state the theory of electrolytic dissociation.

According to this theory, when an electrolyte is dissolved in water, a portion at least of its molecules break up into two parts, one charged with positive electricity and the other with an equal amount of negative electricity. These charged portions of the molecule are called respectively positive and negative ions. Thus, when sodium chloride is dissolved in water, equal amounts of positive sodium ions and of negative chlorine ions are produced. This may be indicated by the equation:

$NaCl$	$\leftrightharpoons$	Na^+	+	Cl^-
sodium chloride molecule		sodium ion		chloride ion

Hydrochloric acid dissociates in solution according to the equation:

HCl	$\leftrightharpoons$	H^+	+	Cl^-
hydrochloric acid molecule		hydrogen ion		chlorine ion

Sodium hydroxide dissociates in solution as follows:

$NaOH$	$\leftrightharpoons$	Na^+	+	OH^-
sodium hydroxide molecule		sodium ion		hydroxyl ion

It will be noted in these typical examples of the dissociation of a salt, an acid, and a base that the hydrogen ion and the metallic ion are positive, and that the non-metallic ions are negative.

In a solution of copper sulphate there are copper ions and sulphate ions:

$CuSO_4$	$\rightleftharpoons$	Cu^{++}	+	SO_4^{--}
copper sulphate molecule		copper ion		sulphate ion

A double charge is indicated here on each ion, as the number of charges which an ion carries is the same as the number expressing its valence. Molecules of the dissolved substance in an electrolyte, then, dissociate, on dissolving, into positive metallic ions and negative non-metallic ions. Hydrogen, in acids and acid salts, acts as a metallic ion; in bases it is a part of the complex non-metallic ion OH^-. The only important complex positive ion is NH_4^+, produced by the dissociation of ammonium hydroxide and the ammonium salts.

The proportion of the molecules dissociated at a particular time in a given electrolyte depends on the nature of the dissolved substance, the degree of dilution of the solution, and the temperature. Water is the only important solvent in which any considerable amount

of dissociation takes place. Many soluble substances, particularly organic compounds such as sugar, alcohol, and glycerine, do not dissociate on dissolving. Such solutions are known as non-electrolytes and are non-conductors of electricity. Pure water is a very poor conductor, and therefore its molecules are only slightly dissociated.

On the basis of the theory just stated the electrolysis of sodium chloride is easily explained. When the electrodes are dipped into the solution and the circuit closed, the Na^+ ions, which have been moving about at random in the solution, are immediately repelled by the positive electrode and attracted by the negative electrode, since like electric charges always repel and unlike charges attract. The Cl^- ions begin to move toward the positive electrode for the same reason. As soon as an ion reaches the electrode, the opposite charges on ion and electrode neutralize each other. The chlorine ion, losing its charge, becomes a chlorine atom; these unite in pairs to form molecules, and escape from the solution, when a sufficiently large number of such molecules have collected at the anode. The sodium ions in a similar way lose their charge at the cathode and become sodium atoms. These do not, however, unite to form pieces of metallic sodium, since they react with the water to form sodium hydroxide:

$$\underset{\text{sodium}}{2Na} + \underset{\text{water}}{2H_2O} \longrightarrow \underset{\text{sodium hydroxide}}{2NaOH} + \underset{\text{hydrogen}}{H_2}$$

Thus bubbles of hydrogen will escape at the cathode. The sodium ion did not react with the water, because the presence of the electric charge gives the ion chemical properties differing from those of the atom.

It may be now explained that when sulphuric acid is added to water to make it a conductor (considering the action first as an electrolysis of sulphuric acid) the acid dissociates on dissolving into hydrogen ions and sulphate ions:

$$\underset{\text{sulphuric acid molecule}}{H_2SO_4} \leftrightarrows \underset{\text{hydrogen ion}}{H^+} + \underset{\text{hydrogen ion}}{H^+} + \underset{\text{sulphate ion}}{SO_4^{--}}$$

As the current passes, the ions lose their charges at the electrodes. At the cathode hydrogen ions change to hydrogen atoms, which unite to form molecules of hydrogen. At the anode, SO_4^{--} changes to SO_4, which immediately reacts with the water as follows:

$$\underset{\text{sulphate radical}}{SO_4} + \underset{\text{water}}{H_2O} \longrightarrow \underset{\text{sulphuric acid}}{H_2SO_4} + \underset{\text{oxygen}}{O}$$

In the reaction a new molecule of sulphuric acid has been produced in place of the one originally dissociated and an atom of oxygen has been liberated. The oxygen atoms liberated at the anode unite to form oxygen molecules, which escape as a gas. The entire reaction therefore may be considered as equivalent to that shown by the equation:

$$\underset{\text{water}}{2H_2O} \longrightarrow \underset{\text{hydrogen}}{2H_2} + \underset{\text{oxygen}}{O_2}$$

In the commercial production of hydrogen and oxygen by electrolysis where a solution of sodium hydroxide or potassium hydroxide is used as the electrolyte, potassium hydroxide has a slightly higher efficiency than sodium hydroxide and was almost exclusively used prior to the war. Due to the high cost and great scarcity caused by the war, potassium hydroxide has been replaced by sodium hydroxide, although it is probable that potassium hydroxide will again be used when market conditions are favorable. The first action in the electrolysis is the dissociation of potassium hydroxide when it dissolves:

$$\underset{\text{potassium hydroxide molecule}}{KOH} \leftrightarrows \underset{\text{potassium ion}}{K^+} + \underset{\text{hydroxyl ion}}{OH^-}$$

When the potassium ion reaches the negative electrode, it loses its charge, becomes a potassium atom, and reacts with the water of the solution, forming potassium hydroxide again and liberating hydrogen:

$$\underset{\text{potassium}}{2K} + \underset{\text{water}}{2H_2O} \longrightarrow \underset{\text{potassium hydroxide}}{2KOH} + \underset{\text{hydrogen}}{H_2}$$

The hydroxyl ions, when they lose their charges, react with each other, forming water and liberating oxygen:

$$\underset{\text{hydroxyl}}{OH} + \underset{\text{hydroxyl}}{OH} \longrightarrow \underset{\text{water}}{H_2O} + \underset{\text{oxygen}}{O}$$

It will be seen that the net result of these reactions is the removal of one molecule of water from the solution and the liberation of two atoms of hydrogen and one atom of oxygen. So it is only the water in the cell which needs to be renewed and not the potassium hydroxide. The results of the reaction are identical if sodium hydroxide is used as the electrolyte.

Faraday's Laws

The dissociation theory having been stated, the theory of relationship between current and volume of hydrogen produced will now be considered.

The theory of relationship between current and volume of hydrogen produced is founded upon laws relating to the decomposition of liquids by the electric current, known as Faraday's laws. They constitute the basis of all electrochemical calculations, determining just how much chemical action is produced by a given flow of current for a given time. These laws are as follows:

1. The amount of chemical effect produced during electrolysis is directly proportional to the product of the current and the time; that is, to the quantity of electricity which flows through the electrolyte.
2. When a current passes through an electrolyte, bringing about chemical changes at the electrodes, the quantity of each substance formed is directly proportional to the equivalent weight of the substance and to the quantity of electricity which has flowed through the electrolyte.

It is obvious that if 1 amp. flowing for 1 min. will deposit a certain amount of silver, 2 amp. flowing for 1 min. will deposit twice that amount. Also that the amount which a given current will deposit in 10 min. is ten times as great as will be deposited by the same current in 1 min.

Electrochemical Equivalent

By knowing the equivalent weight, or, as it is more commonly termed, the chemical equivalent, of the material, the quantity of that material which will be liberated by a known amount of electric current can be readily calculated. Every substance, whether it be a chemical element or a chemical compound, has its electrochemical equivalent, just as it has a certain atomic weight; and in fact the electrochemical equiv-

alent is closely associated with the atomic weight. As many elements have more than one valency, therefore they have more than one chemical equivalent weight, as can be seen from the Table I.

TABLE I. CHEMICAL EQUIVALENT WEIGHTS

Element	Atomic Weight	Valency	Chem. Equiv. Wt. at. wt. / v
Hydrogen	1	1	1
Oxygen	16	2	8
Gold	197	3 or 1	65.6 or 197
Tin	118	4 or 2	29.5 or 59
Tungsten	184	6 or 4	30.6 or 46.0

It is found by experiment that a current of 1 amp. flowing for 1 sec. (one coulomb) deposits 0.001118 g. of silver from an aqueous solution of a silver salt. The atomic weight of silver is 107.94, its valency is unity, therefore its chemical equivalent weight is 107.94. However, the atomic weight of hydrogen is 1.0 and its valency is unity, therefore its chemical equivalent weight is 1.0; therefore it is obvious from Faraday's second law that $\frac{0.001118}{107.94} = 0.000010357$ g. of hydrogen will be liberated by 1 amp. flowing for 1 sec., or the mass of hydrogen liberated by any current in any time may be expressed as $1.0357 \times 10^{-5}At$, where A is the current in amperes and t the time it flows in seconds; which is equivalent to stating that, at 0 deg. C. and 760 mm. barometric pressure (29.92 in.) 1 amp.-hr. will liberate 0.0147 cu.ft. of hydrogen.

Factors Affecting Voltage Drop

It now remains to determine the relationship between power and the volume of hydrogen which should be theoretically liberated. It is evident that to get the current to flow through the electrolyte requires an electrical pressure, as all substances offer resistance to the passage of electricity through them. Therefore a voltage drop between the anode and cathode will be found in cells.

Two factors of resistance cause this voltage drop, one of which is analogous to the resistance of any conductor and is dependent on the length and cross-sectional area of the path of flow of the current—the distance between the electrodes. This resistance is called the back emf. of the cell, or polarization. The resistance in the first instance can be practically eliminated by placing the electrodes close together. The second factor is due to a constant of the electrolyte in the cell and is not caused by a function of cell design. Therefore it is obvious that the current must have a certain theoretical potential to overcome the polarization resistance of the electrolyte to obtain electrolysis in a cell.

Decomposition voltages are given in Table II for various aqueous solutions of bases, acids, and salts containing their chemical equivalent weight in grams per liter. These values are given for minimum voltage to produce continuous electrolysis in a cell whose resistance other than that due to polarization is negligible. These solutions vary in concentration, and it has been found that solutions whose minimum voltage is about 1.7 require no appreciable variation of pressure to produce continuous electrolysis.

Having previously ascertained, from Faraday's laws, that a current of 1 amp. for 1 hr. should produce 0.0147 cu.ft. of hydrogen (at 0 deg. C. and 760 mm. pressure), it is evident when a solution of sodium hydroxide is used, the current must be supplied at 1.69 volts, therefore 1×1.69 watt-hr. produces 0.0147 cu.ft. of hydrogen, or 1,000 watt-hr. produce $\frac{0.0147 \times 1000}{1.69} = 8.7$ cubic feet.

With the liberation of hydrogen at the cathode, oxygen is simultaneously evolved at the anode. Therefore, in accordance with Faraday's laws the volume of oxygen is one-half of that of the hydrogen and theoretically, in the electrolysis of a solution of sodium hydroxide, 1 kw.-hr. should produce 8.7 cu.ft. of hydrogen and 4.4 cu.ft. of oxygen at 0 deg. C. and 760 mm. (29.92 in.).

TABLE II. DECOMPOSITION VOLTAGES (Le Blanc)

Solution of	Minimum Voltage Volts	Solution of	Minimum Voltage Volts
Silver nitrate	0.70	Nitric acid	1.69
Hydrochloric acid	1.31	Zinc chloride	1.78
Potassium hydroxide	1.67	Zinc sulphate	2.35
Sodium hydroxide	1.69		

One of several of the more important commercial applications of the theory of electrolysis will now be described in the production of hydrogen and oxygen.

Types of Commercial Cells

Various types of electrolytic cells for the commercial production of hydrogen and oxygen have been developed. Only those types which are representative will be considered here. They all employ either sulphuric acid or a solution of sodium or potassium hydroxide as electrolyte. When the acid is used, lead is the material used in the cell construction, while with the alkaline electrolyte, iron is employed. This choice of materials is made because of the insolubility of lead and of iron in the respective solutions. It is apparent that insoluble electrodes must be employed to allow the escape of hydrogen and oxygen.

An important point to be attained in water decomposition is that the anode and cathode products be kept as completely separated as possible. The bubbles of the hydrogen coming off at the cathode surface must not mingle with the oxygen bubbles from the neighboring surface, otherwise impurity of products results.

The electrodes must be placed as near together as practicable. If the distance between the anode and cathode is great, the resistance of the cell is high and the production is much below the theoretical.

To obtain reasonably high purity in the gaseous products, some types of cells have a porous diaphragm placed between the electrodes; others have a metallic diaphragm. Cells employing a porous diaphragm create a certain amount of resistance, but they have the advantage of acting as a factor of safety and add to compactness.

A 20 to 30 per cent sulphuric acid solution has a higher conductivity than a 10 to 20 per cent alkali solution. On the other hand, it takes a somewhat higher electromotive force to liberate hydrogen and oxygen from the former solution, so that cells using sodium or potassium hydroxide have a slightly lower energy consumption than those using the acid.

Since the acid or alkali is unaffected by the electrolysis, it is only necessary to add distilled water from time to time to replace that electrolyzed.

The representative types of cells for the commercial production of hydrogen may be classed as:

1. Metal diaphragm type.
2. Filter press or bi-polar type.
3. Suspended diaphragm tank type.
4. Non-porous non-conducting diaphragm type.

Metal Diaphragm Type

The cell developed by Garuti and Pompili[1] is an excellent example of this type. In this cell a partition of iron separates the anode from the cathode, and this

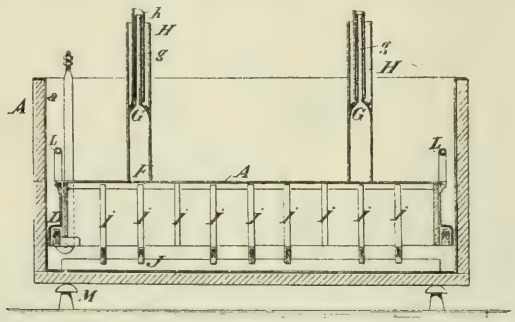


FIG. 1. GARUTI GENERATOR—VERTICAL LONGITUDINAL SECTION

partition is prevented from becoming an intermediate electrode by keeping the voltage applied to the cell too low for this to take place. The current flows from the anode to the cathode around the bottom of the iron partition.

Fig. 1 is a diagrammatic longitudinal vertical section through the center, Fig. 2 is a horizontal section of one end, Fig. 3 is a vertical cross-section of the cell and Fig. 4 a plan view of conductors and electrodes.

Tank *A* of wood lined with iron *a* contains the electrolyzer, which consists of an inverted tank *A* which is divided into cells *E* by longitudinal diaphragms. This case is made of iron and is open only at the bottom. The anodes *b* and cathodes *c* are placed one

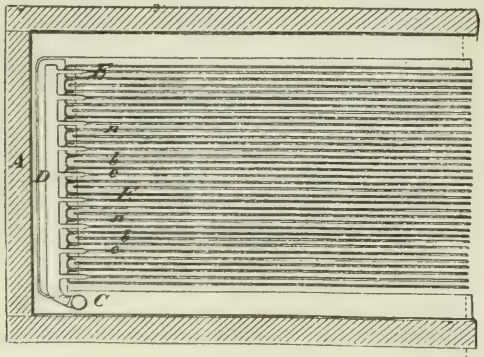


FIG. 2. GARUTI GENERATOR—HORIZONTAL SECTION

in each cell, taking care that each anode is between two cathodes. The gas passes through an opening at the top of each chamber into the gasometer containing the same gas. The electrodes are insulated from the diaphragms by combs *I* made of wood, the teeth of which enter the cells and fill the spaces between the electrodes and diaphragms. *L* is a handle for lifting out the electrolyzer.

The diaphragms may be perforated near the bottom with a large number of small holes, which reduce the electrical resistance, as there is very little danger of the gases becoming mixed at this point.

Using a 25 per cent solution of sodium hydroxide and a current density of 25 to 27 amp. per sq.ft., the gases being measured at 20 deg. C. and 760 mm. pressure, the electrolyzer produces 6.1 cu.ft. of hydrogen per kw.-hr. The purity of the hydrogen is 99 per cent and of the oxygen 97 per cent. This type of cell is quite compact but, owing to the small distance between the electrodes, care must be taken to prevent an internal short circuit in the individual cells.

Filter Press or Bi-Polar Type

In the filter press or bi-polar type cell the polarization or back emf. resistance of the cell from the original anode to the original cathode is doubled by the fact that the interposition of a conductor, to which no electrical connections have been made, turns the original cell into two cells, when the electrodes are placed together and insulated from one another.

The filter press or bi-polar type shown in Fig. 5 consists of a series of metallic plates (electrodes) clamped up together in a heavy frame, electrically insulated from one another, and separated by diaphragms of porous fabric.[2] Each pair of these electrodes forms a closed cell, divided by the diaphragm. These cells are filled with the electrolyte (sodium or potassium hydroxide), which acts as a conductor, connecting up the plates in series.

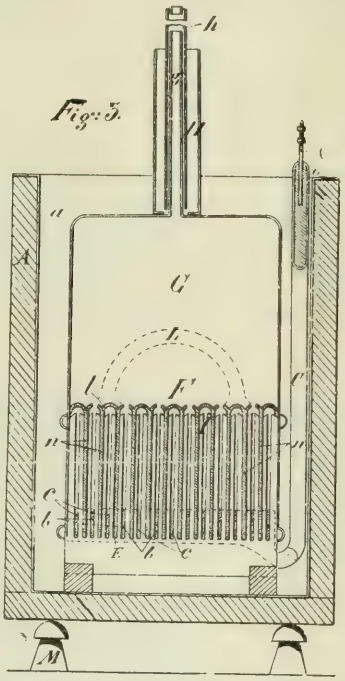


FIG. 3. GARUTI GENERATOR—VERTICAL CROSS-SECTION

An electric current admitted at one end plate passes on through the plates and through the solution to the other end plate. In its passage, it decomposes the water of the solution into the two gases —hydrogen and oxygen —which are released on opposite sides of each plate and emerge upward into the gas offtakes. The mingling of the hydrogen and oxygen in each cell or compartment is prevented by the diaphragm which, while permitting the passage of the fluid, resists the passage of the gases.

FIG. 4. GARUTI GENERATOR — PLAN VIEW OF CONDUCTORS AND ELECTRODES

The electrodes *C* are clamped together by a heavy screw *D* working in the rear support. The surfaces of the electrodes carry vertical corrugations which are interrupted by a large number of depressions to facilitate the flow of electrolyte into the cell and the release of the gases from it.

At top and bottom of each electrode are two openings communicating by cored channels with opposite sides of the plate. Those at the bottom are for the water intakes and those at the top are for the gas offtakes. It will be seen that each half has its own independent water intake and gas outlet, so that there can be no possibility of the two gases mingling through these channels.

[1] U. S. Patent 629,070, July 18, 1899.

[2] Met. & Chem. Eng., vol. 14, p. 108, Jan. 15, 1916.

The diaphragms *H* are of specially prepared asbestos fabric. All around the edge of this fabric is molded a packing rim *G* of pure rubber which is an integral part of the diaphragm and which rests in a recessed groove on the face of the electrode.

Obviously, in a generator of this type, an essential of power economy is that all the current supplied shall pass through the electrolyte and none of it be bypassed through the metal of the generator or through the water inlets and gas outlets, therefore the electrodes are insulated from the side bars of the frames by porcelain insulators *E* resting on a wooden base. They are insulated from one another by the rubber packing rim *G* surrounding the diaphragm and by rubber nipples inserted in the water intake and gas offtake shoulders of the electrodes, which also provide an insulating tube in the interior of the water intake and gas offtakes.

At the front of the cells and elevated above the electrodes is a solution box or tank *B* which receives the distilled water that is supplied to the electrode chambers or cells *C*. From this tank a pipe descends to a water-feed manifold, the latter branching to two independent connections to the two separate water intakes to the cells. And from this manifold two risers lead, one to each of the two gas domes *AA* above.

Into these gas domes the hydrogen and oxygen are separately introduced as generated. The arrangement is such that a constant fluid level between the electrodes is automatically maintained. The description will apply to all filter press type cells.

As the individual resistances are in series, the number of plates in the unit determines the actual voltage necessary. The voltage drop per plate is 2.4 to 2.5 when using a 28.9 per cent solution of sodium hydroxide. The average current density is about 20 to 30 amp. per sq.ft. and the production is 7.5 cu.ft. of hydrogen and 3.75 cu.ft. of oxygen per kw.-hr. measured at 20 deg. C. and 760 mm. pressure. The purity of the gases averages between 99.1 and 99.5 per cent for the hydrogen and 98.7 per cent for the oxygen.

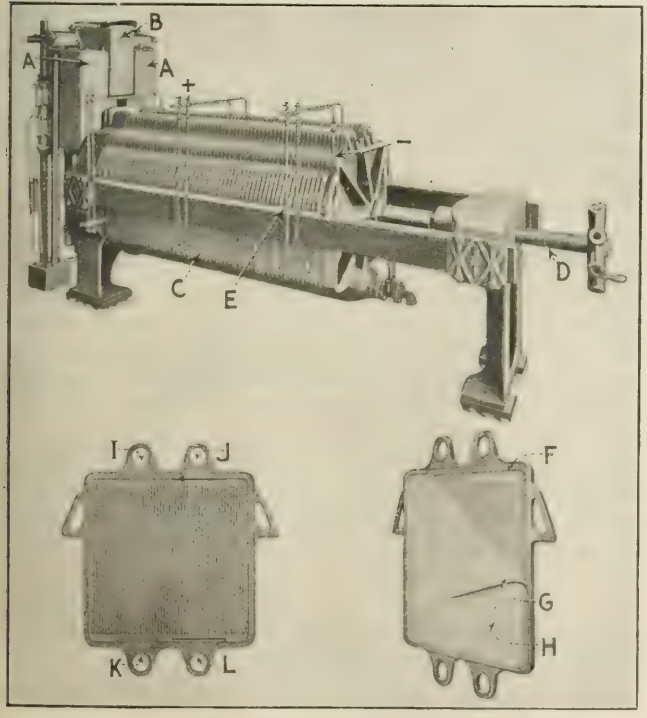


FIG. 5. FILTER PRESS OR BI-POLAR TYPE CELL
Above—Cell completely assembled. Lower left—Electrode from anode side, showing water intake and gas offtake channels and corrugations. Lower right—Electrode with diaphragm partly removed, showing method of holding and packing the diaphragm.

The filter press type of cell is compact, but is offset by other disadvantages. Water and gas tightness in the individual cell depends upon the rubber in the diaphragms and on contraction and expansion. This type of cell requires constant overhauling. The suspended diaphram tank type cell, as illustrated by the diagrammatic drawing (Fig. 6), consists of an oblong tank *G* made of mild sheet steel with flanges at the top standing on insulators *H*. In this tank an oblong diaphragm with curved ends and bottom *L*, perforated with oblong holes, is suspended from the thick steel lid of the cell *O*, by means of hollow electrodes *D*. An asbestos sack *K* surrounds the diaphragm *L*, which forms a partition between the side of the tank *G* and also the metal partition *M*. The asbestos sack is held by a fixture band *J* on the non-conducting separator *I*.

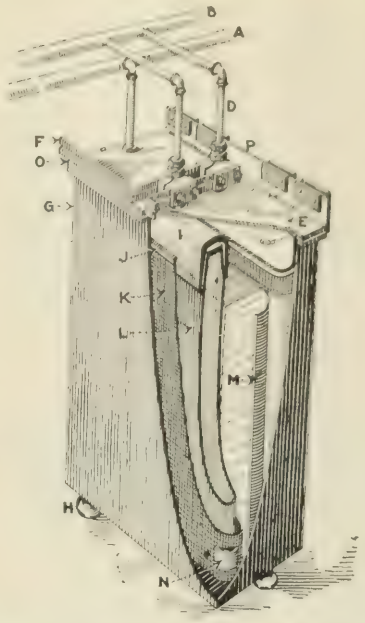


FIG. 6. SUSPENDED DIAPHRAGM TANK TYPE CELL

Either one or two diaphragms may be used in this type cell. In the diagrammatic sketch a partial view of one diaphragm is seen with a partition of mild sheet steel *M* which separates the other diaphragm (not seen in the sketch).

The lid *O* is insulated and bolted down on the flanged top of the tank. To this lid is attached the filling cup *E*, gas outlet pipes *A* and *B* and positive busbar *F*. The negative busbar *P* is attached to the side of the tank and extends above the lid.

The interior of the tank is filled to within about 10 in. of the cover with a 15 per cent solution of sodium hydroxide in distilled water.

The mode of operation of the cell is as follows: If the positive lead of the circuit is connected to busbar *F*, and the negative lead is connected to busbar *P*, electrolysis will take place and hydrogen will be liberated on the side of the tank *G*, rising through the electrolyte, where it is free to circulate to the outlet pipe *A*. While hydrogen is being liberated on the sides of the tank *G* and partition *M* oxygen will be liberated on both sides of the diaphragm *L*, from where it will rise up and pass out of pipe *DD*. In each of the four corners of the asbestos sack is a pocket *N*, which holds an insulator which permits on the outside diaphragm *L* the free circulation of oxygen bubbles by expanding the sack slightly. Distilled water is added to the filling cup *E* from time to time, to replace that decomposed by the current. The voltage drop between anode and cathode is 2.2 volts. The purity of hydrogen is above 99½ per cent and that of the oxygen above 99 per cent. The suspended diaphragm tank cell has been one of the most successful types of cell developed.

An example of the non-porous non-conducting diaphram

type is represented in the Schoop cell (Fig. 7) in which an acid electrolyte is used. The electrolyzer consists of a cylindrical lead-lined tank containing four vertical electrodes. These are in the form of lead tubes filled with fine lead wire to increase active electrode surface. Each electrode is surrounded by a cylindrical tube of glass or porcelain—open below and perforated at the bottom to allow the flow of current. The gas generated on the electrode within the glass or porcelain tube passes upward, where it is collected. Where an alkaline solution is employed the tank and electrodes are made of iron.

Hydrogen as Byproduct From Electrolytic Chlorine Cells

Some electrolytic cells designed for the manufacture of products other than those already discussed yield hydrogen as a byproduct, i.e., those used in the electrolytic process for the manufacture of caustic soda.

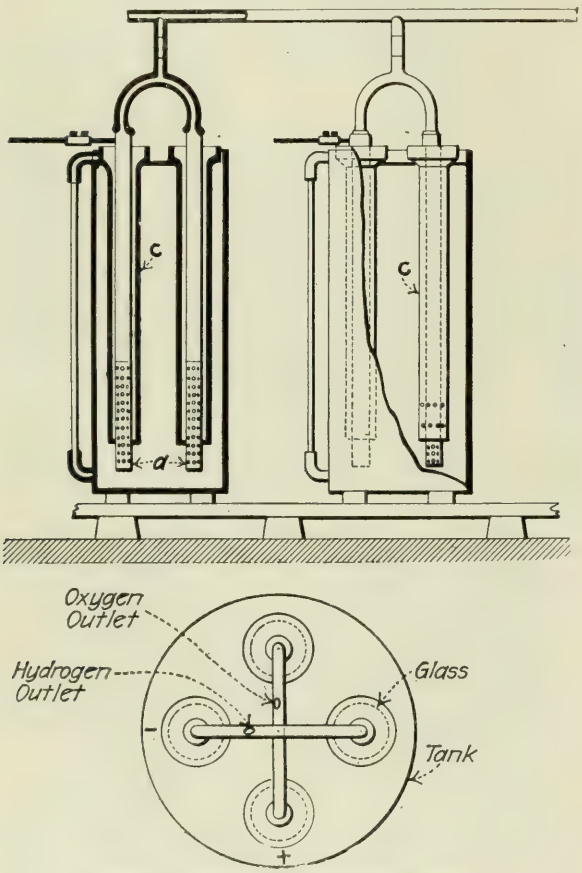


FIG. 7. SCHOOP ELECTROLYZER

The Castner mercury cell (Fig. 8) is probably the most important type of cell yielding hydrogen as a byproduct. The function of this cell is primarily the production of caustic soda and chlorine from a solution of brine, but at the same time hydrogen is produced.

The cell is divided into three compartments by vertical partitions extending almost to the bottom of the cell, but not making a tight joint therewith. In the two end compartments *A* and *C* is placed a strong solution of brine, while the middle compartment *B* is filled with water. The current, in flowing through the cell, passes from the positive carbon *DD* through the brine, thence to the mercury and from the mercury to the negative electrode *E* in the center compartment. By the splitting up of the sodium chloride in the end compartments, chlorine will be liberated at the positive electrode and passes out at *F*, while sodium will be deposited on the mercury, forming sodium mercury amalgam.

This amalgam is transferred to the central compartment by a slow rocking motion which is given the cell by the eccentric *G* and is decomposed at the negative

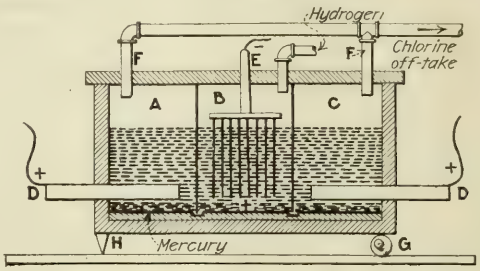


FIG. 8. CASTNER CAUSTIC SODA-CHLORINE CELL

electrode in accordance with the following equation:

$$2Na + 2H_2O = 2NaOH + H_2$$

It will be seen that the net results of the process are that chlorine is produced in the end compartment, and caustic soda and hydrogen in *B*, the center one. The hydrogen usually contains a certain percentage of chlorine which is detrimental.

German Dyes in Java and Their American Competitors

Agents in Holland for German dye manufacturers are circularizing the consumers and dealers in the Dutch East Indies to the effect that they are now in a position to obtain German dyes, but that the prices have greatly increased over the pre-war figures, and give one instance of a color which before the war sold at 1 guilder per gram and is now quoted at 100 guilders.

Java is an important market for dyes, and some of the importers who sold German dyes in pre-war days are now agents for American dye manufacturers. These importers are much encouraged regarding the outlook for the American product, but the American industry is so young on this market that there are points in the dyeing processes of many of the colors that will have to be more fully developed before they are suitable for the native trade, which is the big trade here.

American dye manufacturers should not lean too strongly on the efforts of their agents in Java to sell their product. This is no reflection on the importers, as they are well equipped for selling and distributing, but there is plenty of work still to be done on the technical side of the business to warrant the presence in Java of a practical dye chemist. The importer has not the technical knowledge to do this work, and if it is left to him progress will be slow.

If the German manufacturers are in a position where their prices will have to go up in a fraction of the degree indicated above, it would seem that there is a present opportunity for American dyes to get a very strong place in this trade.

Commissioner to Study South American Market for Industrial Supplies

Philip S. Smith of Schenectady has been appointed trade commissioner to study South American markets for industrial supplies. Mr. Smith has previously reported on markets for electrical goods in Latin America and in Spain.

Dust Exhaust System at Arizona Copper Co. Mill

By M. R. Hull

THE ore which reaches the crushing department of the Arizona Copper Co.'s Morenci Mill carrying 3.85 per cent moisture is crushed dry from run-of-mine size to ¾ in. at the rate of about 250 tons per hr. Fig. 1 shows the crushing plant flow sheet. An equipment for removing dust, for the purpose of improving the working conditions in this plant, was installed in 1917.

Dust Exhaust Hoods

A careful study of the plant previous to designing the exhaust system showed that, with a small amount of judicious housing, the dust could be effectively drawn from seven hoods. These hoods were placed as follows:

Number of Hoods	Location	Size of Hood	Dia. of Branch Pipe, In.
1	Over gyratory crusher.....	5 ft. 6 in. x 5 ft. 6 in.	10
2	At discharge of 24-in. conveyor...	2 ft. 6 in. x 3 ft.	8
2	At discharge of disk crushers onto 26-in. belt conveyor.....	2 ft. 6 in. x 2 ft. 8 in.	8
2	At discharge of 26-in. belt conveyors into feed chute of 54-in. rolls.....	2 ft. x 3 ft.	8

Fig. 2 shows the construction above the gyratory crusher. Near all machines, flanged connections of hoods and pipes were used to facilitate their removal, thereby rendering the machines easily accessible for inspection and repairs.

Details of Construction

Proportioning of Piping. In every case the area of the main is slightly larger than the combined area of all branches discharging into it.

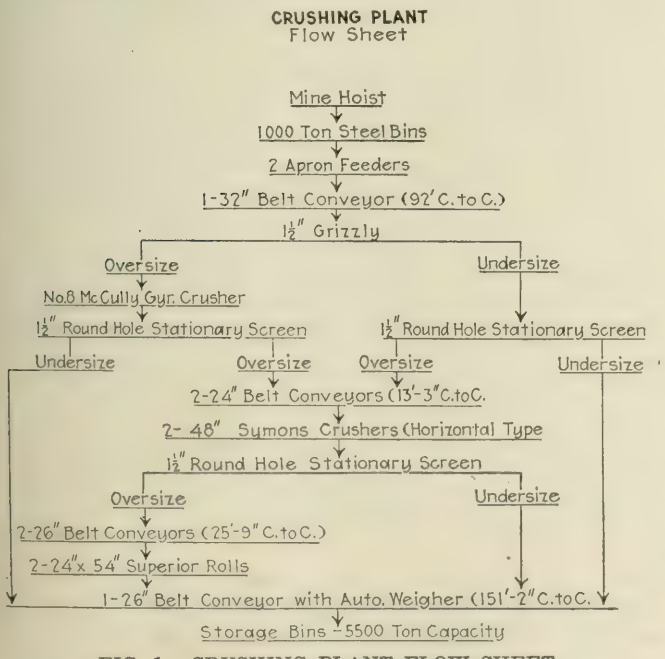


FIG. 1. CRUSHING PLANT FLOW SHEET

Velocity of Air. All branch pipes were proportioned for a velocity of air of 4,000 lin.ft. per min., and the power consumed in operation indicates that this velocity is about 4,200 ft. under operating conditions.

Hoods. In all cases where possible the hoods were so made that the area of the net air opening into the hood does not exceed the area of the exhaust pipe leading from the hood, and the hood so placed that the dust is naturally thrown toward its apex. These conditions are essential to successful operation.

Piping—Bends. No bends, where clearances permit, have a radius of less than $a = 1\frac{1}{2}d$, where a = radius of center line of pipe and d = diameter of pipe, but tests on other air pipes have shown that there is no advantage in making a greater than $2d$.

Intersections. No branches intersect the main pipe at an angle greater than 45 deg.

Laps. All the laps are in the direction to cause least resistance to flow of air.

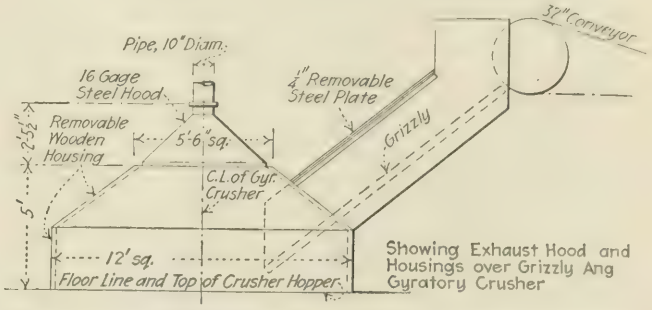


FIG. 2. CONSTRUCTION ABOVE GYRATORY CRUSHER

Joints. All the joints are riveted and soldered, except where flanged joints are required for easy removal.

Thickness of Metal. All straight pipe is made of No. 20 gage galvanized steel. Some of the bends showed considerable wear after 15 months' operation and should have been made of No. 16 gage. All the hoods are of No. 16 gage galvanized steel.

The Collector

The collector is a modification of the well-known cyclone type depending upon centrifugal action to bring the dust particles into contact with the inside cylindrical surface, which is sprayed with water. The dust is thereby arrested and is also washed down the sides, where it accumulates as a thin pulp in a concrete basin. This basin serves also as a foundation for the collector.

The lower part of the collector is cylindrical instead of conical, as they are usually made, to eliminate all chance of the solids adhering to the sides. The center pipe was made with an adjustable sleeve, as it was intended to determine by test the efficiency of the collector and power consumption for various adjustments of this sleeve, and to dispense with it if it proved unnecessary. This test I think has not been made.

Fig. 3 shows the essentials of its construction, an interesting feature of which is the discharge trap which was designed to maintain a suction on the fan of from 5¼ in. to 10 in. head of water. The adjustment is made by raising or lowering the level of the discharge weir by means of wooden strips 2 in. wide x 9 in. long. The fan is operating under a suction of about 6 in. of water.

Exhaust Fan

The exhaust fan is a Sturtevant slow speed planing mill exhauster No. 70 of 20,000 cu.ft. per min. capacity and 4 oz. pressure when running at 545 r.p.m. It is running 577 r.p.m. and by calculation is delivering about 11,000 cu.ft. per min. at about 3½ oz. pressure.

The fan was selected and the collector designed to provide for extending the suction system. The fan is located beyond the collector with the "draw through"

system, the fan exhausting the air from which the dust has been separated directly into the atmosphere.

Remarks and Conclusions

Operating data obtained by tests extending over a period of nine days show average results:

Tons of ore crushed per hour	237
Moisture in ore, per cent	3.85
Tons dry dust collected per hour	0.087
Per cent dust collected as per cent ore crushed	0.0367
Gallons of water per hour	570
Gallons of water per ton dust collected	6,552
Per cent copper in ore	.....
Per cent copper in dust	2.34
Horsepower input to fan motor	23
Cu. ft. of air per minute discharged by fan*	11,100
Velocity in suction pipes, ft. per min*	4,200

* Calculated from hp. absorbed by motor, allowing 90 per cent efficiency for motor and 50 per cent efficiency for fan.

Except for the weight of metal in pipe bends, no criticism of this installation either in construction or

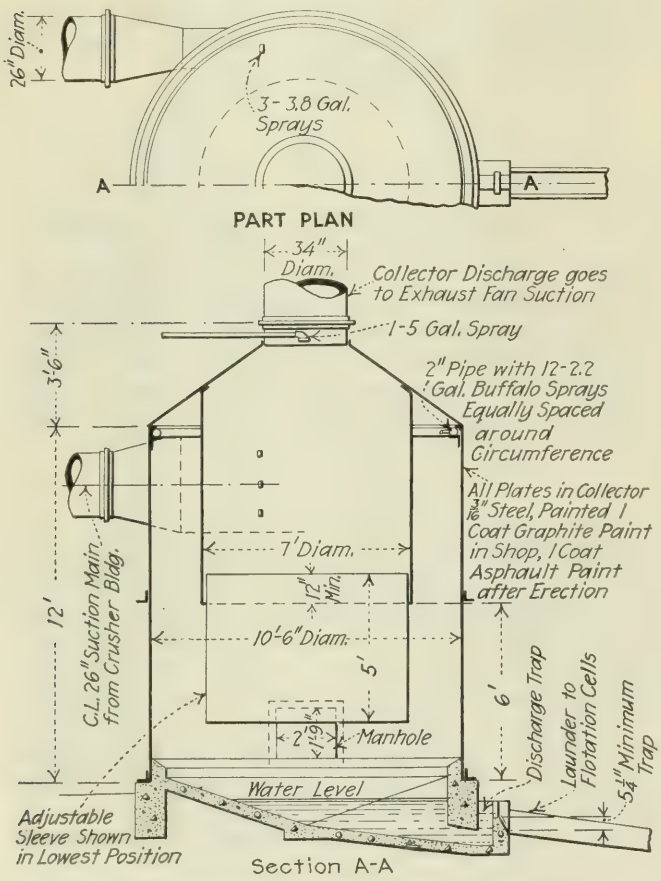


FIG. 3. CONSTRUCTION OF THE COLLECTOR

operation has been made by the operating department.

When it was placed in operation, all complaints from the operators as to dust were ended. It requires practically no attention other than the oiling of the motor and fan bearings.

The amount of water used is in excess of requirements, but no experiments have been made to determine the minimum amount required.

The advantages of the installation are:

(*a*) Improvement in working conditions.

(*b*) A saving of power and wear on mechanical equipment of the crushing plant due to removal of dust.

(*c*) Saving of labor formerly necessary to remove dust from building and equipment.

(*d*) Saving the values formerly lost in the dust. This alone is probably sufficient to pay for the cost of operating the exhaust system.

History of Asbestos Paper*

By Oliver Bowles

THE asbestos used by the ancients, termed amiantus by Pliny, was used for winding sheets, tablecloths and other fabrics. It was probably chrysotile fiber and was a woven and not a felted product, and therefore is not to be confused with asbestos paper. There are, however, some early references to paper manufacture that are of interest. Pontoppidian, Bishop of Bergen, in his Natural History of Norway, published in 1750, refers to paper made from asbestos found in the parish of Waldens. He states that this paper did not burn when thrown in the fire, but the writing on it totally disappeared. This indicates that the primary object was to obtain an indestructible writing paper. About 100 years later, further efforts were made with the same object in view.

In 1853, a patent was issued for a process making paper from a mixture of asbestos and alum. Many experiments were made to manufacture suitable asbestos printing paper. Some such papers contained only about one-third asbestos, the remainder being of combustible material. Such papers would burn, but would leave a white residue which retained its shape and preserved the written characters. On account of the difficulty of obtaining a smooth and even surface, and the tendency for the material to absorb ink like blotting paper, asbestos paper is not well adapted for writing or printing purposes.

Other early uses of asbestos paper were for ornamental wall-paper and carpet linings. None of the uses mentioned have developed to anything of importance in a practical way, but the manufacture of asbestos paper has become a very important industry in the past twenty-five years, and it has found extensive uses in ways that were never dreamed of by the early investigators.

It is recorded that the first sheet of asbestos paper made in America was manufactured in 1876 by John Roberts & Son Co., in a mill near Waltham, Mass. The material first used was a long-fibered amphibole asbestos from Italy. About three years later, Canadian fiber was introduced and proved to be very satisfactory. The shorter grades of fiber which would otherwise be wasted were used for the manufacture of paper and board. From 1881 to 1900, the H. W. Johns Co. of New York took the entire product, which was 300 to 700 tons per year. The latter company built its own asbestos paper mill at Brooklyn in 1900. The Keasbey & Mattison Co. of Ambler, Pa., began to manufacture in 1897. Other early manufacturers were: the Asbestos Paper Co., at Baldwinsville, Mass., and B. S. Binney, at Shirley, Mass. The number of manufacturers gradually increased until at present asbestos paper is manufactured by ten companies.

It is interesting to note that the pioneers, John Roberts & Son Co. still manufacture asbestos paper, the present output being about 1,200 tons per year.

Production has made tremendous strides, some plants manufacturing as much paper in a day as was made in an entire year twenty-five years ago. The average production for the past two or three years has been about 25,000 to 30,000 tons per year. During the war the demand was small, and it is still much below normal. Present plant capacity is, therefore, very much greater

*Abstracts from monthly reports on investigations, Bureau of Mines, November, 1919.

than the above figures would indicate. The present price of asbestos paper is $10 to $15 per cwt.

Manufacturers of asbestos paper also manufacture other pulp products, such as mill-board, which is made in various thicknesses. The chief uses of asbestos paper and mill-board are as follows: For high pressure gaskets and packings, insulations, lining for stoves, air-cell pipe covering, roofing, building paper, and other uses in the building trades. On account of its resistance to fire and high temperature, and its insulating properties, asbestos paper occupies an important place in modern industry.

Use of Spiegeleisen in Steel Manufacture*

By Henry D. Hibbard

SPIEGELEISEN was the first manganese alloy employed, about sixty years ago, for deoxidizing steel made by the bessemer process and later in 1865 for steel made by the Martin process, carried out in the Siemens furnace and now known as the open-hearth process. The name spiegeleisen was that of a white manganiferous pig iron made in Prussia containing from 7 to 8 per cent of manganese. Irons richer in manganese were made from time to time in the years which followed as they were found to be desirable, but the same name—contracted to "spiegel" in the shop—was applied to all such irons up to those containing over 20 per cent of manganese, to which the name of ferromanganese was given when they were first made, about 1870. As time went on richer and richer manganese alloys were made, all of which were called ferromanganese, until our present standard alloy of 80 per cent came into general use in 1880. As ferromanganese became richer in manganese, so did the irons included under the name of spiegel, and now the dividing line between spiegel and ferromanganese may be fairly taken at 40 per cent, all richer alloys being called ferromanganese and all of 40 per cent or less being called spiegel. This is the sense in which the names are used throughout this statement.

Use of Ferromanganese

The advantages of a more condensed form of manganese, because of which ferromanganese became the popular and almost universal form for adding the element to the molten metal in the oxidation processes, lie in the smaller weight to be handled, which renders preheating and pre-melting unnecessary, while at prewar prices it is perhaps the cheapest form of manganese as well. It is brittle, enabling it to be easily broken to size when desired. Then for soft or low carbon steel there is the important additional advantage of its high ratio of manganese to carbon, about 12 to 1, which favors greatly the making of such steels, in that the carbon content can be kept down while an ample amount of manganese is added. When more carbon is needed in the harder steels than the ferromanganese contains it is provided by adding pig iron, or molten crude iron, or carbon in the form of coke or coal.

There has never been a doubt as to the suitability of spiegel for making the higher carbon steels of good quality. Its use requires no particular care, provided that it be melted or heated so as not to cool the metal beyond a permissible amount. When it was supplanted it was for the reasons already given.

It is also being used for the softer low-carbon steels. In practice which we have observed (mentioned below, under the caption "Example A") this is described and difficulties which were encountered are discussed.

Spiegel Practice

Example A. For two years a certain company has used exclusively in its basic open-hearth and bessemer practice spiegel produced from domestic ores. It has the average analysis given below:

	Per Cent		Per Cent
Manganese	31.25	Carbon	4.80
Iron	62.25	Silicon	1.43

In the open-hearth, soft-, medium- and high-carbon steel is produced. The spiegel is added cold. For high-carbon steel three-quarters is added to the bath about 20 min. before tapping and the remainder to the ladle. For low-carbon steels about half is added to the bath 10 min. before tapping and the other half to the ladle. The manganese in the finished steel is from 50 to 70 per cent by weight of that added. The product is fairly free from red shortness, but the effect on the low-carbon steel is somewhat different from that usually obtained by the use of ferromanganese. It rose in the molds before "rimming in"; the ingots were too "thin skinned," the skin holes being too near the surface, so that some of them were opened up in the heating and rolling, causing tears, seams, streaks, pits, and scabs in the bloom or plate into which they were rolled. Whether this was due to the use of spiegel, or to too high silicon contained, or to some other reason, is uncertain. It is indeed possible and perhaps probable that methods might be found or developed which would give non-rising low-carbon steel with the use of spiegel, but to settle that question weeks or perhaps months might be required. This company is installing cupolas for melting the spiegel before adding it to the metal.

In the bessemer practice of this company the spiegel is broken to pieces the size of a hen's egg and smaller, heated to redness, and added in the ladle as the charge is poured from the converter. Only soft steel is made, containing about 0.08 per cent carbon. The heats observed all rose in the mold before "rimming in," in like manner to the open-hearth steel, although to a lesser degree. The steel, when bloomed, showed defects like those of the open-hearth steel mentioned above.

Example B. A spiegel "mixture" has been used exclusively by another company for a number of years for steels containing over 0.30 per cent carbon. The alloy is added molten. A mixture of standard 20 per cent spiegel, pig iron and, in some cases, ferrosilicon is made up, so that the molten alloy will exactly satisfy the requirements of the steel for carbon, silicon and manganese. The carbon in the bath is worked down to 0.15 per cent and the residual manganese averages 0.17 per cent in tapping out time. The following examples show the percentages of manganese used in spiegel mixtures:

Finished Steel			Bath Metal		Spiegel Mixture		
% C	% Mn	% Si	% C	% Mn	% C	% Mn	% Si
0.68	0.75	0.13	0.15	0.17	4.2	6.50	1.60
0.39	0.62	0.17	0.15	0.27	4.3	9.00	4.25

The manganese loss in the cupola and ladle is 30 per cent by weight.

*Abstracts of a report submitted to the director of the Bureau of Mines, Jan. 7, 1918, and withheld from publication at that time because of its confidential character. While primarily an estimate of requirements for 1918, the data on which this estimate is based are of much general interest, and were issued in November, 1919, in the Monthly Reports of Investigations, Bureau of Mines.

The finished steel is fairly uniform in quality, and for steel above 0.30 per cent carbon this company considers it the most effective method of adding manganese. Test samples of finished steel are taken after pouring the first ingot and again near the end of the teeming. These samples are almost identical in manganese and other constituents. This company claims to be the first to use molten spiegel in open-hearth steel, but several other plants are now using it in the same way.

It seems at least possible that steel lower than 0.30 per cent carbon may be satisfactorily made by means of this practice by using a higher manganese spiegel mixture. On the basis of the method used by this company for computing their mixture, the following table has been prepared to show how, from the chemical standpoint, steel containing 0.20 per cent carbon can be made from various spiegel mixtures:

% C in Bath	Lb. Alloy per Ton of Steel	% Mn in Alloy	% Loss Mn Cupola and Ladle	% Carbon in Alloy
0.08	56.0	18.85	30	4.8
0.10	43.2	25.60	33	5.2
0.12	32.5	36.10	37	5.5
0.15	18.7	66.0	40	6.0

From this table, it is evident that with the use of a 66 per cent mixture the heats could be tapped at 0.15 per cent carbon. If carbon were 0.10 per cent at tapping a 25.60 per cent manganese mixture could be used. It would, of course, take somewhat longer to work the carbon down from 0.15 to 0.10 per cent, and the output of a given furnace per day would be decreased proportionately.

Estimated Tonnage of Steel in 1918 for Which Spiegel Can Be Used

The table below gives the estimated steel ingots and castings in 1918, and the tonnage which may be recarburized with spiegel. This estimate is based on the assumption that there will not be a large total increase, because there will not be the fuel available.

ESTIMATED STEEL INGOTS AND CASTINGS IN 1918

	Long Tons	Tonnage Which May Be Recarburized with Spiegel
Rails	3,400,000	3,400,000
Plates and sheets	10,700,000	1,400,000
Nail and spike plate	30,000	30,000
Wire rods	4,000,000	3,000,000
Structural shapes	3,200,000	3,200,000
Merchant bars	9,150,000	8,000,000
Bars (concrete)	450,000	250,000
Skelp	3,150,000	150,000
Splice bars	575,000	575,000
Hoops	285,000	285,000
Bands and cotton ties	570,000	570,000
Rolled sheet piling	17,000	17,000
Railroad ties	40,000	40,000
Rolled forging billets	5,150,000	4,000,000
Blooms, billets, etc	570,000	400,000
Miscellaneous rolled	1,250,000	700,000
Castings	1,500,000	1,000,000
Total	44,037,000	27,017,000

Using spiegeleisen instead of ferromanganese is entirely feasible for about 70 per cent of the steel manufactured in the United States at the present time. Its practicability for the classes of steel enumerated below is not yet demonstrated to satisfaction:

Ingots for plates and the better quality sheets, and for pipe.

Other low-carbon steel requiring extra fine surface.

Steel below 0.10 per cent carbon.

Steel castings made by the converter process where plants are not equipped with crucible or cupola furnaces for melting recarburizers.

The above estimate is made on the assumption that spiegel will be available, if necessary, containing between 20 and 30 per cent manganese.

Estimated Tonnage of Spiegeleisen Required in the Year 1918

On the basis of the estimate of 27,000,000 tons of steel and assuming 14.9 lb. of metallic manganese required per ton, 180,000 tons of metallic manganese must be supplied in the form of spiegel. With an average content of 25 per cent manganese, 720,000 tons of spiegel would be required. For the production of this amount, there would be required about 1,620,000 tons of manganiferous iron ore of the following analysis:

	Per Cent
Manganese	17.50
Iron	32.50
Silicon	12.00

Probably spiegels will be made containing respectively from 10 to 40 per cent of manganese for which proportionate amounts of ores of suitable compositions would be required.

Estimated Tonnage of 80 Per Cent Ferromanganese Required in the Year 1918

By deducting from the estimated total production of the year 1918 the tonnage that may be recarburized with spiegel, there remain 17,000,000 tons of steel ingots and castings which it is not yet demonstrated can be successfully recarburized with spiegel. Assuming 9 lb. of metallic manganese per ton, equivalent to 11.25 lb. of 80 per cent ferromanganese per ton, then 85,000 tons of 80 per cent ferromanganese is the amount proper for recarburizing 17,000,000 tons of steel. The percentage of manganese added to soft steel is substantially lower than added to high carbon steels. The average for all steels made is now about 13 lb. per ton.

For the manufacture of manganese steel, estimated to be about 70,000 tons of steel in ladle, 10,000 tons of ferromanganese will be needed. This, with the 85,000 tons previously mentioned, makes a total of 95,000 tons.

This quantity will probably require about 250,000 tons of manganese ore for its production.

Canadian Chemical Exports

Exports of chemicals and chemical products from Canada fell off decidedly during the seven months ended October, 1919, as compared with the corresponding period of 1918. The total chemical exports for the first seven months of the current year were $12,817,907; the exports for the similar period of the previous year were $36,050,250.

The exportation of non-metallic minerals and products, however, showed a slight increase for the seven months ended October, 1919, the aggregate value of such exports having been $14,037,723, as against $13,777,252 for the seven months ended October, 1918. Exports of ores, metals and metal manufactures other than iron and steel for the same period amounted to $28,288,774 in 1919, and $47,015,270 in 1918.

Imports of chemicals and chemical products and non-metallic minerals showed slight decreases during the month of October, 1919, as compared with the same month of 1918.

Canadian trade as a whole, both imports and exports, increased measurably during the month of October over the previous month of 1919. The total exports amounted to $201,357,291, while the total imports amounted to $91,910,477, for October, 1919.

The Heat Treatment of Beta Brasses

A Study of the Relation Between Various Physical Properties of Beta Brasses as the Annealing and Quenching Temperature Varies — Methods of Procuring Strong, Ductile Pieces Are Described

By H. M. BRAYTON

THE writer while a senior student at the Massachusetts Institute of Technology conducted a lengthy investigation on "The Heat Treatment of Beta Brasses," under supervision of Prof. Henry Fay.[1] Very little scientific data seem to be available on this subject. Such investigative work as has been done by the various brass companies seems to have failed to find its way into the current press or to the public in book form. In order to understand the whole subject better it will be necessary to give here an outline of work thus far done by other investigators in the same field.

Broadly speaking, what data we have available on other compositions seem to have come largely through the efforts of English and Continental scientists. More attention has apparently been given to the development of the practical side in America than to the purely scientific aspect. Such men as Charpy and Le Chatelier in France, Stead, Stedman, Hudson, Austin and Bengough in England have conducted valuable researches in the 70-30 region. Their results have been published from time to time in the *Journal* of the Institute of Metals.

The following is a brief abstract from a paper by Stead and Stedman[2] on their researches into the relations between the heat treatment and mechanical properties of Muntz metal.[3] Tests were made on half-inch round stock of cold-drawn brass. The specimens were kept at a constant temperature for 48 hr. At the end of this time some were quenched in cold water and some were cooled slowly in air. A few of the specimens were kept in a gas flue at a temperature between 430 and 450 deg. C. for three months. The following results were obtained from the experiments:

1. The most ductile cold-drawn Muntz metal is obtained by annealing at 430 deg. C. for three months. It is obvious, however, that such a treatment is not practical commercially.
2. The Brinell hardness increases as the temperature of quenching increases.
3. There is a critical temperature near 750 deg. C. The metal becomes ductile again at higher temperatures.
4. It is dangerous to anneal between 750 and 800 deg. C. because the beta crystals are liable to become enveloped with the alpha constituent. This structural arrangement is conducive to weakness in both chilled and air-cooled brasses.
5. Heating to 800 deg. C. followed by quenching gives homogeneous beta constituent, and a tensile strength of 58,000 lb. per sq.in. Heating to 500 deg. C. followed by quenching reduces the tensile strength to 52,000 lb. per sq.in.
6. Brass is very immune from oxidation during heating. The loss is only 0.8 per cent in 48 hr. at a temperature of 860 deg. C.

Bengough and Hudson[4] published the results of their study on brass of the 70-30 composition which contained 0.2 per cent of lead and 0.15 per cent of tin. The specimens were kept at the required temperature for 50 minutes and cooled in air. Their results are as follows:

1. Heating to 275 deg. C. has no effect on the breaking load.
2. From 275 to 300 deg. C. the breaking load fell off rapidly.
3. From 300 to 900 deg. C. the breaking load fell off more slowly.
4. Temperatures up to 250 deg. had no effect on the ductility.
5. From 275 to 300 deg. C. the elongation rapidly increased.
6. From 300 to 825 deg. C. a regular increase in the elongation was observed.
7. Above 825 deg. C. the elongation decreased.
8. Impurities in brass have the effect of causing it to burn at a lower temperature.

Messrs. Babson and Buhler, two students at Massachusetts Institute of Technology, conducted a series of experiments in 1903 on "The Effects That Different Temperatures of Annealing Have on the Physical Properties of Brass and the Effects of Different Gases at Annealing Temperatures on the Microstructure of Brass." These experimenters worked on the following compositions:

Alloy	Per Cent Cu	Per Cent Zn	Per Cent Pb	Per Cent Sb
No. 1	62.91	34.50	2.64	Trace
No. 2	63.37	33.87	2.69	Trace
No. 3	63.23	34.02	2.61	Trace

Eighteen-inch specimens were cut from ¾-in. round stock and held at the various temperatures for 2 hr., and air cooled with the following results:

1. Tensile strength varies inversely with the temperature of annealing.
2. Percentage elongation is practically constant at temperatures below 340 deg. C.
3. At 420 deg. C. there is a marked decrease in percentage elongation.
4. Maximum elongation takes place at 450 deg. C.

It would appear from these results that there must be an important change of structure between 340 and 450 deg. C.

Recently an excellent article on metallic alloys[5] dealing principally with brass and bronze appeared, copiously illustrated with microphotographs.

Materials Used in the Present Investigation

The series of experiments described below were conducted on material furnished by the American Brass Co., Waterbury, Conn. After drawing to $\frac{1}{2}\frac{5}{2}$ in. the

[1]The writer wishes to acknowledge Dr. Fay's part in the work at this time. The satisfactory completion of the investigation and the knowledge obtained were made possible only by his excellent supervision. Special acknowledgment is also due Prof. Harrison W. Hayward for his careful supervision of mechanical details and arrangement of apparatus. Finally to I. H. Cowdrey, also of the Institute staff, the writer wishes to express his appreciation for the many helpful suggestions during the actual tests.

[2]*J. Inst. Metals*, vol. 12, 1914.

[3]Copper-zinc alloy of the 60-40 composition.

[4]*J. Inst. Metals*, 1910.

[5]*J. Am. Soc. Mech. Eng.*, April, 1917, p. 306.

rods had been annealed, and then cold drawn through a ½-in. die.

Two alloys were furnished which were analyzed:

Alloy	Per Cent Cu	Per Cent Zn	Per Cent Pb	Per Cent Sn
A	60.58	38.67	None	0.75
AA	56.17	41.24	2.53	0.06

Alloy A

This material came in the form of ½-in. round rods about 10 ft. long, finished and machine straightened. Five rods were received and marked 1, 2, 3, 4, and 5 in consecutive order as they came through the die.

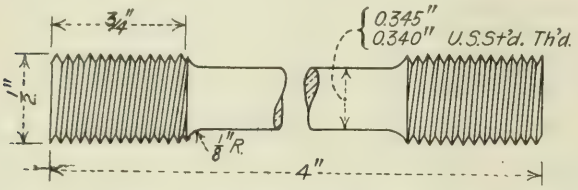


FIG. 1. DETAIL DRAWING OF SPECIMEN USED IN THE TESTS

This arrangement was important, as any variation in the physical properties of the metal as it came through the die had to be carefully considered.

The stock was cut into 4½-in. lengths and each specimen was carefully marked in order to keep track of its position throughout the run of metal. Specimens from alloy A were marked consecutively A1, A2, A3, etc., from the beginning of the run and in a similar manner alloy AA was marked AA1, AA2, AA3, etc.

Variations in Initial Properties of Alloy A

In order to study the variations in strength, ductility, elongation, etc., throughout the run of metal as it came from the die and in the natural or untreated state, five specimens from alloy A were selected and marked A1p, A2p, A3p, A4p, and A5p. These specimens were then made up into the standard tensile test piece shown in Fig. 1, broken in a small Riehle machine, with results as tabulated in Table I.

TABLE I. PHYSICAL PROPERTIES OF ALLOY A AS RECEIVED

Specimen No.	Ultimate Tensile Strength, Lb. per Sq.In.	Elongation in 2 In., Per Cent	Reduction of Area, Per Cent	Hardness — Brinell	Hardness — Scleroscope
A1 p	60,800	21.0	39.5	130	15
A2 p	64,200	19.0	26.7	128	15
A3 p	65,200	17.5	28.4	130	14
A4 p	65,600	17.5	30.6	130	14
A5 p	65,600	17.5	26.4	130	13

TABLE II. PHYSICAL PROPERTIES OF ALLOY AA AS RECEIVED

Specimen No.	Ultimate Tensile Strength, Lb. per Sq.In.	Elongation in 2 In., Per Cent	Reduction of Area, Per Cent	Hardness — Brinell	Hardness — Scleroscope
AA1 p	66,600	8.5	8.0	130	15
AA2 p	68,000	9.0	9.0	128	15
AA3 p	68,800	9.0	10.0	136	14
AA4 p	68,400	7.0	3.8	130	16
AA5 p	68,800	7.0	6.0	134	14
AA5 Ap	58,700	5.0	4.5	136	13
AA1 pp	77,830	20.0	25.4	137	8
AA2 pp	79,270	22.5	27.2	132	8
AA3 pp	78,680	22.5	27.8	124	8

This metal was, of course, all from the same heat and the variations are those due simply to the inaccuracies of manufacture of excellent quality material. The increase in strength of this alloy is very marked. Naturally the ductility decreases as the strength increases. The change in the reduction of area is the most marked. Hardness did not change perceptibly throughout the run of metal. This alloy showed good tendency toward "necking down" and gave ample warning before it finally ruptured. In each case a good clean partial cone break was produced. Due to this variation in the strength and ductility of the metal as received, any conclusions which have been later drawn on the effects of heat treatment in varying the physical properties of these alloys are based on careful consideration of the position of the specimen in the run of metal. Fig. 9 gives its microstructure; the crystals are badly deformed by the cold work.

Alloy AA

This material was received in the same form as alloy A and was prepared and marked in the same way. The untreated pieces were very brittle and each broke in the small punch mark used for obtaining elongation. The tests were therefore of little value. Due to this failure it was necessary to select three more specimens and these were marked AA1pp, AA2pp, AA3pp, to distinguish them from the first lot. These broke properly and the data obtained are shown tabulated in Table II. Tensile strength seemed to reach a maximum at the center of the run, but there is little actual variation. It might well be that if a large number of tests were run the average would be close to a straight line. In a like manner the reduction of area and elongation show but little variation throughout. In general the ductility seems to be about the same as for alloy A, the reduction of area being less and the elongation slightly more. The strength, on the other hand, is decidedly higher. The hardness of AA seems slightly greater than for A, but not as much as would be expected from the difference in tensile strength recorded; it is very brittle and broke with little warning, sometimes with a shearing break.

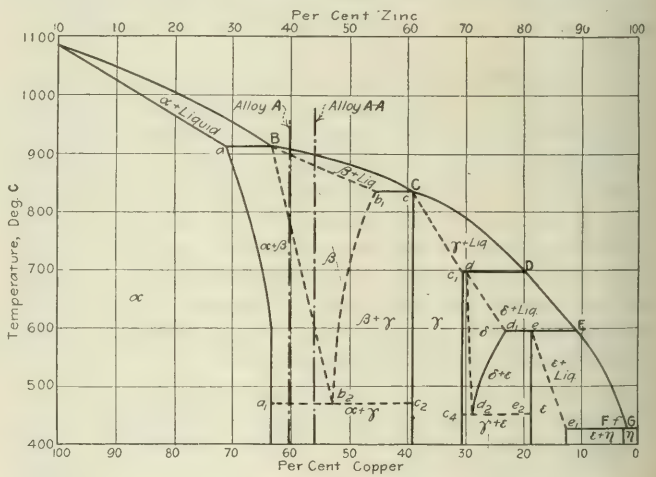


FIG. 2. EQUILIBRIUM DIAGRAM FOR COPPER-ZINC ALLOYS

Fig. 10 gives the original structure of AA, comparatively fine grained, and not badly distorted by the final draw.

Instrumental Equipment

An electric tube furnace with adjoining potentiometer was used in these experiments. An iron-iron constantan thermocouple was inserted in the furnace from the rear and packed with asbestos wool. Two specimens were then placed in the furnace from the front and the opening closed with a wad of the wool. These specimens were placed on an asbestos boat and a piece of iron wire wrapped about each one to facilitate rapid withdrawal

when being quenched. They were placed in the center of the furnace lengthwise and the thermocouple placed on the ridge of asbestos board between them. Temperature was regulated by means of a series resistance in the heating current.

The potentiometers used were Leeds & Northrup instruments, one a recorder, corrected against standard cells for cold junction temperature. A sensitive galvanometer in circuit made it possible to hold the temperature to a precision of 4 or 5 deg. F. The base

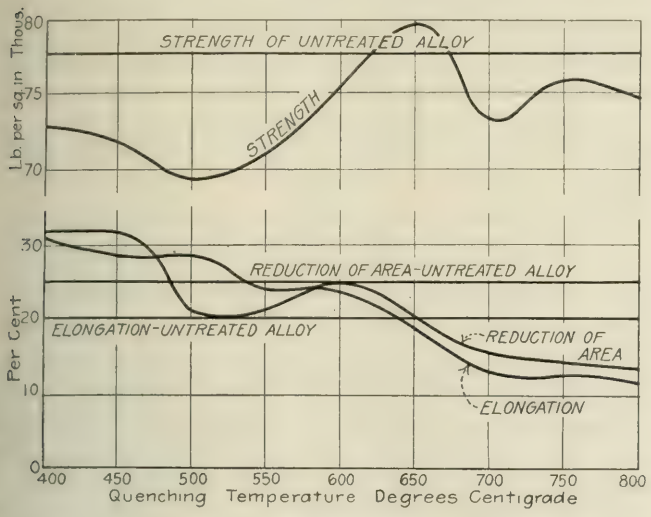


FIG. 3. PHYSICAL PROPERTIES OF QUENCHED SPECIMENS, ALLOY AA

metal couple used was first carefully calibrated against a standard platinum-platinum rhodium couple throughout the whole range of temperatures, and found to be accurate within the limits of precision required.

Effect of Time at 800 Deg. C.

A series of heat treatments were run on alloy AA to determine the effects on the physical properties and microstructure when varying the length of heating at 800 deg. C., followed by quenching. The main object

TABLE III. EFFECT OF TIME AT 800 DEG. C. ON ALLOY AA

Specimen	Hours at 800 Deg. C.	Ultimate Strength	Elongation	Reduction	Hardness — Brinell	Hardness — Scleroscope
AA1 pp	0	77,830	20.0	25.4	137	8
AA2 and 3	1	74,595	11.3	13.3	120	8
AA4 and 5	3	74,170	10.0	11.8	125	8
AA6 and 7	5	73,480	10.0	12.0	119	8

in this test was to determine if possible the length of time required at this temperature to convert the alloy into the beta state.

Three runs were made, check specimens being used in each case. About an hour was taken to reach the maximum temperature of 800 deg. C. When this temperature had been reached the furnace was held constant for 1 hr. in the first test and for 3 and 5 hr. respectively in each of the others, then the specimens were quenched in cold water, turned up into tensile pieces and broken in the Riehle machine. Table III shows the results obtained. Tensile strength falls off rapidly as the time of heating at this temperature is increased, due to two causes. At first it is due to the elimination of the effects of cold work which are present in the initial material; continual fall in strength is due to the rapid grain growth proceeding at high temperature, illustrated by microphotograph 14. A study of this and other photographs revealed that the brass was all in the beta state at the end of 3 hr. of heating. Some alpha crystals remained after the 1-hr. heating, and as a result of this study it was decided to conduct future heat treatments of 2 hr. duration.

It is customary in a study of metals to expect an increase in the ductility as the tensile strength falls off. This does not hold true here, as a very marked reduction in both the reduction of area and the per cent elongation took place as the time of heating at the high temperature was increased. The reason for this apparently lies in the very pronounced grain growth which took place.

Alloy AA was selected for these tests because it lies more nearly in the beta field of the copper-zinc equilibrium diagram shown in Fig. 2. The two alloys used in these experiments are shown on the diagram by the two vertical dash-dot lines. Alloy A lies largely in the $\alpha + \beta$ field and only enters the pure beta structure at high temperatures. The lead present in these alloys is added to better the machining qualities and as it forms only a mechanical mixture with the brass (note black spots in Fig. 13) does not affect the position of the alloy in the diagram. Tin forms a solid solution and for this reason it cannot be detected in the micrographs, while the percentage present is too small to affect the structure appreciably.

It will be interesting perhaps to stop a moment and study this equilibrium diagram. The α region com-

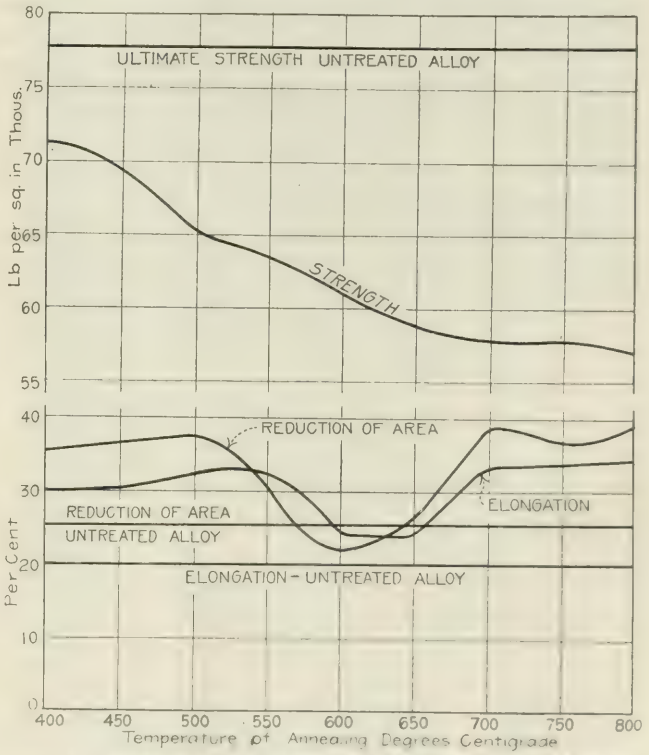


FIG. 4. PHYSICAL PROPERTIES OF FURNACE-COOLED SPECIMENS, ALLOY AA

prises a large portion to the left which represents a high percentage of copper. Alpha brass is soft and ductile—a composition of 70 per cent Cu with 30 per cent Zn is the one most commonly used in the arts. Heat treatment could not be expected to affect such a composition to a great extent because of the single structure extending to the liquid line; grain size would be the only thing changed. As the percentage of zinc increases the alloy becomes harder and the structure more

complicated. Alloys with zinc above 50 per cent are of but little use due to their extreme brittleness and low strength.

By referring to the equilibrium diagram it will be observed that alloy AA falls slightly to the left of the eutectoid point b_2 but still well within the beta region when heated above 600 deg. C. When at equilibrium at room temperature this material should consist of pure alpha crystals imbedded in a eutectoid matrix (alpha plus gamma complex). When heated to 470 deg. C. we should have a mixture of α plus β present and when heated still higher the whole field should consist of the beta structure. This last conclusion was found to be true when the specimens were heated to 800 deg. C. and quenched. This ideal condition does not always exist, as the time element enters in and may greatly affect the structure. Cooling needs to be very slow and heating carried out for some time in order to have these changes complete.

Quenching Alloy AA

It was desirable to find the physical properties of the various constituents throughout the various fields. Specimens were held for 2 hr. at various temperatures starting at 400 deg. C. and varying by 50 deg. increments up to 800 deg. C. At the end of this time the specimens were quickly withdrawn from the furnace and quenched in cold water. Check specimens were used in each case and the heat applied slowly, usually at the rate of 60 to 80 deg. rise every 5 min. It was not deemed advisable to carry the heat treatments above 800 because of the coarse structure formed and the danger of meeting the liquidus, which might well be lowered for this alloy by the tin content. Half an inch was cut from the end of each specimen for a microscopic study. Results obtained from the physical tests are given in curve form in Fig. 3.

This curve is of special interest because it shows how the strength of the alloy varies throughout the range of treatment. The strength drops off at low

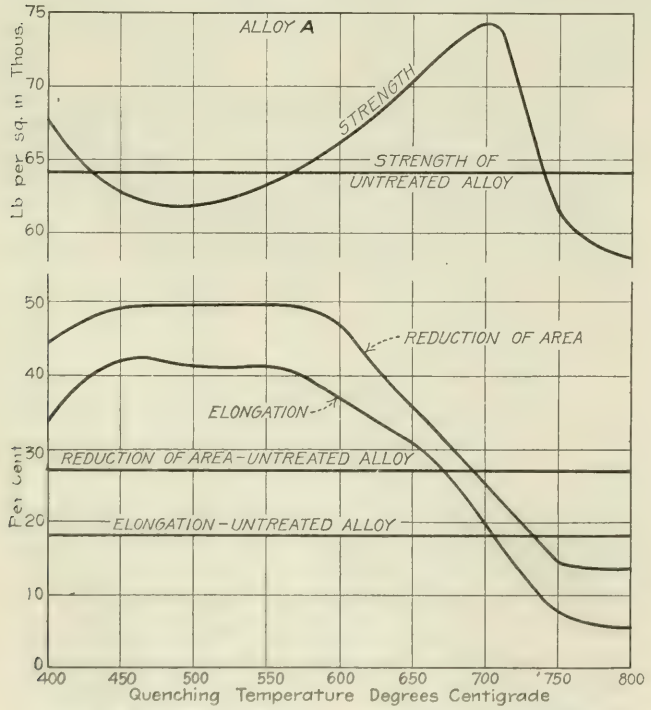


FIG. 5. PHYSICAL PROPERTIES OF QUENCHED SPECIMENS, ALLOY A

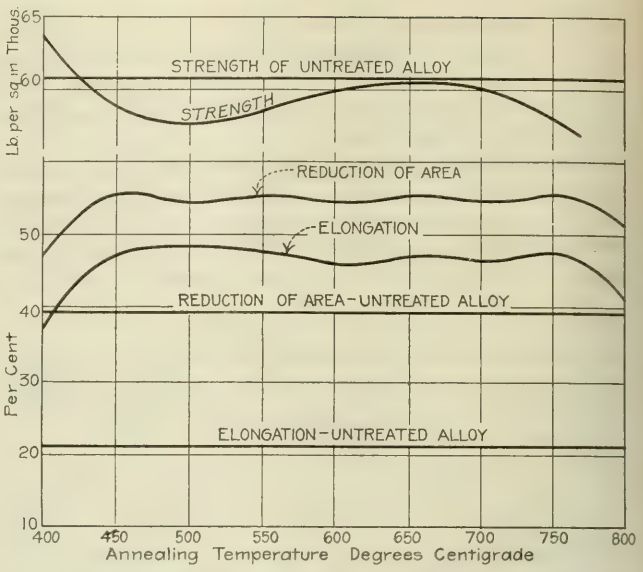


FIG. 6. PHYSICAL PROPERTIES OF ANNEALED SPECIMENS, ALLOY A

temperature anneal, which shows internal strains in the original rolled material. Above 500 deg. C. the strength curve rapidly rises, reaching a maximum when the alloy is heated for 2 hr. at a temperature of 650 deg. C. By referring to the equilibrium diagram, Fig. 2, it will be observed that this is about the transition range from the alpha plus beta into the pure beta field. The drop in the strength curve above 650 deg. may be accounted for in the large grain growth which takes place at these high temperatures. This is brought out by comparing microphotographs Figs. 10 and 14.

The two curves shown in Fig. 3 representing the reduction of area and the per cent elongation will give a good idea of the variation in ductility of the metal under these treatments. They show that at the lower temperatures the ductility is somewhat increased by the relieving of the internal strains. The general tendency of the curves is downward, however, showing a decrease of ductility as the temperature of quenching increases.

From the results of these tests it is possible to pick out the best heat treatment for a given result. If maximum strength together with high ductility is required, the curves show us that heating for two hours at a temperature of 600 to 650 deg. C. will give the best results.

The effects of this treatment on the hardness of the metal is also of interest. In these tests the Brinell hardness increased from 124 to 144 as the temperature of quenching increased. The Brinell method is open to some criticism in the measurement of these soft alloys, as the metal will flow under the load. For this reason the time which the load is allowed to remain on the specimen is very important. The longer the time the lower the hardness, time being a factor which obviously should not affect the hardness.

Alloy AA When Slowly Cooled

A series of treatments subjecting alloy AA to very slow cooling after having been held at the various temperatures for 2 hr. were carried out, 50 deg. increments being taken as before in the range from 400 to 800 deg. C. The specimens were heated at the rate of 70 deg. C. per 5 minutes.

After holding the specimen at a constant temperature

for 2 hr. the current was entirely shut off and the closed furnace allowed to cool slowly. The rate of this cooling is given in Table IV, over 8 hr. being required for the furnace to cool from 800 deg. C. to room temperature. Check specimens were used in each case and a micro specimen prepared for each treatment. The results obtained from the physical tests of these heat-treated specimens are plotted in Fig. 4.

The tensile strength curve shows that slow cooling without mechanical work on the metal seems to greatly weaken it. This may be due to grain growth, which is free to take place under such conditions. The micrographs of this metal are shown in Figs. 11, 12, and 13.

TABLE IV. COOLING CURVE OF CLOSED TUBE FURNACE

Time, Hr.	Temp., Deg. F.	Time, Hr.	Temp., Deg. F.
0	1470	2	560
½	1010	3	390
1	820	4	280
1½	680	5	210

Even though the alloy is in the beta condition at high temperature (Fig. 14) large alpha crystals separate out during the slow cooling. The ductility curves show a marked similarity throughout the whole range. Comparing the strength curve, one might expect to find an increase of ductility as the annealing temperature increased. This is not the case, however, because it increases at first, then drops rather sharply and finally rises very noticeably at the end of the range; the maximum point at the higher temperature is, in fact, higher than at the beginning. It is interesting to note that the strength is lowered considerably below that obtained from the other treatments thus far carried out and that this treatment increases the elongation and the reduction of area to a very marked amount. Where strength is not of vital importance this treatment will produce an alloy which will resist shock in an excellent manner. Heating to 500 deg. C. and slowly cooling will relieve the strains due to drawing and will give a material of high ductility and good strength.

Comparison Between Quenching and Slow Cooling

It may be of interest here to compare the results obtained from these two radically different heat treatments. At a temperature of 650 deg. C. the strength differs by more than 20,000 lb. per sq.in. under these two treatments. Under quenching the general trend of the strength curve is to rise, while under annealing the trend is definitely downward. By means of the two charts one may obtain almost any strength desired within the range of the metal. The ductility curves are very irregular, but in general the ductility of the annealed material is higher than expected. Quenched material has low ductility at the high temperatures.

It may be concluded as a general deduction from these experiments that the quenching treatment produced a high strength-low ductility material and that the annealing treatments produced high ductility with relatively low strength.

Several of the specimens broke in the prick punch marks and in the threads. The material seemed very brittle and caused considerable trouble in this way, often breaking without warning and with a sharp report. Strangely enough this trouble seemed most evident in the slowly cooled specimens.

Sections of the treated specimens were carefully filed and polished before the hardness was taken. A dead load of 500 kg. was used with a ball of 10 mm. diameter. The load was permitted to remain on the specimen exactly 30 seconds, since it was soon discovered that the time factor was very important. The hardness of these alloys does not seem to be affected by heat treatment; the small variations noted are due to unavoidable errors.

Heat Treatment of Alloy A

Alloy A, containing 60.53 per cent copper, 38.67 per cent zinc, 0.75 per cent tin and no lead, was treated exactly the same as has been described for alloy AA.

Alloy A Quenched

Fig. 5 gives the results of the physical tests on the quenched specimens. The strength of the alloy is increased by this quenching treatment, especially at the higher temperatures. The initial strength of the bar as received, it should be remembered, is considerably below that of alloy AA. Note the rapid falling off in the strength when heated and quenched above 700 deg. C., this again being due to grain growth. Pure beta brass is not obtained with this material, high strength being obtained by fixing the structure in the alpha plus beta region.

Fig. 5 also gives ductility curves. These are of special interest because of the way the high ductility holds

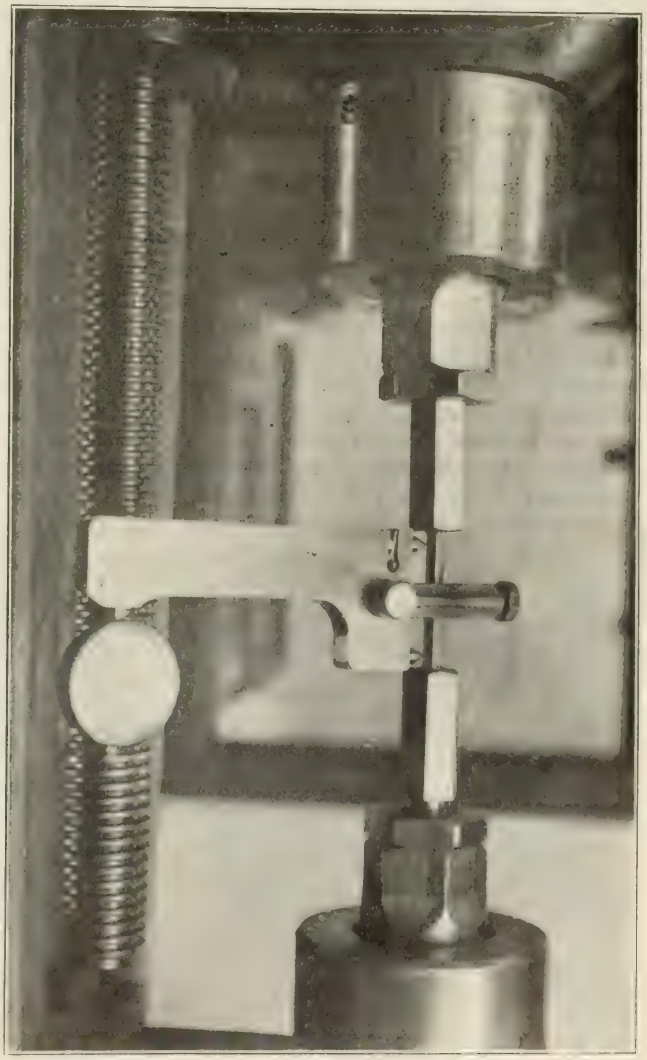


FIG. 7. TEST PIECE MOUNTED, WITH EXTENSOMETER ATTACHED

even at high quenching temperatures. Note that the reduction of area actually reaches 50 per cent and remains there up to a quenching temperature of 550 deg. C. The strength is correspondingly low in these ranges. The two ductility curves are strikingly parallel, and it is worthy of note that the ductility stays above that of the untreated alloy, which is shown in both cases by the horizontal line, until a quenching temperature of nearly 700 deg. C. has been reached. From these curves the best treatment to produce and desired combination of strength and ductility may be procured.

TABLE V. HARDNESS OF ALLOY A AFTER QUENCHING

Quenching Temperature	Brinell Hardness	Quenching Temperature	Brinell Hardnes
400	94	650	96
450	94	700	102
500	92	750	114
550	89	800	119
600	92		

The hardness number under the Brinell test showed a general tendency to increase as the temperature of quenching increased. The scleroscope hardness on the other hand showed no appreciable change. These data are given in Table V.

Alloy A Slowly Cooled

The same slow cooling treatment was applied to this alloy as that described above for alloy AA, the closed electric tube furnace was used as before and the rate of cooling was exactly the same. The curves given in Fig. 6 show the tests graphically. Decrease in strength due to this annealing treatment is very evident. The whole curve is below the line for untreated rod. There is a range between 600 and 700 deg. C. as before where the strength rises, but the total variation in strength due to annealing is not very great.

The ductility curves are very striking. Note the enormous increase in both elongation and reduction in area. The former is greater than the latter. These curves are quite parallel and show that the ductility holds up even at high temperatures. It will at once be apparent that fairly high strength and very high ductility can be obtained in one material and one rod. Take such a treatment for example as heating for 2 hr. at a temperature of 650 deg. C. and then slowly cooling. This treatment has not affected the strength, but the ductility has been increased from 21 per cent elongation to about 47 per cent, representing a 100 per cent increase. If a slightly lower strength is just as satisfactory, this high temperature need not be employed, since the curves show about the same ductility for an annealing temperature of 450 deg C.

Microscopic study showed that the original structure shown in Fig. 9 was somewhat recrystallized after an annealing at 500 deg. C., the crystals losing their parallel orientation and disintegrating somewhat. Annealing at 650 increased this tendency, the alpha crystals being materially spheroidized. Fig. 15 shows the structure

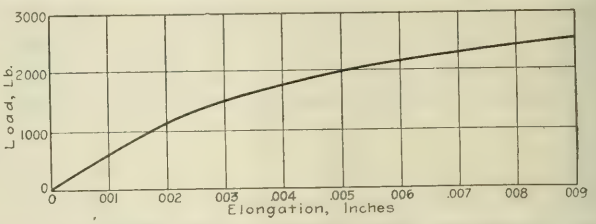


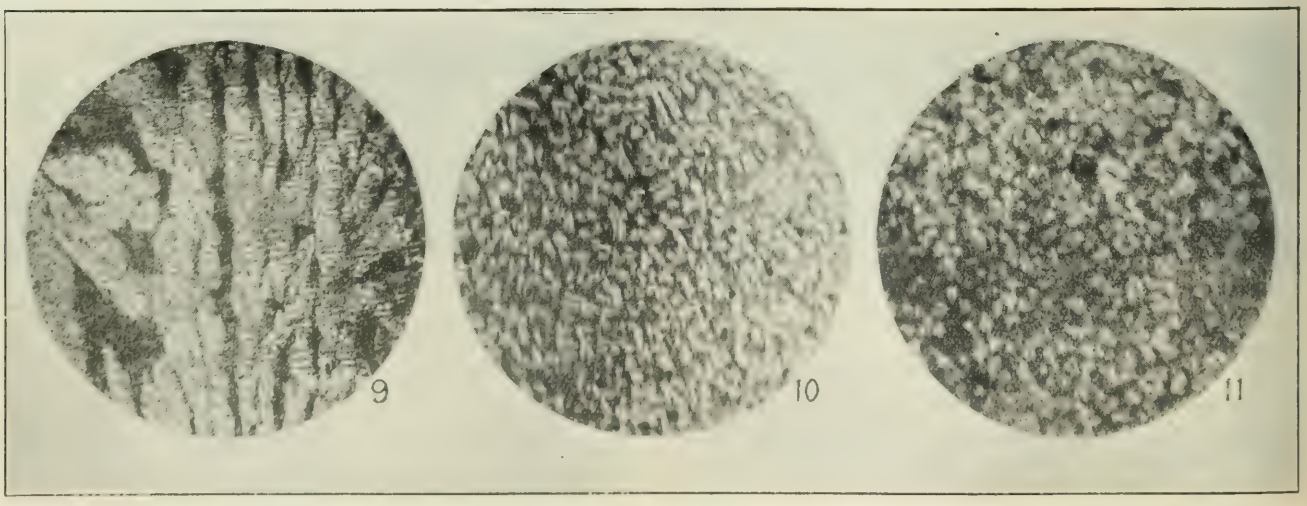
FIG. 8. STRESS-STRAIN CURVE FOR SPECIMEN A29

on annealing at 800 deg. C. Evidently the whole metal reverted to large crystals of solid solution, which decomposed to a certain extent on slow cooling.

Comparison Between Quenching and Slow Cooling

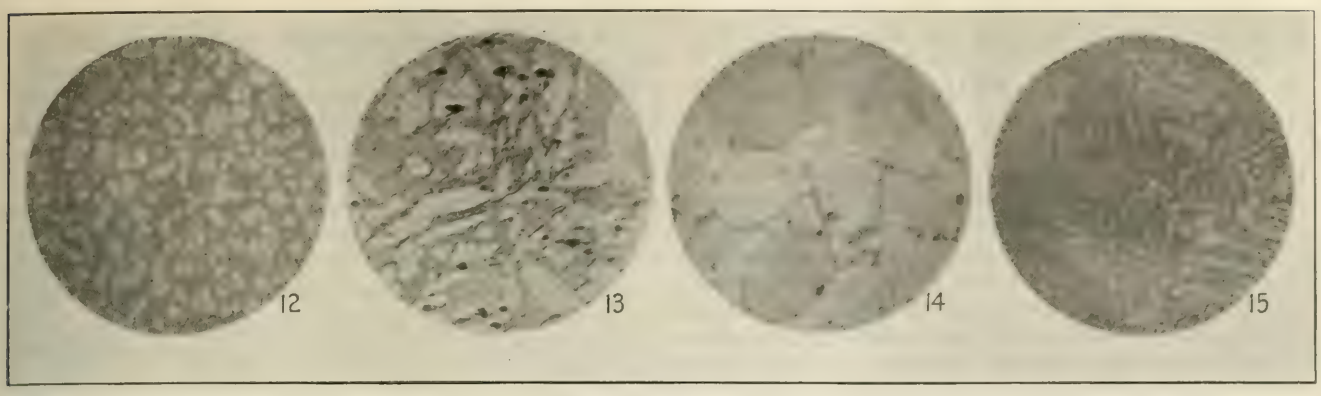
When comparing annealed with quenched specimens the differing values of the untreated samples must be considered. The specimens used for the quenching tests were of higher strength and lower ductility than those used for the slowly cooled treatments. For this reason the difference shown by the two curves must be properly discounted. It will be recalled that all these specimens were cut from the same run of metal and not far removed from each other as the metal came through the die.

Reduction of area falls off above 600 deg. C. when the alloy is quenched, but this property is maintained at a high value by slow cooling. Even at 800 deg. C. the ductility had not appreciably diminished. It is also interesting to note that the ductility is nearly as high with the quenched specimens up to a temperature of 550 deg. C. as it is with the annealed alloy. This is significant, as it shows that no appreciable change has taken place in the structure due to the heating up to this point. This is probably due to the change from the alpha plus gamma, which is present at ordinary temperatures, to the alpha plus beta, stable at that tempera-



FIGS. 9 TO 11

Fig. 9—A2p, untreated; × 100. Fig. 10—AA2p, untreated; × 100. Fig. 11—AA30, furnace cooled after 2 hr. at 500 deg. C.



FIGS. 12 TO 15

Fig. 12—AA34, furnace cooled after 2 hr. at 600 deg. C.; × 75. Fig. 13—AA42, furnace cooled after 2 hr. at 800 deg. C.; × 75.
Fig. 14—AA24, water quenched after 2 hr. at 800 deg. C.; × 75. Fig. 15—A17, furnace cooled after 2 hr. at 800 deg. C.; × 75.

ture, taking place at low velocity. If the alloy were heated for an extended time at say 500 deg. C. it is probable that the quenching would produce a smaller ductility, as more of the structure would be transformed.

Stress-Strain Curves

Two specimens marked A20 and A29 were selected for extensometer tests. A sensitive instrument shown in Fig. 7 was used, with which 0.0002 in. could be read. Loading was carefully applied by hand. For the range considered the reduction of area was so small that the stress was considered as being applied on the original area. The strain, or elongation in inches per inch, is plotted on Fig. 8 for specimen A29.

As before, the elastic limit is well marked at about 1,100 lb. load. When transferred into standard units we have the true elastic limit, at 12,000 lb. per sq.in. (Length of specimen 2 in., initial area 0.0913 sq.in.)

When these values are substituted in the formula we have

$$E = \frac{12{,}000}{0.00095} = 12{,}630{,}000$$

Specimen A20 gave an elastic limit of 11,000 lb. per sq.in. and a modulus of 16,900,000.

Evidently considerable variation occurred in the modulus of elasticity as determined from the tests of these two specimens. This variation was due almost entirely to the greater strain occurring in A29, the elastic limit occurred at about the same point in both specimens. It would appear from these limited tests that 12,000 lb. per sq.in. is about right for the elastic limit, a very low value, but such is to be expected in copper-zinc alloys. The elastic limit appears to be about 20 per cent of the ultimate tensile strength. No yield point, or so-called commercial elastic limit, could be detected in any of the specimens tested. If there were a yield point it was too small to affect the beam.

Microstudy

In order to supplement the data and information obtained from the physical study and tests outlined above for these various heat treatments a number of microphotographs were taken. In each case an attempt was made to study the structure at those points where the physical properties, as shown by the accompanying curves, abruptly changed.

Polishing

Fine floated rouge on broadcloth would not give the desired results, and a surface free from fine scratches was finally obtained by using very finely powdered alumina with water on the polishing wheel. Even with this abrasive a large amount of work was necessary to produce a satisfactory surface for etching.

Etching

Numerous acid and basic reagents may be used depending upon the structure which it is desired to bring out and the constituent which it is desired to have attacked. The etching reagent used on these specimens was chromic acid (H_2CrO_4) crystals dissolved in water. This attacks beta constituent more rapidly than alpha; the latter appears white in the photographs. The acid solution was rubbed on the polished surface of the specimen with the finger to insure good contact and allowed to remain for about 30 seconds. In case this treatment did not bring out the structure the above operation was repeated until a sharp outline of the structure appeared under the microscope.

Production of Gold and Silver in the United States in 1919

The Bureau of the Mint and the Geological Survey have issued the following preliminary estimate of the production of gold and silver in the United States during the calendar year 1919:

State or Territory	Gold		Silver	
	Fine Oz.	Value	Fine Oz.	Value*
Alaska	437,131	$9,036,300	1,072,137	$1,201,705
Arizona	202,038	4,176,500	4,296,769	4,816,033
California	840,758	17,380,000	1,204,004	1,349,508
Colorado	470,998	9,736,400	6,044,911	6,775,438
Georgia	48	1,000	10	11
Idaho	34,365	710,400	6,042,01[illegible]	6,772,194
Illinois	.....	...	2,39[illegible]	2,682
Maine	5	100	4,142	4,643
Michigan	.....	...	375,284	420,637
Missouri	5	100	59,460	66,646
Montana	119,085	2,461,700	14,940,527	16,746,090
Nevada	230,004	4,754,600	7,312,454	8,196,164
New Hampshire	.....	...	659	739
New Mexico	28,817	595,700	712,791	798,932
North Carolina	48	1,000	49	55
Oregon	51,848	1,071,800	223,578	250,597
Philippine Islands	39,962	826,100	14,392	16,131
Pennsylvania	.....	...	78	87
South Carolina	5	100	4	4
South Dakota	254,820	5,267,600	122,164	136,928
Tennessee	256	5,300	93,087	104,337
Texas	53	1,100	540,239	605,527
Utah	104,137	2,152,799	11,936,152	13,345,010
Vermont	10	200	1,819	2,039
Virginia	.....	...	8	9
Washington	14,987	309,830	316,028	354,220
Wyoming	15	300	41	46
	2,829,395	$58,488,800	55,285,196	$61,965,412

* Value at the average New York price of fine silver, $1.12085 per oz.

These figures, compared with those for 1918, show a reduction in the output of gold of $10,157,900 and in that of silver of 12,524,943 oz.; compared with those for 1917 they show a reduction of $25,261,900, and in silver of 16,455,166 oz.

Lessons for Chemical Engineers in Other Industries*

By A. E. Marshall

WAR-TIME demand for the products of the chemical industry has of necessity resulted in improvements in chemical engineering practice during the last three years. Inability of the factories in existence at the outbreak of the war to cope with war requirements was responsible for the erection, in this country and in England, of plants designed to produce large tonnage outputs of specific finished materials. As the desired capacity was known in advance and as the product was definite, the designers of these plants had opportunities in arrangement of units which are lacking to a certain extent in the design of factories which have an indefinite future capacity and which will have to be extended later to take care of new products and byproducts.

Yet an inspection of a number of the war-time American factories, and six weeks spent in the English factories during the early summer of this year, have resulted in a conclusion that full advantage was not taken of routing of operations and of labor-saving devices which in other industries had reached advanced states of development. The imperative need for production and the necessity of adapting equipment available during the building of the plants have to be taken into account, and a full knowledge of the difficulties in securing prompt supplies of adequate machinery would doubtless modify in some measure conclusions based only on a study of the completed plants. Even with such allowance, a survey of the latest developments of chemical engineering leaves a sufficient reason for the suggestion that the chemical engineer should broaden his lines of study from the limited one of the purely chemical field to the wider viewpoint of engineering work and operation in other industries which present problems analagous to the manufacture of chemicals. A chemical engineer, or a chemical plant executive, is prone to believe that his manufacturing problems are peculiar not only to the chemical industry but even to his specific branch of the industry, whereas other industries have had similar problems and have reached solutions.

Chemical Plants Built Wrong

In the past, the average chemical plant has started out as a producer of one or of several standard chemical products, and with the development of the business, new but usually inter-related products have been added to the factory output. Invariably the original design was a complete unit, so that even an increase in the output of the original products necessitated the addition of separate complete units without the possibility of effecting economies through the use of labor-saving devices applicable only to tonnage movements. When extensions through the multiplication of products became necessary, the situation was much worse, as the new additions had to be located externally to the original plant unit, and the conveyance of materials produced in the original plant to the new units in which they were to be utilized was necessarily reduced to primitive forms of transportation. There are few industries today other than chemical manufacture which present the anachronism of manual handling the semi-finished product of one operation to its final point of utilization.

A generalization of this nature must of course be qualified by exceptions in the case of plants designed to produce large tonnages of the low-priced chemical staples, or as they are more generally termed, "heavy chemicals." Such factories invariably have labor-saving tonnage movement devices, although they are not always in the forward state of development of the means used in other industries. This difference in chemical factories is clearly evident in comparing the facilities for moving raw and finished materials in, say, a large-tonnage ammonia-soda plant, and a plant producing six or eight products by stages. The soda plant will move its materials progressively with mechanisms which require the smallest amount of human labor, whereas the average several-product factory makes each separate movement discontinuous. Between the various inter-related units of a several-product chemical factory there is frequently a bottle-neck of transportation of materials.

Examples in the South

The South furnishes through its fertilizer industry excellent examples of discontinuous work. A fertilizer plant can be as well ordered in its progressive stages of manufacture as an automobile plant, but the majority of the fertilizer factories move their entire material in process at least once and sometimes twice by hand labor in buggies. Labor in the South was once cheap. These conditions have changed with apparently no chance of return, and so the fertilizer manufacturer, and the chemical engineer specializing in fertilizer plant design, will be forced to build new plants in which economies in labor are possible. This brings up the point of original design of chemical plants and the necessity of designing with an eye to the future.

Suggestions From Other Fields

Some chemical plants built within the last five years will find it difficult to make extensions which permit of a lowered cost of production or even a cost equal to the original plant, for reasons such as lack of strength in the building structure preventing the employment of monorail cranes or similar mechanism to convey supplies of raw materials from the original storage bins or piles to the new extensions. Time can more profitably be spent in designing the present to suit the future than in trying to add in the future to a completed unit which has no outlets for expansion.

The statement made in the early part of this paper that other industries can furnish useful ideas to the designer and the operator of chemical plants is intended as a suggestion. To cover in detail the comparisons which present themselves would require several papers, so that an attempt will be made to simply draw attention to some developments in other industries which are just finding their way into the chemical field or which are still awaiting proper recognition.

As a preliminary, there are some useful guide posts on the road along which the industry has passed. Take the Chemical Catalog, which is issued under the auspices of this Institute, and compare the mechanical and labor-saving devices shown in the first volume (1916) with the much greater variety in the present (1919) volume. The manufacturers are not listing plant equipment in 1919 that was not in existence in 1916, but rather they are listing equipment which in 1916 was used only in other industries. Compare also the advertising pages of the chemical journals, say, from 1912 to the present time, and note the introduction into chemical

*Read at the Savannah meeting of the American Institute of Chemical Engineers, December, 1919.

advertising, of filters which had found extensive use in the metallurgical field, of grinding machinery primarily developed for metallurgical plants and cement mills, belt conveyors, monorail cranes, grab buckets and other mechanical devices for handling materials which were introduced into chemical manufacturing processes after they had become standardized in other industries. And today other industries have in use types of equipment which would solve many of the problems we consider solely as chemical engineering problems.

Moving Materials

First, there is the matter of moving materials through the cycle of the plant operation. The movement, at the lowest possible cost, of large tonnages of raw and finished materials has assumed great importance in industries where there is close price competition. The progress of chemical manufacture with the consequent increase in size of chemical plants will make this feature of plant design of vital interest to the owners of these plants. Waterfront factories bringing in their raw material by steamer will be forced to adopt unloading methods equivalent to those used in the iron and steel industry. Factories in the interior will have to be arranged so that railroad cars can be placed directly at the discharging or loading points so that double handling of materials is avoided. The linkage of materials, moving from one part of the plant to another, and referred to in the earlier part of this paper, will have to be changed from manual to mechanical means, and the plant units so arranged that the intervals to be bridged in the movement occupy the shortest possible distance while still permitting the future growth of the units.

All of these improvements in handling have become part of the routine design of other industries, and the chemical engineer, by extending his observation outside of the chemical field, can usually find an operation with characteristics similar to the project he is interested in, which has developed handling facilities adaptable by him.

Central Station Power Plant

In the case of the chemical engineer concerned in the layout of a furnacing operation, a study of a modern central station power plant will suggest improvements over existing chemical practice. There are many chemical plants which use as much coal under furnaces each day as a large power plant does under its boilers. The power plant is in the business of utilizing coal for profit, so it has, in the movement of coal, displaced manual labor by mechanical methods. The power plant unloads its coal into storage with grab buckets operated from gantry or overhead cranes, and has developed other forms of mechanical equipment to convey the coal from storage to the boiler room and to the individual mechanical stokers. The ash from the boilers is gathered either by drag conveyors, pressure or suction devices and is delivered to hoppers which discharge direct into cars or ash scows. The arrangement of the average chemical plant carrying on furnacing operations effectually prevents the use of a complete scheme of mechanically handling coal and ashes, as the furnaces have grown, Topsy-like, in various parts of the factory, and even the coal storage must usually be placed remote from the furnaces.

The control of combustion, which is essentially a chemical problem, has progressed to a greater extent in power plants than in chemical factories, and it is the unusual chemical factory which has its furnaces equipped with CO_2 recorders, pyrometers, and draft-gages.

Further suggestions along these same lines are afforded by the study of flow sheets of metallurgical works. The flow sheet of a modern smelter with its allied leaching and flotation plants represents a development in low cost movement far ahead of the average large chemical plant, although the equipment used in the smelter is in many instances equally serviceable in chemical factories. Leaching by counter-current decantation in its present efficient state is a development due to metallurgical engineers who were faced with the problem of economically treating low-grade ores. The same apparatus will serve the chemical manufacturer for the production of solutions or an insoluble precipitate through the interaction of a solid and a solvent or solution. Various types of classifiers have made closed circuit grinding a possibility, and the chemical manufacturer can adopt from the metallurgist a method of operation which gives a continuous finely ground product without a distinct intermediate separation.

Brief mention has already been made of filters used in metallurgical work and of their adoption in chemical processes. The continuous removal of a solid product from a waste liquid or the continuous separation of a solution from a waste solid in suspension means a great reduction in cost as compared to the use of intermittent plate and frame presses.

Use of Gas Washers

The various processes of illuminating gas manufacture afford useful study, and some interesting developments should result from the adoption by the chemical industry of gas washers of the Feld type. Feld washers have provided the gas engineer with a compact mechanism which gives an intimate contact between the gas and an absorbing or scrubbing liquid, while the arrangement of the washer permits the liquid to reach a high concentration in solid particles without danger of stoppage. A cast iron washer of this type would, as an example, remove chlorine, using caustic soda solution as the liquid, from the exit of a chlorinating operation, and going for the moment outside the strictly chemical field, it might serve in an absorption method of recovering gasoline from natural gas, in place of the present expensive compressor plants. Made of acid-proof materials, and somewhat modified in arrangement, this same type of washer might be used to replace one of the unsatisfactory details in a sulphuric acid chamber plant —the Gay-Lussac tower.

Adaptability of Grain Unloaders

As an illustration of the satisfactory use of mechanisms developed in other industries, an instance at the factory with which the writer is connected may be cited. One portion of the plant operation depends on the continuous supply of large tonnages of raw material. Prior to 1918 this raw material had always been delivered at the plant in steamers—and a complete scheme of mechanical unloading had been installed and had given excellent results. The shipping strike and the shortage of steamers in 1918 made it necessary to change over from steamer to box car conveyance, and as the raw material was used at the rate of 600 tons a day it meant either excessive hand labor in unloading the cars or the adoption of some mechanical unloading device. A review of practice in the chemical industry did not afford any suggestions, neither did the usual engineering catalogues or trade publications refer to a machine which would solve the problem. Consideration of materials that were

moved in tonnages in box cars led to an investigation of the grain trade, and it was found that grain elevators had been using a mechanical box car unloading device for at least ten years and that this device could be adopted without change to our conditions.

Grain unloaders were installed, and the congestion of plant facilities which would have occurred under hand unloading conditions were avoided, and, most important of all, the cost of putting the material into the plant was kept down to a reasonable figure.

Conclusion

The examples which have been selected do not exhaust the possibilities of comparison, but they will serve the writer's purpose if they are accepted as evidence in support of the conclusions that the chemical engineer can study, to his advantage, engineering progress in other lines of industry.

Crucible Graphite

GRAPHITE for making crucibles should be of the crystalline variety and should have a high degree of purity, according to *Mineral Resources*, 1918, Part II. Most makers of crucibles prefer to use Ceylon graphite either alone or mixed with varying proportions of American flake, usually not exceeding 25 per cent of the mixture. The reason for this preference is in part because the more nearly cubical fragments of Ceylon graphite have a much smaller surface area in proportion to their volume than the thin flakes of domestic graphite and hence require proportionately less clay as a binder. Ceylon graphite is also said to be more nearly free from undesirable impurities, such as mica and pyrite. It is possible, however, to use domestic flake graphite alone with good success in crucible manufacture.

Specifications as to graphite for use in crucibles vary widely. Dub[1] suggests the following specifications for American graphite for use in crucibles:

"It is recommended that the graphitic carbon contents of No. 1 flake be not less than 85 per cent. By graphitic carbon is tentatively meant the carbon remaining after the dried sample has been burned for 3 min. at 800 deg. C."

The following tentative specifications as to screen analysis for No. 1 flake are recommended:

	Per Cent
Over 35 standard mesh	3
Over 65 standard mesh	50
Over 100 standard mesh	100

The following analyses show the present practice:

CUMULATIVE PERCENTAGES OF GRAPHITE FOR USE IN CRUCIBLES

American No. 1 Flake[1]

	1	2	3	4	5	6	7	8
Over 20-mesh	...	...	...	0.1	...	0.1	...	...
Over 35-mesh	0.1	2.5	3.3	15.4	5.7	6.7	9.7	8.2
Over 65-mesh	42.0	28.0	31.0	69.6	58.5	56.4	62.2	69.6
Over 100-mesh	94.8	60.0	74.3	95.6	93.0	97.0	92.4	99.7
Under 100-mesh	5.2	40.0	25.7	4.4	7.0	3.0	7.8	0.3
Graphitic carbon	82.02	92.09	74.67	...	86.18	86.30	...	92.43

American No. 2 Flake[1]

	1	2	3
Over 20-mesh	...	...	...
Over 35-mesh	...	0.2	0.1
Over 65-mesh	...	9.9	0.3
Over 100-mesh	10.5	67.6	22.2
Under 100-mesh	89.5	32.4	77.8
Graphitic carbon	80.44	81.43	86.30

Canadian No. 1 Flake[2]

(Average of product from 7 mills)	
Over 20-mesh	1.76
Over 40-mesh	20.32
Over 60-mesh	87.32
Over 80-mesh	95.38
Over 100-mesh	96.48
Under 100-mesh	2.98

[1]Dub, George D., "Preparation of Crucible Graphite." Bureau of Mines War Min. Inv. Ser. 3, pp. 20-21, December, 1918.

[2]Spence, H. S., "Canadian Graphite Industry," Mines Branch Summary Report for 1917, p. 50, 1918.

It has been found in practice that although flake carrying 85 per cent of graphitic carbon can be readily produced, the cost of a product containing 90 per cent of graphitic carbon is very greatly increased. This is owing to the fact that small quantities of quartz, mica and other impurities are interbedded in the graphite flakes themselves, and the flake must be broken to remove them. Seemingly pure graphite flakes were on analysis found to contain only slightly more than 90 per cent of carbon.[3] A sample of Ceylon graphite prepared for crucible use contained 85.06 per cent of graphitic carbon.[2] In purity, therefore, the American graphite compares favorably with that from Ceylon. The question of the relative value of American and Ceylon graphite for use in crucibles is now being investigated by the Bureau of Mines.

Use of Graphite for Crucibles Decreasing

The graphite consumed yearly for crucibles in this country for 1916 and 1917 amounted to about 24,000 tons. It is probable that more than 90 per cent of the graphite used was of foreign origin. During 1918 the graphite consumed for crucibles was probably not more than 20,000 tons. This decrease was due in part to the increased use of electric steel furnaces and open-flame brass furnaces, in part to the export on war orders of raw materials rather than manufactured finished products, and in part also to the fact that a better quality of crucible was made, thus reducing the quantity of crucible graphite used. The normal peace-time requirements of crucible graphite, as measured by the apparent consumption for the years 1911 to 1913, probably do not exceed 13,000 tons a year. It is probable that the further demand for crucibles will diminish rather than increase.

Rapid Increase in the Manufacture of Electric Furnace Steel

The following table shows a rapid increase in the manufacture of electric furnace steel, while the production of crucible steel has remained stationary.

STEEL INGOTS AND CASTINGS PRODUCED IN THE UNITED STATES, 1908–1917, BY PROCESSES, IN GROSS TONS[4]

	Crucible	Electric		Crucible	Electric
1908	63,631	...	1913	121,226	30,180
1909	107,355	13,762	1914	89,869	24,009
1910	122,303	52,141	1915	113,782	69,412
1911	97,653	29,105	1916	129,692	168,918
1912	121,517	18,309	1917	126,716	304,543

It is believed that with the return to normal conditions this difference will be further accentuated. Recent developments in the electric furnace as applied to non-ferrous alloys also give promise of a decrease in the use of crucibles. It is even stated that the time is ripe for the practical elimination of the crucible from the brass industry.[5] A rocking electric furnace designed in the Bureau of Mines showed costs of operation about one-half that of the coke-fired crucible furnaces used in the same plant.[6] It was found that the cost to melt cupro-nickel, the most refractory alloy handled at the mint, in an electric furnace was less than half that in the gas-fired crucible furnace.[7]

[3]Moses, F. G., "Refining Alabama Graphite for Crucible Use." Bureau Mines War Min. Inv. Ser. 8, p. 26, 1918.

[4]Am. Iron and Steel Inst.; Special statistical Bull. 4, 1918.

[5]Gillett, H. W., and Rhoads, A. E., "A Rocking Electric Blast Furnace." Met. & Chem. Eng., vol. 18, p. 583, June 1, 1918.

[6]Gillett, H. W., and Rhoads, A. E., "Melting Brass in a Rocking Electric Furnace." Bur. Mines. Bull. 171, 1918.

[7]Report of the Director of the Mint; abstract in *Eng. and Mining J.*, vol. 107, p. 323, Feb. 23, 1919.

The Technical Engineer's Judgment of the Oxy-Acetylene Process

By Alfred S. Kinsey*

THE commercial success of a mechanical process or device often may depend on two factors: Its utility as determined by the manufacturer, and its efficiency as judged by the technical engineer. No one knows better than does the owner of the metal-working plant or the superintendent of the repair shop how great the need has been for quicker and more thorough methods of manufacture and ways of making repairs, and few have looked forward with greater interest than has the mechanical engineer to the coming of safer and more efficient mechanical devices and processes. One has been the stimulus of the inventor, the other the surety of the manufacturing world.

The technical engineer's position in this progressive age requires no evalution, his critical scientific attitude no defense. His is the problem of casting beyond the superficiality to the durability of things, from the flimsy to the substantial. Unquestionably this has produced in the engineer a conservatism, a habit of close inquiry, which makes for safety and success. The manufacturing world therefore still seeks the judgment of such a mind, and the technical engineer's indorsement is often final. It may be of interest therefore to learn what he thinks of such a modern process as that of oxy-acetylene welding.

Forge Welding

Up to the advent of autogenous welding the engineer had only his experience with the forge weld upon which to base his calculations and judgment. In a way this proved somewhat unfortunate for the new method of welding, as the forge weld has nearly lost its value as a dependable means of joining metals. Imagine two pieces of steel being brought to a soft plastic condition in a forge fire charged with sulphur from the fuel, an excess of oxygen from the indifferently operated bellows or fan blower, the cinders and refuse of the fuel, and one can readily realize the cause of weak forge welds. Such welds never were reckoned to have a tensile efficiency of more than about 50 per cent, and many observations of welds which had failed showed crystallization and even entrapped cinders. Navy yards and many other large shops had practically abandoned the forge weld, preferring the expensive substitute of machining a job out of the solid when it was possible to do so. Serious failures of forge welds were too common. The author recalls many of these, and particularly one regarding which he assisted in a suit for damages where a hoisting hook on a city pier had parted at the weld, causing the death of the father of a family of small children. There was a demand for a safer and more efficient way to weld steel and wrought iron.

Then, too, in those earlier days the only metals which could be welded were wrought iron and steel. There was no way to weld cast iron and the non-ferrous metals like copper, brass, aluminum. The mechanical engineer, of all men, realized these limitations. He knew that the time was ripe for a new method of welding metals.

Then came autogenous welding and cutting by the oxy-hydrogen process, soon to be superseded by oxy-acetylene, thanks to the electric furnace's efficient method of producing calcium carbide and making acetylene a commercial possibility. From that time—practically only about fifteen years ago—metal workers, manufacturers, engineers, nearly the whole industrial world, have eagerly watched the progress of the oxy-acetylene process. The mechanical engineer recognized at once that there were certain fundamental principles involved in oxy-acetylene welding which were new to shop practice, such as:

Comparative Results of Forge and Oxy-Acetylene Welding

The autogenous welding was accomplished by fusion instead of plasticity. The old method required that the metal be heated merely to a soft pasty condition and then hammered or pressed together, while the new way was to melt the metal and flow the two ends into one mass. By the former method there could not be a thorough mingling of the grains of the metal, because it was only plastic, and besides there was every opportunity for such a weld to receive gas and fuel impurities from the forge fire. By the new process there could be nearly perfect rearrangement of the grains due to the liquid condition of the metal. The mechanical engineer recognized at once, however, that while the fusion of castings for welding would be consistent with the method of their formation, that is, that both the original metal and the weld itself would be in the cast condition, this would not be true in the case of the welding of rolled or forged wrought iron or steel. There the two pieces of rolled or forged metal would be joined by a cast weld, the former being fine grained and strong, the latter of coarse grains and reduced tensile strength. This was not a new situation to the engineer. The benefits derived from hammer-refining the grains of steel are well known. An ordinary machinist hammer therefore proved to be the cure of this trouble, and it may be of interest to relate that in some experiments performed during the past year by the author for the Air Reduction Co. of New York at the shops of the Baltimore & Ohio Railroad at Martinsburg, W. Va., and at Brunswick, Md., some worn railroad frogs which were built up by the oxy-acetylene process and allowed to cool directly from the liquid in the solid condition lasted only a few weeks in service, but when a progressive method of building up and hammering was resorted to some of the frogs lasted over 9 months in continuous severe service.

Broader Adaptability of the Oxy-Acetylene Method

As fusion is the chief requisite of a good weld, the new process might be used to join other metals than wrought iron and steel. This opened up wonderful possibilities, new indeed to welders, for cast iron and the non-ferrous metals had not yet been welded. Would it be possible for the new welders to learn the marked differences of characteristics of steel, cast iron, copper, brass, aluminum? We have but to call to mind the work being done in the welding of iron castings alone to get an answer and to form an idea of the possibilities and value of the oxy-acetylene process for the welding of cast iron. The author recently had to do with the oxy-acetylene welding of three broken cast iron cylinders of freight locomotives, which cost $515

*Professor of Shop Practice, Stevens Institute of Technology, and Advisory Engineer, Air Reduction Co., 120 Broadway, N. Y.

to weld and put in good working order, but would have cost $3600 to replace by new cylinders if oxy-acetylene welding had not been available, leaving out of consideration the long delay in getting the locomotives back in service by the old method of making repairs as compared with the few days' lay-up for welding.

The gases used in an oxy-acetylene torch operated by inexperienced welders might easily be made to lower the value of the weld. Many of the first oxy-acetylene welds were badly crystallized. The engineer knew this and waited for developments. The first designs of torches were much to blame for this condition, but the inexperience of the welder was more so. It is not unusual now to find oxy-acetylene welds so homogeneous as to make it practically impossible to see any difference between the original material and its weld.

The unusual problems of expansion and contraction must be reckoned with in the job welded by oxy-acetylene. No one would attempt to dispute this. The cautiousness of the engineer in this regard may well be understood. It has required an experimental experience to master these difficulties, but they do not stand in our way now.

The heating of the oxy-acetylene weld being accomplished by the powerful quick-acting flame instead of a slow forge fire, it can readily be seen that a trained eye would be required to bring about good results from the working of the metal in the molten condition. What would happen if the metal were overheated? What if the original metal were not thoroughly melted when the molten rod was dropped upon it? A man must know more than a blacksmith about hot metals to be an oxy-acetylene welder. Could such men be gotten and could their skill be relied upon? We know the encouraging answer to these questions now, but they recall to some at least the time of not so long ago when the mechanical engineer struggled with his welders to teach them the difference between molten metal and burnt metal. We venture to say that it will be much easier to make good oxy-acetylene welders from now on than it has been heretofore.

Need of Training Oxy-Acetylene Welders

The author's experience of the war-time period illustrates the need of training for the special work of oxy-acetylene welding. There was a great demand for the use of the oxy-acetylene welding and cutting of metals. Trained welders were scarce and many men were being pressed into the work without proper knowledge of the way it should be performed. At the request of those in charge of these men it became our privilege to form a night school for oxy-acetylene welders at the Twenty-third Street Y. M. C. A., New York. The course consisted of lectures on the metallurgy and general principles of the work followed by the actual use of the welding and cutting torches on special jobs in the shop. We took in men who were working on war orders in the shipyards and other large shops, and also any other men who would learn to be welders and take positions in the shops doing war work. Over 200 men were trained the first year, about 75 per cent of whom proved to be successful welders, so far as we have been able to follow them up. It was easy to see why these men were failing in their daily labors with the torch, and their rapid advancement after a few evenings of instruction clearly proved the importance of a special training in the subject. As a more marked illustration of the value of such a training, however, we may mention an experiment in this same evening school of a special class selected from the non-essential industries. The men had been earning a livelihood as furniture salesman, laundryman, hat dyer, printer, bookkeeper, waiter, plasterer, signalman, art student, saloonkeeper, etc. Seventeen out of the twenty in the class became good welders, and went to work in shipyard and shop with a zeal that was surprisingly new to them.

Teaching the Uses of Oxy-Acetylene Processes

It is timely to outline the attitude of the technical engineer toward the teaching of the oxy-acetylene processes in the engineering colleges. Some of these institutions were not slow to grasp the importance of the subject. The Stevens Institute of Technology was probably the first college to take up the work. The author has lectured for about ten years on the subject as head of the department of shop practice in that institution and some time ago we added a course of jobs to be welded by the oxy-acetylene torch which every student at Stevens has been required to take. We have heard of other engineering colleges which have introduced such a course, and we understand that Harvard's new Engineering School is about to include oxy-acetylene welding in the instruction of its shop department.

In college and abroad in the world of engineering construction and repairs the technical engineer has been giving careful thought to the possibilities and advantages of oxy-acetylene welding. He has encouraged its trial in shop, foundry and manufacturing plant. He has studied its evolution from the rough joint of doubtful value to the homogeneous weld of nearly 100 per cent efficiency. If he has been conservative in his judgment it was because he knew better than others of the undeveloped parts of the new field being entered by the welder; if he has appeared to be slow to accept the process for the most important high pressure and high tension work it is because he has waited to prove that the new welder could measure up to his increased responsibility. One thing he will not do, he will not forget the inherent crudeness of the work, nor the varying personal error of the best workmen, and expect impractical refinements. A small fraction of sulphuretted hydrogen and phosphoretted hydrogen in the acetylene or a little difference in the purity of oxygen will not disturb his acquired confidence in the possibilities of a good weld by the new process. He has learned to appreciate the difference between a 50 per cent plastic weld and a 90 per cent fusion weld.

Generalization

The author has discussed oxy-acetylene welding with many of the leading technical engineers of the country, men who are in responsible charge of immense engineering plants. Five years ago almost all of these men would have advised a delayed acceptance and further study of the advantages of the process. Today they do not hesitate. Their minds are made up. From study and experience they speak, and because of the nature of the heat supply which can easily be made a non-oxidizing reducing flame, because of the effect of the process on the physical efficiency of the actual weld, because of the portability of the welding apparatus, and because of the economy of the process, their judgment is that the oxy-acetylene process of welding metals is an engineering success and a fine commercial asset.

Fatigue Research in Tinplate Manufacture*

THE Industrial Fatigue Research Board has issued an interesting report on "The Influence of Hours of Work and of Ventilation on Output in Tinplate Manufacture," by Dr. H. M. Vernon, an investigator to the Board. According to this the hours actually worked up to the beginning of 1919 by the tinplate workers very seldom exceeded 54 per week, and were usually considerably fewer than this. The millmen usually worked five or six 8-hr. shifts per week; but their work is so heavy that a reduction to 6-hr. shifts, making 30 to 36 hours per week, has been proposed.

Duties of Millmen

The millmen work in groups of four, consisting of a rollerman, a doubler, a furnaceman and a behinder. Each rolling mill consists of two pairs of rolls and two, or occasionally three, furnaces. The doubler charges one of the furnaces with a definite number of steel bars, usually 30 to 46, which take about an hour to reach the required temperature. They are usually about 9 in. wide, 20 in. long, and $\frac{3}{8}$ to $\frac{7}{8}$ in. thick, and weigh 20 to 40 lb. The doubler pulls out the bars, two at a time, from the furnace, pushes them along the floor to one pair of rolls, and rests them on a small tank, about 2 ft. in height. The rollerman takes up each bar separately and passes it between the rolls, while the behinder, on the other side, grasps and raises it to the top of the upper roll, and thus it is carried back to the rollerman. Each bar is passed through the rolls four or five times, and gets rolled out to a sheet. The rollerman takes hold of the two sheets together and flings them across the floor to the doubler, who returns them to the furnace. To do this, he has to lift a weight of 40 to 80 lb. a height of over 3 ft.

The rolling of the 15 to 23 pairs of bars takes 10 or 12 minutes, and the squad of workers usually pause for about two minutes at the end of it. Then the furnaceman (who has been resting during the first stage of the rolling, or stoking his furnaces) withdraws the rolled bars from the furnace, one by one as they are wanted, and flings them across the floor to the rollerman. The rollerman passes them twice through the other pair of rolls, which are heated to a blue heat by constant contact with the red-hot sheets of metal. He flings each rolled sheet to the doubler, who doubles it over, presses on it with his foot, and raises it to a table about 2½ ft. in height. Here he places the folded portion under the squeezer, which flattens the two layers of the sheet together. He flings the sheet on the floor to the furnacer, who returns it to the furnace.

In the third stage of the rolling the twofold sheet is again passed twice through the hot rolls, and the doubler doubles it again, and with shears trims off the edges which have come together. In the fourth stage, the fourfold sheet is rolled, doubled and trimmed as before, while in the fifth and final stage the eightfold sheets are rolled out to the required length. This usually requires two passes through the rolls, but if after measurement the sheet is found to be too short, it is allowed to cool a little and is rolled again.

Finally, the behinder (who has been constantly returning the rolled sheets to the rollerman) pulls it on to the floor, and, in a single complex movement, swings it and his whole body round back to front, and bounces and lifts the sheets from the floor level on to a stand or a trolley. The trolley is about a foot above floor level, but the pile of sheets accumulate on it to a height of one or two feet, so it means a considerable effort to land the long thin sheet on the top.

The whole cycle of five stages was found to take about 96 minutes when 46 bars of 29 lb. each were rolled, and 78 minutes when 36 bars of 30 lb. each were rolled. There is never any break in the rolling process of more than a very few minutes right through the working week, i.e., from 6 a.m. on Monday till 2 p.m. (or 12 noon) on Saturday. The workmen seldom pause more than four minutes between any of the stages, and there is no delay when the shifts change, as the doubler of one shift puts in the furnace the bars required by the succeeding shift, and the fresh men are all ready and waiting to take their turn.

The temperature of the air near the millmen was found to be sometimes as high as 110 deg. F., but this figure gives an inadequate idea of the heat experienced. The red-hot sheets of metal manipulated by the men average about 4 sq.ft. in area, and at some stages the large sizes may attain 10 sq.ft. or more, so the radiant heat from them must be considerable. In addition, the furnacer, and at times the doubler, experience the radiant heat from the partly open furnace, while the rollerman and the behinder stand close to the heated rolls. All four men are constantly raising and lowering metal sheets and bars weighing 20 to 80 lb.; hence the physical effort of millmen's work is very great. The men stream with perspiration within a few minutes of starting work, and they drink many pints of home-brewed ginger beer, milk, cider and water during their shift in order to quench their thirst.

Influence of Hours of Work Upon Output

For inquiry into the influence of the hours of work upon output recourse was had: (1) to records, available in five factories, A, B, C, D, E, for periods dating back in one case to 1911, giving length of shifts worked and output obtained; (2) to a certain number of stop-watch measurements obtained in factories D, F, G of the times taken by millmen on 6- and 8-hr. shifts to work through the various operations, and the rest-pauses taken by these millmen. The influence of hours of work upon output lends itself to investigation in the case of millmen owing to the clear cut reductions of working hours to which their work is sometimes subjected. If some of the mills break down, or if there is a shortage of material, it is common custom to convert the three 8-hr. shifts into four 6-hr. shifts, or even into six 4-hr. shifts, in order that as many of the men as possible may be provided with work.

The author recapitulates his evidence thus: The very reliable data from the records at factory A showed the hourly output during 4-hr. shifts to be 11.5 per cent greater than that obtaining during 8-hr. shifts. Turning to 6-hr. shifts, the less reliable observations from factory C showed the output to be 8.5 per cent greater for the shorter hours; those at

*Abstracts from the *Iron and Coal Trades Review*, Sept. 12, 1919, p. 336.

factory D showed it to be 10.6 per cent greater (for a 19-week period); and those at factory E 4.7 per cent greater. Hence we may conclude with considerable probability that when 6-hr. shifts are worked the hourly output is about 10 per cent greater than when 8-hr. shifts are worked. However, this increment, small as it is, does not mean a corresponding increase of total output. The men stop at 12 on Saturday when they work 6-hr. shifts, or put in 126 hours per week, whereas they stop at 2 p. m. when they work 8-hr. shifts, or put in 128 hours per week. Hence the total output of the factory would be increased by only 8.3 per cent when 6-hr. shifts were substituted for 8-hr. shifts; i.e., a smaller improvement might presumably be brought about than by the installation of thoroughly efficient ventilation. Supposing it were possible to work an extra 6-hr. shift (i.e., till 6 p.m. on Saturday), the total output would be increased by 13.4 per cent, but the author has heard of no suggestion of this kind.

Seasonal Variation in Output

The fatiguing character of millmen's work is shown by the fact that their output varies with the atmospheric temperature, and is distinctly smaller in the summer than in the winter. The author was able to obtain data showing the weekly output per mill at the five factories A to E for a number of consecutive years which proved that there is a distinct seasonal variation in the output of the men. Their hourly output decreases as the weather grows warmer, and the degree of variation is dependent mainly on the ventilation. In a factory where a good ventilation was effected by means of large vertical fans or paddles, the mean output in the summer months (May to September) was only 2.9 per cent less than in the winter months (December to March). In two other factories where a moderately efficient ventilation was effected by cold-air douches, the summer output was 5.2 per cent less than that of the winter, while in two other factories, which had no artificial ventilation at all, it was 6.8 and 9.2 per cent less. The real effect of temperature on output is considerably greater than is indicated by these figures, for it was found that in the two unventilated factories the average output was, respectively, 11 and 18 per cent less in the hottest weeks of the year (when the mean temperature was 65 deg. F. or more) than in the coldest weeks (when it was 40 deg. or less). In the ventilated factories it was 8 per cent less. It is probable that thoroughly efficient ventilation may increase the average output of an unventilated factory by 12 per cent or more.

Ventilating Systems

At factory B, air douches were provided between each furnace and pair of rolls, but the air current was not powerful enough to extend in any strength to the legs and lower part of the bodies of the men. In factory A large fans, consisting of iron sheets about 6 ft. x 2 ft., revolved rapidly in a vertical plane midway between each furnace and pair of rolls, the bottom of the fan being about 7 ft. from the floor. This system could be improved by bringing in fresh air from outside. It should be possible to change the rate of speed of the fans to conform with seasonal temperature changes. Also, the rate of revolution of the fans should not be constant but rhythmical. Such rhythmic ventilation is more pleasant and efficient than steady ventilation.

In many American tinplate works cold air is driven up from the floor of the millhouses, but according to a workman who had experienced this system it was much less pleasant than the English system, as it produced chronic irritation of the skin of the legs. Again, in some American works the mill floor is cooled by running cold water through pipes inserted in the floor plates, and this method is said to be very efficient in keeping the millhouse cool.

Reducing Physical Exertion

The call upon the physical endurance of the millmen is so great that everything possible ought to be done to reduce it to its lowest limits. Lowering the furnace floor, rolls, tank and doubler's table would undoubtedly entail more bending on the part of the men, but the lack of uniformity in these heights in different factories suggests the need of further experimentation to determine the most suitable heights. Moreover, in American mills the rolls are several inches lower than in our mills, and this is said to be an advantage, not only because it entails less weight lifting, but because it enables the men to roll the iron with long tongs. The heaviest lifting of all is that of the doubler in returning the pieces to the furnace after their first rolling. The two together weigh 40 to 80 lb., and probably it would cause him less fatigue to lift them separately than conjointly, as is the present custom.

It is probable that some of the labor-saving devices employed in sheet steel mills might be adopted with advantage in tinplate mills. In the mills visited by the author the sheet steel was being rolled from bars weighing 40 to 100 lb., and when the sheets were put back into the furnace for re-heating they were not lifted from floor level, but were pushed up inclined steel rails running from floor to furnace mouth. The work of the behinder in raising the sheets of metal to the top of the roll for their return to the rollerman was greatly reduced by the use of a little platform on wheels. This was tilted down in front so that the metal sheet coming through the roll slid on to the platform, and then it was raised and pushed near to the upper roll, so that the sheet was caught and carried back. Again, the work of the doubler was reduced by having the shears absolutely at floor level, instead of on a table.

A much more important innovation than any of those mentioned is the so-called "double-manning" of the mills. This system, which is widely employed in America, consists in duplicating the number of men running each mill. The men work in relays and replace one another every few minutes. Thereby the rolls are kept much more fully occupied, and the men have much longer rest periods in which to recover. This system of double-manning has not yet been established in any English works, though its introduction is under consideration.

Practical Conclusions

The chief practical conclusions drawn by the author from his own investigations are two. Firstly, they confirm the importance of maintaining the agreement reached at the conference in 1913 and 1914 in

regard to introduction of cool air to reduce the temperature of the working places near the rolls and furnaces. Secondly, it suggests the importance of introducing changes in the clothing of the men. Before starting work, the men put on a short loose flannel shirt ending at the waist and open at the neck, and they thereby do what they can to keep the upper part of the body cool; but throughout the shift they wear the same trousers and pants in which they came to the works, and these garments are generally thick and woolen. If they were to put on gray flannel trousers without the pants they would keep much cooler and healthier. All tinplate workers taken together (other than those in the tinhouse) are two to five times more subject to rheumatism, rheumatic fever and neuralgia than any other manual workers such as brass casters, brass polishers, grinders and cutlers.

United States Foreign Trade in Glycerine*

AS A direct result of the war the United States trade in glycerine has been completely revolutionized. Imports ranging from 20,000,000 to 40,000,000 lb. annually for a decade and a half prior to 1914 dwindled to a little over 1,000,000 lb. in 1919; and the increase in the production of glycerine in the United States since the outbreak of the war has been such as not only to supply in large measure the enormously expanded domestic consumption but also to make possible the exportation of 21,000,000 lb. in 1918, and 13,000,000 lb. in 1919. (Before the war exports of glycerine, if any, were included with "all other chemicals"; but the increase in the exportation of glycerine was so great as to lead to its separate enumeration in 1918 in the statistical classification of exported merchandise.)

Imports of glycerine into the United States have formed a separate statistical schedule since 1884, and these imports, together with the average price per lb. are shown in Table I.

TABLE I

Fiscal Years Ending June 30	Lb.	Value	Average Price	Fiscal Years Ending June 30	Lb.	Value	Average Price
1884....	5,832,825	$679,818	$0.116	1902..	28,576,400	$2,358,325	$0.083
1885....	7,573,034	453,930	.060	1903..	35,295,575	2,937,802	.083
1886....	10,442,910	586,237	.056	1904..	31,078,455	2,583,270	.083
1887....	12,765,072	1,094,607	.086	1905..	27,010,255	2,052,011	.077
1888....	10,060,719	1,064,756	.106	1906..	34,122,953	2,302,183	.068
1889....	10,959,719	933,354	.085	1907..	37,992,433	2,459,458	.064
1890....	11,147,684	928,935	.083	1908..	32,481,068	2,470,178	.076
1891....	13,975,577	996,686	.071	1909..	36,248,421	3,021,272	.083
1892....	14,197,549	831,810	.059	1910..	41,181,526	3,665,763	.089
1893....	16,540,213	893,636	.054	1911..	40,109,007	4,364,419	.109
1894....	8,321,853	519,296	.062	1912..	29,933,320	3,674,926	.123
1895....	13,488,825	784,613	.058	1913..	34,413,507	4,251,841	.124
1896....	21,158,829	1,472,302	.069	1914..	36,409,619	4,486,415	.123
1897....	12,717,098	1,182,099	.093	1915..	17,620,509	2,186,755	.124
1898....	12,274,987	774,709	.063	1916..	10,621,403	2,232,494	.210
1899....	15,665,252	1,024,131	.065	1917..	4,122,410	1,297,159	.315
1900....	27,943,106	2,155,414	.077	1918..	1,875,531	804,618	.429
1901....	20,369,712	1,722,882	.085	1919..	1,171,679	372,272	.318

World Production—American Purchases

Glycerine was discovered by Scheele in 1779 when preparing lead plaster from olive oil, and was produced extensively in England, France and other European countries as a by-product of the soap and candle industries long before its manufacture was begun in the United States in 1847. In 1850 only 150 lb. of glycerine was produced in this country. Six years later glycerine was still comparatively rare, selling at $1.75 per pound.

The world production of crude glycerine prior to the war has been stated to be 40,000 tons per annum, 14,000 of which were from soap manufacture and 26,000 tons from stearine manufacture, of which England produced 5500 tons, France 3500 tons, the United States 3000 tons, and Germany 2000 tons from soap-making; and France 6000 tons, Germany and the United States 3000 tons each, Holland, Austria and Russia 200 tons each, with smaller amounts in other countries from the manufacture of stearic acid.

By 1884, imports of glycerine into the United States were of sufficient importance to be segregated from "all other chemicals" and, as stated, are shown separately in the import schedule thereafter. Notwithstanding wide fluctuations in both quantity and value from year to year, the import trade continued to grow until the high-record quantity of 41,181,526 lb. was reached in 1910, and the high-record value of $4,486,415 in the fiscal year ended June 30, 1914, immediately preceding the war.

The magnitude and value of this import trade in glycerine are evidenced from the total receipts in the period 1884-1919, amounting to 725,699,035 lb. of the aggregate value of $65,620,376.

Imports From Leading European Countries

From 1884 to 1910 France led as a supplier of glycerine to the United States, with the exception of the year 1900, when the United Kingdom sent a slightly larger quantity. England ranked first in 1911, 1912, 1913 and 1915, France again in 1914 and 1916; and in 1917 imports of glycerine from these countries ceased, to be resumed with shipments aggregating only 102,655 lb. from the United Kingdom in 1919. Other important European sources of glycerine since 1884 are given in Table II.

New Source of Supply

With the outbreak of the war the United States had naturally to seek other sources for a goodly part of such glycerine as it continued to import. Cuba had long been a shipper of glycerine to this country, and sent steadily increasing quantities each year from 1914 to 1918, but shipments declined somewhat in 1919. Canada contributed important amounts in 1914 and 1915, as did Mexico also, though there has been a decided drop in the shipments from the latter country to the United States dating from 1916 and shipments from the former entirely disappeared in 1918—to reappear, however, in 1919. Argentina and Brazil, and in lesser degree Uruguay, Venezuela and Japan, have been the chief new sources of supply. Details of this trade from 1914 to 1919 appear in Table III, the "eight European countries" being those for which data have already been given, namely, Austria-Hungary, Belgium, France, Germany, Italy, Netherlands, Spain and the United Kingdom.

In July, 1919, the United States imported 418,253 lb. of glycerine, valued at $45,061, or an average price of $0.108 a lb., contrasted with 233,660 lb. valued at $109,564, or $0.469 a lb. in July, 1918; in August, 231,791 lb., valued at $24,930, or $0.107 a lb., contrasted with 4,421 lb., valued at $1,348, or $0.305 a lb., in August of last year. For the eight months, January-August, 1919, imports of glycerine into the United States totaled 1,219,715 lb., valued at $184,839, or $0.151 a lb., against 1,080,920 lb., valued at $472,019, or $0.437 a lb., in the corresponding period of the calendar year 1918.

No accurate statistics are available showing the production of glycerine in the United States since the cen-

*Prepared by the Division of Statistics, Bureau of Foreign and Domestic Commerce.

TABLE III. MPORTANT EUROPEAN SOURCES OF GLYCERINE

Fiscal Years Ending June 30	Austria-Hungary Lb.	Belgium Lb.	France Lb.	Germany Lb.	Italy Lb.	Netherlands Lb.	Spain Lb.	United Kingdom Lb.
1884	95,579	57,124	3,535,759	1,251,290	87,500	100,184	.....	636,953
1885	52,864	269,492	5,815,251	1,049,072	89,663	10,703	.....	285,988
1886	73,404	873,438	7,359,574	1,421,797	376,058	43,453	.....	290,628
1887	60,252	1,106,264	8,717,263	876,555	408,721	1,140,597	.....	361,843
1888	233,661	291,493	6,874,971	769,149	556,048	1,039,677	11,041	163,637
1889	43,086	344,104	8,766,570	331,599	299,940	578,092	484,845	35,129
1890	25,020	381,173	9,153,630	412,684	324,008	156,500	306,009	177,681
1891	16,576	113,793	10,472,271	309,109	458,086	115,090	1,413,858	993,628
1892	27,182	228,000	10,233,504	525,358	535,588	9,727	989,476	1,542,701
1893	8,960	563,013	10,274,057	41,886	963,771	72,552	2,118,509	2,431,170
1894	9,710	998,250	4,667,471	214,764	764,844	48,224	1,306,731	154,544
1895	.....	463,879	7,777,133	37,570	722,064	361,181	2,074,174	1,466,898
1896	112,101	319,768	11,771,219	200,675	1,585,085	483,777	1,972,549	4,448,636
1897	26,937	502,367	9,630,353	125,748	558,339	271,787	642,174	659,721
1898	5,210	442,952	6,654,835	26,259	613,720	107,874	1,081,606	3,238,526
1899	2,361	510,792	5,967,814	149,374	1,386,256	46,501	219,611	7,260,120
1900	122,592	2,259,005	10,018,598	104,484	2,364,162	978,408	1,188,522	10,673,266
1901	379,666	1,119,805	7,675,183	8,814	2,315,953	1,034,708	693,492	6,696,259
1902	527,592	1,354,436	9,836,883	296,250	2,363,815	1,545,829	1,781,912	9,528,253
1903	8,960	1,818,753	14,503,651	567,621	2,497,744	1,819,573	1,903,431	10,552,139
1904	198,627	1,354,248	14,341,120	572,875	1,771,875	1,734,882	1,338,597	7,627,030
1905	.....	1,217,572	14,511,141	393,083	2,136,035	1,823,149	505,943	4,768,492
1906	89,608	1,412,532	15,857,044	158,040	3,492,304	3,369,776	1,360,484	6,377,172
1907	73,881	1,910,482	18,067,412	381,636	1,675,384	2,519,420	1,177,006	9,522,493
1908	.....	2,545,712	14,574,473	835,430	1,785,488	3,188,012	1,101,803	7,022,958
1909	403,185	3,069,759	16,145,936	951,611	1,466,091	2,773,416	939,034	8,752,745
1910	613,754	3,670,617	15,943,692	859,992	2,213,472	2,282,766	563,072	12,996,366
1911	197,885	3,245,435	13,620,247	530,337	2,019,702	2,607,142	946,944	14,721,449
1912	317,013	2,119,804	7,986,295	1,741,032	1,586,579	1,613,100	147,189	12,063,245
1913	702,081	4,047,395	9,442,429	1,895,070	1,422,045	1,674,031	1,525,585	10,299,166
1914	256,151	2,672,405	11,204,503	1,881,779	859,202	2,566,056	1,664,782	10,566,395
1915	117,726	507,017	3,961,393	44,808	159,029	789,377	157,672	7,871,474
1916	.....	.....	1,754,537	.....	.....	898,855	2,553,486	858,854
1917	.....	.....	.....	.....	.....	499,124	792,555	.....
1918	.....	.....	.....	.....	.....	.....	.....	.....
1919	.....	.....	.....	.....	.....	.....	.....	102,655

sus taken in 1914. One of the war boards no longer functioning ventured an estimate of 70,000,000 lb. of crude glycerine as the domestic output in 1917.

The Bureau of the Census gives the production of crude glycerine for sale in the calendar year 1914 as 16,568,920 lb., valued at $2,278,976, but adds that figures are not available for the total production of crude glycerine, as that made and consumed in the manufacture of the refined glycerine was not reported. The refined glycerine made during the same year amounted to 60,944,799 lb., valued at $10,779,204. This glycerine was produced in 119 establishments, 19 of which were located in New York and the same number in Ohio, 12 in Illinois, 10 in Pennsylvania, 9 each in California and Massachusetts and the others scattered throughout the States.

Comparing these figures with the domestic exports of crude glycerine aggregating 21,045,991 lb. in the year ended June 30, 1918, and 13,018,882 lb. in the fiscal year 1919, while imports dropped to 1,875,531 lb. in the former year and to 1,171,679 in the latter, and in view of the well-known fact that enormous quantities of domestic glycerine were utilized in the increased manufacture of explosives in this country since 1914, it is evident that tremendous expansion in the recovery of crude glycerine has taken place in our domestic industries since the war began, no estimate of which would be more than guesswork until returns from the forthcoming census are available.

Growth of the Export Trade

As glycerine was not separately shown in the export schedule prior to the fiscal year 1918, a detailed study of the newly developed export trade in this commodity as disclosed by recent statistics is of interest.

Glycerine made in the United States was exported to 54 countries during the fiscal year 1918, 91 per cent of it going to Europe. The bulk of the 21,045,991 lb. exported in that year went to allied countries, Italy taking 18,886,974 lb., Canada 1,436,922, England 214,953, France 100,940, and Japan only 80,917.

Following the signing of the armistice there was a radical change in the destination of American exports of glycerine. Compared with the previous year, shipments to Italy show a sharp decline in 1919, none whatever having been made during the last half of the year,

TABLE III. IMPORTS OF GLYCERINE TO U. S. BY COUNTRIES

Imported from	Fiscal Years Ending June 30 — 1914 Lb.	1915 Lb.	1916 Lb.	1917 Lb.	1918 Lb.	1919 Lb.
Eight European countries	31,671,273	13,608,496	6,065,732	1,291,679	.....	102,655
Denmark	135,268	66,026	.....	.....	.....	.....
Russia in Europe	1,959,298	623,675	.....	.....	.....	.....
Switzerland	225,843	.....	650,856	223,367	.....	.....
Canada	1,324,594	1,436,209	845,822	34,661	.....	176,469
Mexico	541,054	1,157,998	531,055	305,780	204,192	80,030
Cuba	222,183	307,939	316,990	377,962	428,495	366,568
Dominican Republic	.....	.....	9,834	25,108	16,417	11,170
Argentina	291,038	66,535	1,088,737	907,491	507,403	86,986
Brazil	.....	348,091	941,990	800,202	644,290	297,009
Peru	.....	.....	2,250	13,693	.....	.....
Uruguay	.....	.....	82,212	34,926	31,658	.....
Venezuela	.....	.....	.....	.....	556	34,394
Japan	.....	.....	.....	80,000	42,520	.....
Total	36,409,619	17,620,509	10,621,403	4,122,410	1,875,531	1,171,679

while those to the United Kingdom and Japan materially increased. Larger amounts are also going to South America. Further, a movement to Oriental markets may be noted. The principal countries to which the domestic glycerine exported during the year ended June 30, 1919, went are as enumerated in Table IV.

TABLE IV. EXPORTS OF GLYCERINE FROM U. S.

Exported to	Lb.	Value	Exported to	Lb.	Value
United Kingdom	6,840,022	$3,873,393	China	66,485	$21,067
Japan	2,515,543	1,136,244	British India	42,858	11,951
Italy	1,713,636	937,144			
Canada	1,022,824	600,696	Total to countries named	12,695,853	6,710,236
Norway	262,930	57,926			
Argentina	143,994	37,775	Total to all countries	13,018,882	6,833,432
Cuba	87,561	34,040			

Nearly the whole of the amounts credited above to the United Kingdom and Canada was shipped prior to January, 1919. In normal times the British production of glycerine is more than sufficient to supply both England and Canada, while Italy finds a more convenient source of supply in France than in the United States, if its own production fails to fully meet all demands.

A decline in the United States export trade in glycerine during the last fiscal year is strikingly shown by comparing the total shipments for the first six months (July-December, 1918), amounting to 10,318,717 lb., valued at $5,927,028, with the 2,700,165 lb., invoiced at $906,404, for the second half, ending with June, 1919. That this decline, in comparison with corresponding figures for 1918, still continues is shown in the shipments for July and August, 1919, given in Table V.

TABLE V. EXPORTS FOR JULY AND AUGUST, 1919

Period	Lb.	Value	Average Price
July:			
1918	485,985	$245,164	$0.504
1919	67,980	15,659	.230
August:			
1918	570,405	340,768	.597
1919	391,154	82,956	.212
Eight months ending August—			
1918	12,492,401	6,425,540	.514
1919	3,158,899	1,005,019	.318

While the production of glycerine is not confined to any one section of the country, exports for the fiscal year 1918 cleared chiefly from the ports of Baltimore and New York, 79 per cent of the total quantity shipped to all countries passing through the Maryland district and 13 per cent through New York. Of the 2,700,165 lb. of glycerine exported during the six months ended June, 1919, 1,277,828 lb., valued at $323,464, was shipped through the customs district of New York; 488,918 lb., worth $107,891, from San Francisco; 769,993 lb., invoiced at $406,941, through Washington; and smaller amounts through other districts, none, however, passing through Maryland.

Exchange a Factor—Average Prices

A factor of prime importance to be considered if the United States is to maintain an export trade in glycerine is the difference in the rate of exchange. It is stated that the present rate is such as to make the purchase of foreign glycerine possible in this country at a price considerably below domestic quotations. This seems to be borne out by the increased imports at lower average prices, and decreased exports in July, August, and the eight months ended with August, as compared with corresponding figures for 1918.

Import prices in American official statistics are based on the actual market value or wholesale price at the time of shipment to the United States in the principal markets of the countries from which imported, including values of all containers and coverings. Export prices are based on the value of the article at the time of exportation at the ports in the United States from which shipped.

The average annual import price of glycerine in 1884 was $0.116 a lb., dropping to $0.06 the following year and to $0.056 in 1886 as imports continued to increase, reaching the low record of $0.054 in 1893. Considerable variation thereafter is shown in the price from year to year, but always below $0.10 per lb., until 1911, when it reached $0.109, with a further rise to $0.123 in 1914 just prior to the war. From 1915 to 1916 imports of glycerine decreased 7,000,000 lb. and the price rose from $0.124 to $0.210 a lb. Further declines in the quantity imported brought the annual average price up to $0.315 in 1917, and the high record of $0.429 a lb. in 1918, when the total importation was less than 2,000,000 pounds.

Although imports of glycerine during the fiscal year 1919 show a further decline of 700,000 lb. as compared with the previous year, the close of the war is marked by a drop to $0.318 in the average import price. These average annual prices, covering as they do all grades of commercial glycerine, give no idea of the actual market fluctuations from the highest to the lowest prices on single shipments during shorter periods; and the same applies to exports during the war period, when prices shown on invoices for export ranged from $0.18 to $1 a lb. for domestic glycerine. Prices of chemically pure and dynamite glycerine were quoted as high as $0.70 per lb. in the New York market during the latter months of 1917, and as low as $0.20 per lb. for chemically pure and $0.17 for dynamite glycerine at the end of 1918.

Effect of War's End on Prices

The close of the war released for industrial purposes glycerine formerly used in the manufacture of high explosives. The resulting competition among the nations caused a sharp decline from war prices of both imports and exports, the extent of which is shown in the months of July and August and the eight-month period ending August, 1919, as compared with corresponding data for the previous year.

The monthly average import price of glycerine declined from $0.469 in July, 1918, to $0.108 in July, 1919, receipts being nearly doubled in quantity; and from $0.305 in August, 1918, to $0.107 in August, 1919. The average import price for the eight-month period ending in August, 1918, was $0.437, as compared with $0.151 for the corresponding period in 1919.

There was 21,045,991 lb. of glycerine exported during the fiscal year 1918 at an average price of $0.503 a lb., compared with 13,018,882 lb. in 1919 at $0.525. July, 1919, shows a decline to $0.23 a lb., as compared with $0.504 in 1918; and August, 1919, $0.212 as compared with $0.597 in the corresponding month of 1918. For the eight months ended with August, 1918, the average export price was $0.514, dropping to $0.318 during the corresponding period of 1919.

Varied Uses of Glycerine

By far the largest application for glycerine is for the manufacture of nitroglycerine. The combination of nitroglycerine with nitrocellulose, or guncotton, forms a more recently developed class of high explosives known as blasting gelatine, cordite, etc. Glycerine is also employed extensively for filling hydraulic jacks, gas meters, and tubes liable to be exposed to great cold, and in the manufacture of toilet soaps, inks, waterproof paper, preservatives for food products, "sizes" for textiles, for the production of plastic masses, such as printing rollers and hectograph mass, and in the treatment (scheelizing) of wine, beer and vinegar. The bulk of the distilled glycerine is employed in the manufacture of dynamite and other high explosives and the commercially pure product in pharmacy and medicine. In medical practice nitroglycerine is for the treatment of angina pectoris.

Proposed "Efficiency Exhibition" in London

The London *Daily Mail* proposes to hold an Efficiency Exhibition at Olympia in February, 1920. It is intended that every machine, method or system that can save labor, time and materials shall be represented. The demonstration will cover the farm, the counting house, factory, office and warehouse. Support has been promised by a number of organizations, including the Federation of British Industries, the British Science Guild and the Electrical Development Association.

Legal Notes

By Wellington Gustin

Legality of Resale Prices—Manufacturers' Rights Under the Sherman Act

THE RIGHT of a manufacturer to make and maintain the resale price of his products has been upheld in the latest case on the proposition decided in the United States Supreme Court. The manner and methods pursued in establishing resale prices has been the subject of various attacks by the Federal Government in prosecutions under the "act to protect trade and commerce against unlawful restraints and monopolies," known as the Sherman anti-trust act. From this decision it would seem that the manufacturer may announce in advance under what conditions it will deal or sell its products, and it is perfectly within its rights in refusing to sell to those who cut the prices. But the manufacturer cannot go further and enforce any agreement that would uphold the resale prices, that is, the dealer may actually resell at any price he chooses. The court undoubtedly would not uphold any action the manufacturer might institute against the dealers, but it does extend to it his common law right to refuse to deal with them further.

In the present case of the United States vs. Colgate & Co. (39 Sup. Ct., 465) an indictment was returned charging the defendant company with a violation of the Sherman act. The indictment ran only against the company and not against any of the dealers handling its products.

The trial court held that the indictment should set out such facts as to make it clear "that a manufacturer, engaged in what was believed to be the lawful conduct of its business, has violated some known law before it can be haled into court to answer the charge of a commission of a crime," and held that this indictment did not in substance charge any offense under the Sherman act or under any other law of the United States. Hence the indictment was quashed by the trial court and counsel for the Government appealed to the Supreme Court.

Indictment Was for Unlawful Combination of Manufacturer and Dealers

This indictment proceeded upon the theory of an unlawful combination of the manufacturer and the dealers, and made no reference to monopoly. The charges were in vague and general language, but perhaps presented the case with as much certainty and definiteness as the facts warranted. After setting out the company's general methods of doing business in the sale and distribution of its products, the material part of the indictment alleged the following:

"During the aforesaid period of time, within the said Eastern District of Virginia and throughout the United States, the defendant knowingly and unlawfully created and engaged in a combination with said wholesale and retail dealers, in the said Eastern District of Virginia and throughout the United States, for the purpose and with the effect of procuring adherence on the part of such dealers (in reselling such products sold to them aforesaid) to resale prices fixed by the defendant, and of preventing such dealers from reselling such products at lower prices, thus suppressing competition amongst such wholesale dealers, in restraint of the aforesaid trade and commerce among the several States in violation of the act entitled 'An act to protect trade and commerce against unlawful restraints and monopolies,' approved July 2, 1890."

It charged the purposes of the combination were accomplished by the distribution of letters, telegrams, circulars, and lists showing uniform prices to be charged, among the dealers, urging these to adhere to such prices; and notices, stating that no sales would be made to those who did not; requests for information concerning dealers who had departed from the prices specified; investigation and discovery of those not adhering thereto, and placing their names upon "suspended lists"; requests sent to offending dealers for assurances and promises of future adherence to prices, which were often given; uniform refusals to sell to those who did not; similar assurances and promises required of, and given by other dealers, followed by sales to them; while there were unrestricted sales to dealers who had observed the specified resale prices.

By the employment of these methods and means, the indictment charged, wholesalers in the company's products throughout the United States, with few exceptions, resold their goods at uniform prices fixed by the defendant, and refused to resell the products to retail dealers at lower prices. In turn, because of these things the retailers throughout the United States resold the products to the consuming public at the uniform price fixed by the company. In this manner competition in the sale of the products was suppressed, thus maintaining and enhancing the prices of such products to the retail dealers and the consuming public.

Was This a Violation of the Sherman Law?

The question for answer by the Supreme Court was the interpretation placed upon the indictment by the trial court, and thereupon to determine whether, so construed, it fairly charges violation of the Sherman act. The counsel for the Government contended that, as interpreted, the indictment adequately charged an unlawful combination within the doctrine stated in the case of Miles Medical Co. against Park & Sons Co. (31 Sup. Ct., 376), such unlawful combination resulting from restrictive agreements between defendant and sundry dealers whereby the latter obligated themselves not to resell except at agreed prices. However, in the Miles case the unlawful combination was effected through contracts which undertook to prevent dealers from freely exercising the right to sell.

The defendant company contended against this view and maintained that the trial court's opinion construed the charges as alleging only recognition of the manufacturer's right to specify resale prices and of refusal to deal with any one who failed to maintain these prices. A part of this opinion said that no charge was made that the company entered into any contract with any of its retail dealers in restraint of interstate trade and commerce, but the charge, in effect, was that it unlawfully created and engaged in a combination with certain of its wholesale and retail customers to procure adherence to resale prices fixed by the company which resulted in enhancement and maintenance of such prices, suppression of competition, etc. The view of the trial court was that the question was fairly presented of whether a manufacturer of products shipped in interstate trade is subject to criminal prosecution "for entering into a combination in restraint of such trade and commerce, because he agrees with his wholesale and retail customers upon prices claimed by them to

be fair and reasonable, at which the same may be resold, and declines to sell his product to those who will not thus stipulate as to prices. This, at the threshold, presents for the determination of the court, how far one may control and dispose of his own property, that is to say, whether there is any limitation thereon, if he proceeds in respect thereto in a bona fide and lawful manner. That he may not do so fraudulently, collusively, and in unlawful combination with others may be conceded. But it by no means follows that, being a manufacturer of a given article, he may not, without incurring any criminal liability, refuse absolutely to sell the same at any price, or to sell at a named sum to a customer, with the understanding that such customer will resell only at an agreed price between them, and should the customer not observe the understanding as to retail prices, exercise his undoubted right to deal with such person. . . .

ANY DEALER IN REALITY FREE TO SELL AT ANY PRICE HE CHOSE

"No suggestion is made that the manufacturer attempted to reserve or retain any interest in the goods sold, or to restrain the vendee in his right to barter or sell the same without restriction. The retailer after buying could, if he chose, give away his purchase or sell it at any price he saw fit, or not sell it at all, his course in these respects being affected only by the fact that he might by his action incur the displeasure of the manufacturer, who could refuse to make further sales to him, as he had the undoubted right to do. There is no charge that the retailers themselves entered into any combination or agreement with each other, or that the defendant acted other than with his customers individually."

MANUFACTURER MAY REFUSE TO SELL TO ANY RETAILER

The purpose of the Sherman act, said the Supreme Court, is to prohibit monopolies, contracts and combinations which probably would unduly interfere with the free exercise of their rights by those engaged or who wish to engage in trade and commerce. It aims to preserve the right to freedom to trade. In the absence of any purpose to create or maintain a monopoly, the act does not restrict the long recognized right of trader or manufacturer, engaged in an entirely private business, freely to exercise his own independent discretion as to parties with whom he will deal; and of course he may announce in advance the circumstances under which he will refuse to sell, said the court. Quoting from another case the court said: "A retail dealer has the unquestioned right to stop dealing with a wholesaler for reasons sufficient to himself, and may do so because he thinks such dealer is acting unfairly in trying to undermine his trade."

The affirmation of the judgment of the lower court was a vindication of the company in the manner and methods employed by it in attempting to maintain its resale prices. However, it will be noted it was not charged with selling its products to dealers under agreements which obligated the latter not to resell except at prices fixed by the company.

THE SCHRADER CO. CASE

Judge Westenhaven in the U. S. District Court for Ohio has just quashed an indictment returned by the Federal Grand Jury against A. Schrader's Son, Inc., for having entered into certain contracts with the tire maker and jobber for the handling of its goods, which contracts fixed the prices at which the tire maker might sell to the jobber, retailer and consumer, and the jobber might sell to the retailer and consumer.

The Government contended that the entering into these contracts was an offense under the Sherman act, and that the case was not controlled by the decision of the Supreme Court in the Colgate case, which held, among other things, that a manufacturer could choose his own customers and announce in advance that it would deal only with such customers as maintained the prices fixed by the said manufacturer.

The contention of the Schrader company was that there was no essential difference between its selling plan and that of the Colgate company, and that the mere fact that it announced its prices in a written license agreement which was signed by the tire makers and jobbers did not bring the case within the Sherman act.

The decision of Judge Westenhaven was in effect that the charges in the Schrader indictment did not constitute a crime under the Sherman anti-trust act, and the indictment was accordingly dismissed.

Measure of Damages for Failure to Deliver Specified Quantity of Goods

The measure of damages for failure to deliver a specified quantity of goods as agreed was decided in the case of De Greeff against the Franco-American Chemical Co. (174 N. Y. S., 70). Plaintiff sued for breach of defendant's agreement to deliver certain goods under a written contract which called for delivery during March. The delivery was made on April 6, and was short about five tons. In reply to plaintiff's protest against the shortage of the goods, the defendant consistently and persistently maintained that it would not furnish the balance. Since it chose to break its contract, the measure of damage recoverable against it is the difference between the contract price and the market price of the amount of goods undelivered at the time and place of the delivery called for by the contract or selected by the parties by a subsequent valid agreement.

The trial judge admitted in evidence the range of prices of the goods undelivered, up to June, which was two months after the breach of the agreement. The Supreme Court held this to be unjustified, it appearing that there was a ready market for the goods at all times, and that the market price at the time of the breach varied but little, if at all, from the contract price.

The jury having found that defendant was in default, the plaintiff was entitled to be compensated for his loss, said the court, but he was not entitled to speculate at defendant's expense on the course of the market for two months after the default occurred.

New Process for Converting Ore Into Metal

A Norwegian firm, A/S Norsk Staal (Elektrisk-Gas-Reduktion of Christiania) worked out, during the war, a general process for reducing tungstic acid into tungsten powder and molybdenum sulphide into metallic molybdenum. It claims that the final products, which are in the form of small tablets, are of the most superior quality, being completely free from sulphur, carbon, or oxygen. It also says that the cost of converting the ores into metal is lower than by any other method known by it.

A New Plug Valve

ONE of the recent developments in chemical accessory apparatus of vital importance to the industry is a non-stick lubricated plug valve.

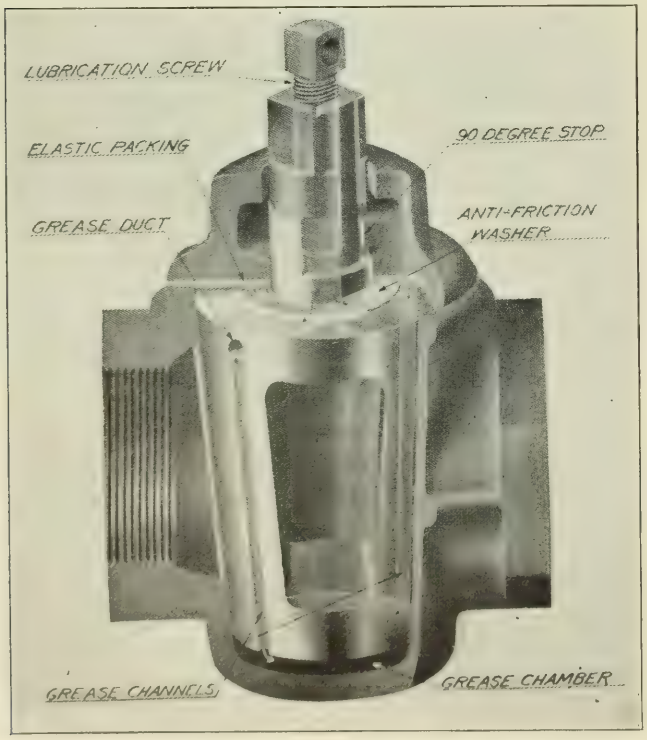
A plug valve is the logical type for use in pipe lines handling slimes, slurries containing abrasive materials and all other liquors where solid materials are carried in suspension. The difficulty of using this type has been, however, that the bearing surfaces of the valve have rapidly corroded, causing the plug to stick and resulting in high breakage costs when workmen attempted to keep the valve in operation. This has been particularly true in the operation of cyanide plants, and it was to do away with this trouble that the Nordstrom lubricated plug valve was first designed and placed on the market by the Merrill Co. of San Francisco. Its basic principle is the combination in a plug valve of lubricant conduits, and a lubricant chamber at the base of the plug, so positioned that when pressure is applied to the lubrication screw, this pressure operates to lift the plug from its seat and simultaneously to distribute lubricants over the bearing surfaces. A flexible packing is provided between the body of the valve and the cover. This packing also rests upon an anti-friction washer forming the thrust bearing of the plug, which is grooved concentrically to prevent leakage.

The flexible packing furnishes the necessary elasticity to allow the plug to be forced from its seat for the purposes of lubrication and to force the plug back into its seat when the pressure in the lubricant chamber is released. A stop is cast as an integral part of the plug and cover and is so positioned that the lubricant conduit can never be exposed to the fluid passing through the valve.

An investigation of this valve in operation has shown that no matter how firmly the plug may be stuck to the body of the valve, when force is applied to the lubricating screw, a pressure is created in the grease chamber at the base of the plug and this pressure must either raise the plug from its seat or break the body of the valve. This screw may be turned even in the 6- and 8-in. sizes by the application of an ordinary 18- or 24-in. monkey wrench.

The protective coating of lubricants on the bearing surfaces insures a tight fit at all times.

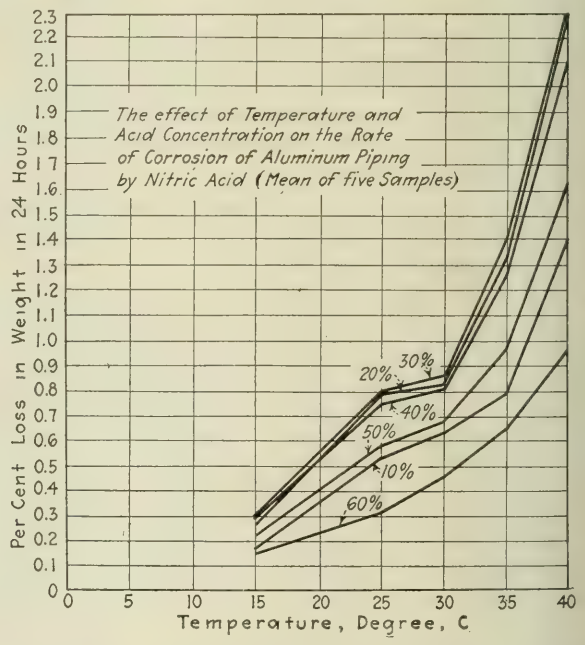
These valves may be made from any acids or alkali-resisting metals, such as Duriron, aluminum, ceramic ware. Such a piece of apparatus should prove a boon to many operators in chemical plants in maintaining the flow of important fluids through the processes.



NON-STICK LUBRICATED PLUG VALVE

Acid-Resisting Qualities of Aluminum

A SERIES of experiments recently conducted have shown that aluminum metal makes a good material for use around nitric-acid towers and as piping for the construction of the acid lifts. After considerable work by the producing companies it has been found that aluminum can be manufactured on a commercial basis with a purity in excess of 99 per cent.


The effect of Temperature and Acid Concentration on the Rate of Corrosion of Aluminum Piping by Nitric Acid (Mean of five Samples)
Per Cent Loss in Weight in 24 Hours
Temperature, Degree, C
20%
30%
40%
50%
10%
60%

Contrary to the usual belief, the corrosion of aluminum piping by nitric acid is in more direct proportion to the temperature and not affected by the concentration; in fact, the higher the concentration the less the corrosion, temperature being the same in both cases. This is very clearly shown in the accompanying figure.

In making up the curves shown, five pieces of 1-in. aluminum pipe were selected at random and immersed in the acid concentration designated for each curve. The first set of experiments was made at room temperature averaging about 15 deg. C. After this, runs were made at 25 deg. C., 30 deg. C., 35 deg. C. and 40 deg. C. In the experiments at room temperature the corrosion tests were continued for 21 hr. per day for five days, the test pieces being weighed each day. In the runs at higher temperatures five 6-hr. periods were used, weighings being made after each 6-hr. period. This procedure eliminated errors and made

certain that the behavior of each piece of pipe was substantially uniform.

It is therefore concluded that where piping is used for acid lifts they should be immersed in a well continually overflowing with running water. The trouble with the use of aluminum, however, for acid lifts is not so much on account of the corrosion feature as because of the short life of rubber gaskets which are used between the joints of piping in the construction of lifts. Duriron or high-silica iron connections should be used in all cases.

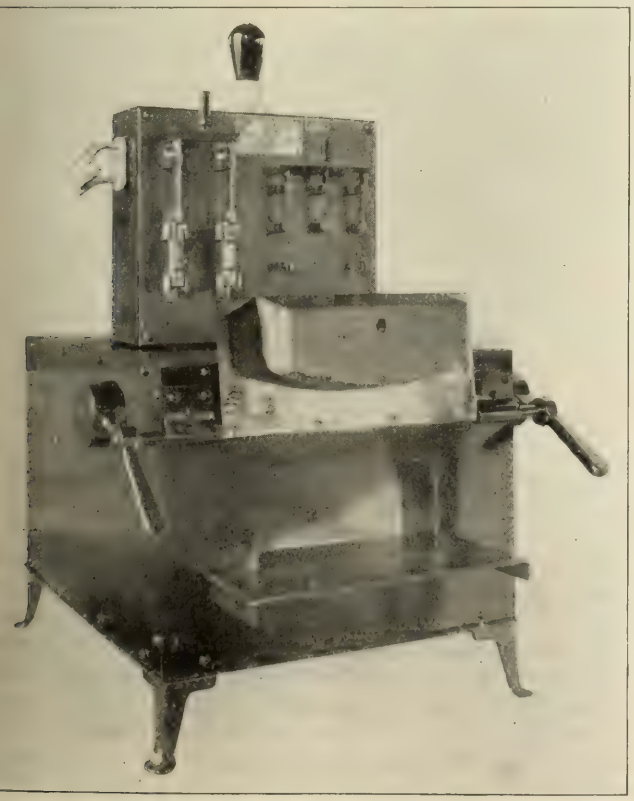
An alloy has recently been prepared by the Chemical Equipment Co. consisting of aluminum and a small percentage of some of the rare earths, the formula being secret. This alloy is known as No. 78 and has the following physical properties:

Weight, lb. per cu.in.	0.09
Yield point, lb.	9,530
Tensile strength, lb. per sq.in.	18,040
Elongation, per cent in 2 in.	2.5
Reduction of area, per cent	5.3

The percentage of aluminum contained in this alloy is about 96. It has been found a perfect metal for resistance against the action of acetic acid. Tests have been made by immersing a bar having a total surface of 34 sq.cm. weighing about 30 g. in 70 per cent of acetic acid for 46 hr. at room temperature, and then bringing the solution to a boil for 5 min. and allowing to cool for 2 hr. The loss in grams per sq.cm. was 0.00006. This metal is used by the company in the construction of acid-resisting equipment.

Electrically-Heated Laboratory Metal Furnace

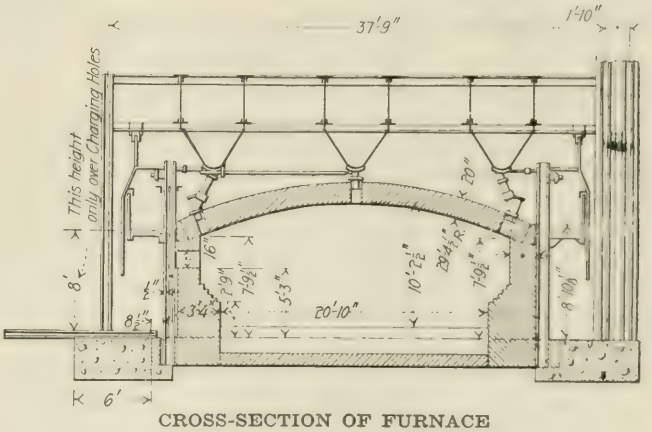
The General Electric Co. has designed and placed on the market an electrically-heated metal furnace for use in laboratories where heat of 1560 deg. F. and below are required on control and research work. This furnace is lined with fireclay and has inside dimensions of 15 in. long x 8½ in. wide x 4½ in. high. The current consumed at the maximum heat is 4 kw. and at the secondary heat, 2 kw. The heat is hand controlled and an indication lamp is provided on the top of the furnace for showing when the full amount of current is turned on. The accompanying illustration gives a general idea of the design, the metal parts consisting of sheet iron and malleable castings. A slate panel is mounted on the top and is an integral part of the furnace. This panel mounts switches for controlling the temperature as shown. The refractory door is counterweighted with handles for opening at either end of the furnace.



METAL FURNACE, ELECTRICALLY HEATED, FOR LABORATORIES

Synopsis of Recent Chemical and Metallurgical Literature

Furnace for Converter Slag.—A large reverberatory furnace was erected on the converter floor at the Washoe smelter about three years ago, whose operation is to be described by FRED LAIST and H. J. MAGUIRE, of the Anaconda staff, before the forthcoming meeting of the Mining & Metallurgical Engineers.



CROSS-SECTION OF FURNACE

The figure shows a cross-section; it is 153 ft. (46 m.) long inside, with rectangular hearth, the roof being drawn down at the skimming end. The flue is 6 ft. wide x 8 ft. 6 in. high (2.5 x 1.8 m.). Three-side doors are provided near the firing end of the furnace through which hot slag can be laundered; two matte taps are about 25 ft. (8 m.) from the other end; skim line is 18 in. (45.7 cm.) above furnace bottom. It is equipped with hoppers on both sides for the fuel length, and down the center for 100 ft. Five pulverized coal burners, using 16-oz. air, supply the fuel. Immediately over and opposite the slag-charging spout the hopper carries concentrates; from this point back to the burners the sides are banked with special (high S) calcine, and thence forward the banks are siliceous material. In operation the sulphur in calcine reduces Fe_2O_3 and Fe_3O_4 in converter slag to FeO, which is slagged by silica from the banks to produce a slag containing not less than 30 per cent silica; calcine also provides matte for washing disseminated globules of white metal from the slag. The slag is charged from 9-ton ladles at intervals of 15 min., a small stream of free concentrate dropping into the furnace just over the inflowing liquid.

Two Stirling boilers, type M, rated at 865 hp. each, are placed in a double 15 x 13 ft. (45 x 3.9 m.) flue leading from the furnace in such a way that either or both may be operated. Cooled gases are then discharged through a brick-lined 12 x 200 ft. (3.6 x 60.9 m.) steel stack, connection to the main flue system not being available without extensive and costly construction. Skimming block and magnesite-lined slag launder are both water cooled, while the cast-iron tap hole plates are set in a long, narrow water jacket.

Results for July, 1918, are tabulated below:

PER CENT BY WEIGHT OF MATERIAL TREATED

	Total Tons	Daily Average	Per Cent
Converter slag	16,813.0	54.2	54.5
Concentrate	1,748.0	56.4	5.7
Calcine	11,681.1	376.8	37.9
Tailings	595.7	19.2	1.9
Total	30,838.1	994.7	100.0
Coal burned	2,436	78.6	.....
Coal ratio, to whole charge			1:12.66
Coal ratio, to solid charge			1:5.76

Analyses

	Converter Slag	Furnace Slag	Calcine	Concentrate
SiO_2	23.3	34.1	30.8	19.2
Cu	3.95	0.55	7.85	7.64
FeO	61.2	53.3	36.3	37.9
S	0.8	....	8.8	35.6
CaO	0.1	1.7	3.3	0.1
Al_2O_3	5.9	....	5.9	4.2

Copper in all material treated, lb.	3,459,448
Copper in all converter slag, lb.	1,328,227
Copper in all other material, lb.	2,131,221
Silica to slag, lb.	17,232,647
Slag produced, tons	25,268
Copper in slag, lb.	277,948

Recovery of copper based on silica balance, 91.97 per cent

Average cost for 1918 = 61c. per ton of converter slag, less credit of 26c. for waste heat power.

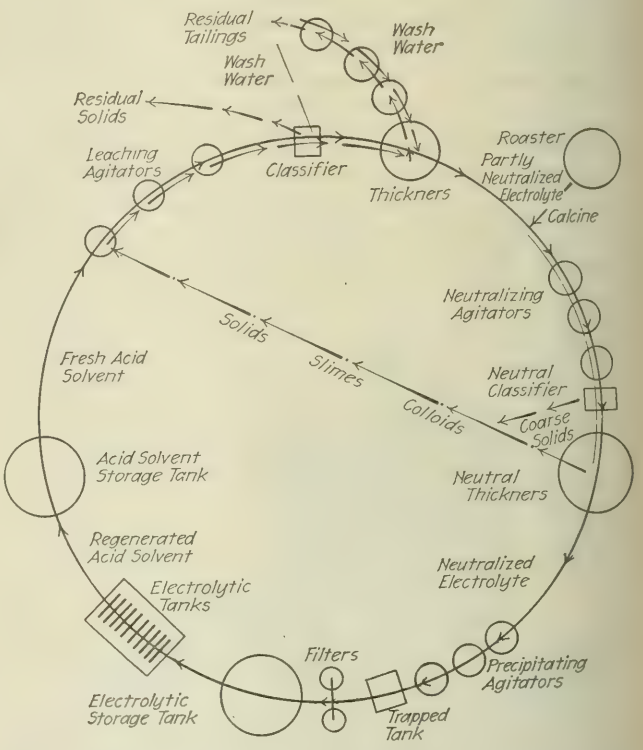
In a run of 409 days ending early in 1919 the waste slag averaged 0.57 per cent copper. This is equivalent to an increase of only 0.05 per cent in the copper content of all of the reverberatory slag produced, and is probably fully as good a result if not better than if the converter slag had been spread uniformly through all of the furnaces.

Magnetic Analysis.—R. L. SANFORD and WILLIAM B. KOUWENHOVEN describe a testing machine designed to locate flaws in rifle-barrel steel by magnetic analysis, in Scientific Paper 343 of the Bureau of Standards. Their method is similar to that of Burrows' for steel rails (See MET. & CHEM. ENG., vol. 17, p. 130), and mounts the bar to be studied vertically, as a solenoid core, the counterweighted coils moving along it as a guide. Mounted within this magnetizing solenoid is a test coil by means of which variations in magnetic flux within the bar can be measured. For uniform bars, no electromotive force will be induced in the test coil; if, on the other hand, the permeability is not constant, the flux will vary and an induced electromotive force will be indicated by a galvanometer in circuit. Records were automatically made by photographing a beam of light from the galvanometer mirror in an oscillograph.

Experiments showed that a flux density of 15,000 gausses and a travel of 6 in. per sec. with a short-period (1-sec.) galvanometer gave best results. Great difficulty lies, however, in the interpretation of the results, and while many bars in a lot rejected on account of pipes were examined, not a single pipe was discovered in drilling samples for which records of magnetic uniformity had been obtained. The sensitivity must be reduced to prevent rejection of satisfactory material, and the record which indicates a pipe is still to be determined.

Recent Chemical and Metallurgical Patents

Process for the Extraction of Zinc.—R. H. STEWART, of Vancouver, B. C., and S. G. BLAYLOCK, ROBERT VAUGHAN and J. K. BATCHELDER, of Trail, B. C., have been granted a patent for the hydrochemical extraction of zinc from ores or other zinc-containing material in which the zinc has been made soluble by roasting. This patent covers the process in use at Trail, B. C., by the Consolidated Mining & Smelting Co. of Toronto, Canada. In order to obtain a coherent deposit of zinc on the cathodes of an electrolytic cell, it is essential that metal electro-negative to zinc be removed from the electrolyte. This is usually accomplished by precipitating these metals on metallic zinc in a neutral or nearly neutral solution. The zinc and precipitated metals are removed from solution by filtration and the solution is delivered to the electrolytic tanks. This neutralization is accomplished by pulverized limerock, zinc hydrate or other base. In the process described, however, the neutralization is accomplished by agitation with freshly roasted zinc



ore or calcine. The use of the solution is cyclical; being delivered to the neutralizing agitation tanks from a preceding operation, it does not contain a sufficient amount of acid to remove all the soluble zinc. The pulp from the agitation tanks, which consists of neutralized solution and suspended solids, passes from the agitation tanks to a classifier, where the coarse solids are removed, thence to a continuous decantation thickener, in which the solution is separated from slimes and colloids. The coarse solids, slimes and colloids are delivered to leaching agitators. The neutral solution is treated in agitating tanks with metallic zinc, freed from zinc and precipitated metals by means of filter presses and the solution

delivered to storage tanks for use in the elctrolytic zinc cells as desired. Sulphuric acid is regenerated on the electrolytic tanks and the acid electrolyte depleted in zinc is delivered from the electrolytic cells to a storage tank. From this tank the acid solution is delivered to the leaching agitators previously mentioned, together with the solids, slimes and colloids from the classifier and thickeners. The remaining soluble zinc is dissolved and the acid in solution partly neutralized. The solids are removed from the solution and washed by a second classifier and set of thickeners; the solution and wash water pass on to the neutralizing agitators, where it is again treated with calcine, completing the cycle. The solid from the thickeners is discharged to the dump. In the accompanying sketch the cycle of the solution is shown by the full line circle, the flow of solids by the dash and dot lines, and the wash water by the broken lines. (1,320,805; Nov. 4, 1919.)

Method of Obtaining Pure Tungsten.—JOHN B. EKELEY and W. B. STODDARD, of Boulder, Col., produce pure sodium tungsten from wolframite, hubnerite, ferberite, scheelite, tungstite or other ores of tungsten as follows: The ore is crushed and ground to a suitable degree of fineness, depending upon the facility with which it responds to subsequent treatment, and mixed with salt, sodium carbonate and, if necessary, silica. Sufficient carbonate is added to combine with all the tungstic acid and leave an excess; sufficient silica must be present to combine with the excess of carbonate. With some ores sodium nitrate or chlorate is added to provide an oxidizing agent. This mixture is fused in a suitable furnace. The fusion is cooled, crushed and lixiviated with twice its weight of water. The sodium tungstate is soluble and the solution in addition contains compounds of phosphorus and arsenic. The solution is heated and magnesium chloride or nitrate added in excess of the amount necessary to precipitate $MgHPO_4$. The solution is then boiled. To the boiling solution is added a mixture of sodium hypochlorite and ammonia. This precipitates almost immediately all but minute traces of arsenic and phosphorus from the solution. In addition to the sodium tungstate the solution will contain sodium chloride and small amounts of carbonate and sulphates. The precipitate is filtered from the solution and treated with a fresh charge of ore. Arsenic and phosphorus do not accumulate in the process, since the larger portion of the elements are removed in the slag of the fusion furnace. (1,322,485; Nov. 18, 1919.)

Treatment of Zinc-Bearing Ores for Recovery of Zinc by Electrodeposition.—The usual methods of purifying zinc sulphate electrolyte by treatment with limestone for the removal of iron and other impurities and with zinc dust for the removal of silver, copper, cadmium, antimony and arsenic do not remove cobalt. This element adversely affects the electrodeposition of zinc from this solution, but where cobalt has not accumulated to more than 200 to 300 mg. per liter this deleterious effect can be overcome by the addition of glue. In solutions containing up to 100 mg. cobalt per liter, 5 lb. glue per ton of zinc produced is required and it is desirable to add 1 lb. glue for each additional 50 mg. cobalt per liter present. When the amount of cobalt has accumulated in excess of 300 mg. per liter, it becomes necessary to remove this element from the electrolyte. This may be accomplished by adding to the solution 1.5 mg. copper as sulphate and 1.5 mg. arsenic as sodium arsenate for each milligram cobalt present and then agitating with from 8 to 10 times the quantity of zinc dust as there was copper added. This purification is carried out at a temperature of 75 deg. C. and removes cobalt and other impurities effectively. (H. W. GEPP, DAVID AVERY, R. H. STEVENS and H. W. SNOW. Assigned to Electrolytic Zinc Co. of Australia Proprietary, Ltd., of Melbourne, Australia. 1,322,104; Nov. 18, 1919.)

Hardening After Long Reheating.—GABRIEL VAN OORDT, of Basel, Switzerland, has found that many alloys and pure metals, when reheated to a certain moderate temperature (characteristic for each composition) for several days or weeks, convert castings or forgings which are machined with difficulty into pieces which cut satisfactorily, yet have a higher tenacity and hardness. Prolonged heating to a lesser temperature produces only a partial hardening. As instances of his patented method he cites the following:

Alloy	Original hardness	Reheat	Time	Subsequent hardness
85 Al : 15 Zn	50	70° C.	5 days	92.6
98 Al : 2 Cu	32.7	160°	10 days	55.3
Zn	35	300°	1 day	39.0
Cu	30	200°	20 days	42.9
72 Cu : 28 Zn	41.2	300°	3 days	47.4
Fe	85.7	300°	50 days	104

(1,326,775, assigned to Société Anonyme des Usines Giulini, Basel; Dec. 30, 1919.)

Combination Converter and Electric Furnace.—A side-blown converter is patented by P. F. SARRON and JULES SIMON, of Lyons, France, having a hinged door over the mouth, and two large removable plugs closing corresponding openings through the lining and shell between wind box and mouth. After a blow is completed in the ordinary way, the converter is tipped over horizonally, the mouth tightly closed, and the plugs, now on top of the shell, replaced by electrodes, with proper holders and operating mechanism. In this way the vessel is quickly converted into an electric furnace for final refining. (1,325,114; Dec. 16, 1919.)

Regeneration of Pickling Solution. — WILLIAM FEENIE of Buhl, Minn., and WILLIAM W. RHODES of Wilmington, Del., note that a pickling bath of sodium bisulphate solution gives a better surface for many uses than sulphuric acid, but the solution becomes inactive before all the reagent is consumed, resulting in a large waste in chemicals. The activity may be regenerated by decreasing the ratio of normal sulphates (especially of sodium) to the bisulphates, most easily done by cooling from 60 deg. C., the usual working temperature, to 30 deg. C., when a large portion of Na_2SO_4 and a smaller amount of $FeSO_4$ will salt out. (1,326,585, assigned to E. I. du Pont de Nemours & Co.; Dec. 30, 1919.)

Melting Light Scrap in Acid Open-Hearth.—SIR ROBERT HADFIELD, of Westminster, England, patents a method of melting turnings in an acid open-hearth without adding pig iron and without damage to the furnace. As an instance he covers the hot bottom with crushed slag from a previous heat, and then with a layer of equal parts of 50 per cent ferrosilicon and anthracite crushed to ¾ in. (2 cm.). Nine tons (9,100 kg., or one-third the charge) of turnings was then quickly charged and melted to protect the loose material from oxidation and the remainder of the charge

introduced over a period of four hours. Immediately before each batch was charged, a layer of the ferro-carbon mixture was spread on the banks, and after the final melting, a layer of fine anthracite thrown around the edge of the bath. About 550 lb. (250 kg.) of Cumberland iron ore was introduced just before the charge came to boil, and the boil maintained until the carbon was as low as necessary; then being stopped with the usual addition of ferrosilicon. Ferromanganese was then added to desulphurize. (1,326,861; Dec. 30, 1919.)

Personal

E. M. Bond, formerly metallurgist and chemist of the American Platinum Works of Newark, N. J., has resigned to assume similar duties with the Interstate Smelting & Refining Co., Newark, N. J.

Elmer H. Bunting has accepted a position as research associate in ceramics at the University of Illinois.

Dr. Charles E. Caspari, professor of chemistry at the St. Louis College of Pharmacy, has just been elected chairman of the St. Louis Section of the American Chemical Society and will have charge of the general arrangements for the national meeting to be held in St. Louis, April 13 to 16.

E. B. Clark, formerly in the laboratory of the Ward Baking Co., New York City, is now chief chemist of the Omaha Flour Mills Co., Omaha, Neb.

H. S. Emlaw has been appointed general manager of the American Trona Corp. in California, and Frederick Vieweg assistant general manager.

Leo Finkelstein has resigned his commission as lieutenant in the Chemical Warfare Service and has resumed duties as instructor in chemistry at the University of Chicago.

N. J. Gothard has resigned his position in the laboratory of the Sanitary District of Chicago to accept a position with the Sinclair Refining Co., East Chicago, Ind.

Dr. A. O. Lundell has become associated with the Allbright-Nell Co., manufacturer of packing house machinery and equipment. Dr. Lundell has been in the U. S. Bureau of Animal Industry Service for fifteen years, and has been prominent in the development of mechanical packing house equipment for the conservation of meat food products.

Dr. C. S. Miner read a paper on "The Verification of Percentage Formulas" before the annual convention of the Association of Feed Control Officials at Washington recently.

Dr. H. W. Morse has resigned from the position of technical manager of the American Trona Corp. and accepted the position of consulting physical chemist to the company.

A. V. H. Mory, recently director of the technical laboratories of Sears, Roebuck & Co., has resigned this connection to engage in executive duties as head of the chemical division of the Procter & Gamble Co., at Cincinnati. Mr. Mory was graduated from Ross Polytechnic Institute in 1894; was assistant chemist of Armour & Co. 1896-1901; in charge of the laboratory of Armour Packing Co., Kansas City, 1901-1907; chief of the U. S. Food and Drug Inspection Laboratory, Kansas City, 1907-1911. In 1911 he was invited by Sears, Roebuck & Co. to put into effect his ideas concerning the organization of a technical department, applying the spirit of the food and drug act to a general line of merchandise, including almost every article of commerce. His marked success in this work during the past nine years is well known to the members of the profession.

R. W. Mumford has accepted the position of chemical engineer in charge of development at the American Trona Corp. plant at Searles Lake, Cal.

E. C. Prins, chemical engineer of the University of Delft, Holland, is in the United States for the purpose of visiting industrial chemical plants.

Oliver C. Ralston of Colorado Springs, Col., has been appointed superintendent of the Seattle experiment station of the Bureau of Mines. Mr. Ralston is a chemist and an electrometallurgist. He was formerly connected with the Salt Lake City experiment station of the Bureau of Mines, but for the past two years has been engaged in electrochemical work at Niagara Falls for private interests.

Edward N. Roberts has resigned his lieutenancy in the Sanitary Corps and has accepted a position as assistant professor of chemistry at the University of West Virginia.

Dr. W. F. Straub, who was formerly with the Abbott Laboratories, has recently organized a chemical and biological laboratory with Dr. C. A. Zell, to be known as the Zell-Straub Laboratories, located at 1611 Masonic Temple, Chicago, Ill.

U. B. White, who has been connected with the administrative branch of the experiment station work of the Bureau of Mines, has resigned to become assistant secretary of the American Chemical Society. He will be attached to the office of Dr. Charles L. Parsons, in Washington.

Obituary

Richmond Levering, president of Richmond Levering & Co., Inc., promoters and developers of oil interests, died on Jan. 28, of pneumonia, in his thirty-ninth year, at his residence, 1 East 56th St., New York City.

Mr. Levering was graduated in 1902 from Sheffield Scientific School at Yale, where he rowed on the crew. Going to the Middle West, he became a pioneer in the development of the Illinois oil fields. His first large promotion was that of the Indian Oil Refining Co. Later he organized many oil properties in Texas and Mexico. Two of the leading concerns he promoted, both often in the public prints as a result of the enormous speculation of the period, were the Metropolitan Petroleum Corp. and the Island Oil & Transport Co.

During the war Mr. Levering was chief of the secret service division of the American Protective League in New York and special representative of the Department of Justice in Latin-American countries. With the rank of major he was chief engineer of the mechanical section of the American University Experiment Station in Washington. He was director of a half dozen oil companies.

Current Market Reports

The Non-Ferrous Metal Market

New York, Feb. 2, 1920.—The metal market was very firm last week. The only changes were in tin, zinc, silver and mercury.

	Cents per Lb.
Copper, electrolytic	19.50
Aluminum, 98 to 99 per cent	32 @ 33
Antimony, wholesale lots	11.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	60.12½
Lead, New York, spot	8.62½
Lead, E. St. Louis, spot	8.30
Zinc, spot, New York	9.40
Zinc, spot, E. St. Louis	9.05
Silver (Dollars per oz.)	1.34½

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS*

Cadmium	lb.	$1.50 @ 2.50
Cobalt	lb.	1.90
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	85.00

SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap	23½ @ 24½
Aluminum, sheet scrap	22½ @ 23½
Aluminum clippings	25½ @ 27
Copper, heavy machinery comp.	14½ @ 14¾
Copper, heavy and wire	13¾ @ 14
Copper, light and bottoms	12½ @ 12¾
Copper, heavy cut and crucible	15½ @ 16
Brass, heavy	7½ @ 8½
Brass, casting	10½ @ 10¾
Brass, light	5¾ @ 6¾
No. 1 clean brass turnings	8¼ @ 8¾
No. 1 comp. turnings	12 @ 12½
Lead, tea	5½ @ 5¾
Lead, heavy	6½@ 7
Zinc, scrap	4½@ 4¾

The Iron and Steel Market

Pittsburgh, January 30, 1920.

The aspect of the steel market has changed radically in the past week. The recent prospect has now disappeared that the market would be stabilized by the independents definitely restraining the advancing tendency after Steel Corporation leadership, on the basis of March 21 or Industrial Board prices, had been renounced. Definite and precise action was necessary to avoid a runaway, and this action has not been taken. Prices quoted by the various independents show a wide variation and show no direct relation with either of the price schedules upon which the independent market might possibly have been stabilized, those two being the war control prices and the prices ruling from Dec. 12, 1918, when certain reductions were made, to the date of the Industrial Board reductions of March 21, 1919. It had become clear several weeks ago that the independents would not follow the Steel Corporation leadership. The corporation has not departed from its policy, and it has not only adhered to the March 21 prices but has sold rather heavily at those prices, necessarily to its regular customers only.

The Steel Corporation has now announced a general wage advance of 10 per cent, this percentage to apply to common labor, while other wage rates will be adjusted in keeping. The independents will necessarily follow. While price changes and wage rate changes are naturally supposed to have more or less relation with each other, it is of interest to note that while it is the independents that have been advancing prices, the Steel Corporation making no change, it is the Steel Corporation that takes the lead in advancing wages.

Not only are independent steel producers advancing prices, some of them remain practically out of the market, having definite sales that will carry them only until about April 1, while they have made some promises to regular customers to the effect that they will take care of their requirements in the second quarter, at prices to be named later, perhaps by March 1 or March 10. These conditions add to the nervousness of consumers, who are even more disposed to make bids to producers in hopes of securing protection. All the conditions are conducive to there being a runaway instead of a stabilized market.

Runaway in the Steel Market

It is reasonably clear, therefore, that a runaway in the steel market has actually begun. It is entirely a matter of doubt why the runaway is permitted and how long it will last. The independents may have wished that a runaway could be prevented, but felt powerless to hold the market, or they may have felt that the profits to be secured during a runaway would overbalance the obvious disadvantages involved. There has been only one complete runaway in the steel market's history, that of 1899, and thus there is no experience as to how long a runaway in steel may last. In 1917 a runaway started, but the expectation of the imposition of Government control dampened it long before the actual control was established. The runaway of 1899 lasted only a few months. Then there was no Steel Corporation, and it is possible that the independents feel now that whenever the ground covered by their sally becomes untenable they can retire to the Steel Corporation's line of defense. It may possibly be found that the farther the independents advance their prices above the March 21 schedule the more strongly, if possible, the Steel Corporation will be disposed to adhere to that schedule. Though without abandoning one iota of the policy adopted, the Steel Corporation is free to make moderate advances in its prices, in keeping with increases in production costs, and particularly the increase caused by the 10 per cent wage advance effective Feb. 1, which will increase costs on several millions of tons of steel sold at March 21 prices and still to be manufactured.

The argument need not be elaborated that there are no alternatives but a stabilized steel market and a runaway. Except from the long range view the market is not a matter of actual production and actual consumption, but one of demand and offerings. Even in a market that is safe against radical advances and with producers relatively free in selling, buyers become nervous and seek to purchase farther and farther ahead. Now there is no assurance of price advances being moderate, but rather the contrary prospect, and the independent producers are very reserved in the matter of selling, some having been almost out of the market for months. Consumptive requirements may exceed production, but apart from that the demand greatly exceeds the offerings, hence the only alternatives are a runaway and a stabilized market.

While the Steel Corporation has absolutely stabilized its own prices up to date by refraining from making any sales at above the March 21 schedule, the independents have done nothing to stabilize their market and the time when such a thing could be done has in all probability passed. There is no coherence between prices quoted by one independent and another, and the same producer frequently quotes different products at different levels, offering one product at the Jan. 1 price, another at the war control price and another at a price still higher. The theories recently propounded that the independents would by individual action adopt either the Jan. 1 price schedule or the war control schedule has been exploded by the prices they actually quote to prospective buyers, and at which they have made sales to regular customers of long standing.

Pig Iron Market Likewise in a Runaway

The pig iron market is likewise engaged in a runaway. It had the earmarks of a runaway in the rapid advances that occurred from about the beginning of October until the short holiday dullness intervened, but at that time there was the influence of steel prices, which were not advancing markedly, and thus the steel market might have held the pig iron market within some kind of bounds. That influence has now disappeared. Basic and foundry iron have advanced to $40, valley, and bessemer to $41, further advances being in clear prospect since the furnaces that are selling—second half delivery being about all that is available—profess to be selling some "backlog" business only. The Eastern market has advanced to $44.35, delivered Philadelphia, for No. 2X. While $50 pig iron is being predicted, that price is merely selected as a round figure for predicting purposes. It does not represent the buyers' limit any better than $45 or $55 would, since the buyers' limit is not known.

Some independent steel mills recently sold sheet bars to regular customers at $50, the March 21 price being $42, but will sell no more at that figure, and now ask $55 from regular customers, and about $60 from chance buyers.

Ferro-Alloys

Producers of ferromanganese continue to jump prices, and are said to be fully sold up for the first half, quotations now being $150 to $160, delivered, for 76 to 80 per cent. Spiegeleisen is quotable at $47.50 for spot and $50 to $55 for futures, at furnace.

Electrolytic ferrosilicon is quoted at $80 for 50 per cent and at $140 for 75 per cent, delivered Pittsburgh, valleys and Cleveland. Bessemer ferrosilicon is quoted still by some sellers at $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, but one or two producers are reported to have made advances and others may follow.

The Chemical Market

New York, February 2, 1920.

Firmness was the predominating note of last week's heavy chemical market. No drop has occurred in foreign inquiry, the alkalis receiving special attention. Spot material on any item is hard to find, the supply still remaining limited, which has sustained the present price level. Contract business with year-end delivery is being sought, as many producers are all sold up until that time.

Heavy Chemicals

Soda ash has been causing trouble, as it is practically off the market at present. The quotation of $2.25 per cwt. is nominal, as whatever material is on hand is being quoted at higher prices. Manufacturers are pressing their plants to the limit in order to meet contracts, and it is evident that it will be some time before this item recovers. *Bichromate of soda* is stronger and another jump is expected soon. Small lots are to be had on spot, but the 20@21c. quotation on contract prevails.

Epsom salts have increased in demand at a quotation $2.50@$2.70 per cwt., varying with the quantity. The association's price on *caustic soda* remains $4.25 per cwt., but it is unable to furnish any at this price. The average quotation is about $4.35 with no increased stocks in sight. *Formaldehyde* is stronger at 51@52c. per lb., with the entire output filling contracts. Even small quantities used by jobbers are practically exhausted. *Sal ammoniac* continues strong at 12¼@14c. per lb. and a rise in this item is due owing to an increased demand and decreased supply. The quotation on English material jumped 1c. to 11¼c., with the supply falling off. Exporting from England to this country is considerably less than it was a few months ago due to a shortage of ammonia liquor, and when these stocks are depleted a rise is expected on the domestic. *Chloroform* remains firm at 30@31c., most business being done on small lots. *Cream of tartar* has been active, but previous quotation of 56@60c. still holds. *Permanganate of potash* has been rather quiet, but owing to the scarcity of spot material the price still remains 65@75c. per lb. *Borax* continues under good demand with the same prices holding. The offerings on this item have fallen off slightly.

Coal-Tar Products

The extreme shortage in nearly all branches of this field has not become any easier. Large producers have withdrawn a number of items from this market and are reserving them for their own use. Expansion of plants has been going along steadily, but until there is some definite arrangement made whereby the American manufacturer will be protected from foreign markets, production will continue to fall short of demand, as the present facilities are not sufficient to meet the requirements. *Solvent naphtha*, water white, is to be had at 22@27c. per gal. The supply is fair, but inquiry has been light. *Benzol* is practically unattainable at present and there is no immediate relief in sight from this pressure. The reserve stocks, surplus after the war, of *toluol* are now being drawn upon and this branch has been easier, 28@29c. still holding.

Waxes

The waxes have been quiet, with the usual trading in small quantities and prices remaining at the same level. *Montan* is back on the market after an absence of several years and the present quotation is 30@31c. per lb. *Paraffines* remain unchanged in price with no relief in supplies. Buyers are not overanxious to stock up at the present prices, which accounts for this firmness.

Naval Stores

Spirits of turpentine is still active at $1.97 per gal., with a good supply of material in this market. The Savannah market has been advancing steadily and at present is quoted $1.88¼, while the London market remains unchanged, speculation is ripe and supply remains far behind the demand. All grades of the *rosins* continue firm, with F grade in a place of special importance, quoted at $19.75 per ton.

The much abused difficulty of rate of exchange is accountable for the quietness in the *crude rubber* market. Buyers are not out for spot, and on the other hand sellers seem averse to parting with stocks that were bought at a higher rate of exchange, but despite this condition the market has remained fairly steady, with a slight drop of ½c. on *para*, upriver fine, to 47c. per lb. and also plantation, ribbed smoked, sheets, came down to 50@51c. per lb., against 51¾ of last week.

Vegetable Oils

Buyers of *linseed oil* seem well stocked up, as very few sales have been reported. The current price is $1.77 per gal. carlot, $1.80 less than carlot. A price of $1.65 can be obtained on forward delivery of May or June. *Soya bean* remains firm, with little new business, Manchurian remaining firm at 19@23c. per lb.

Cincinnati, February 2, 1920.

The continued scarcity of all raw materials has created a very firm tendency to the market for chemicals in Cincinnati. The market in all lines is very strong and in some instances stocks are sold up to as far as April. No improvement in the situation is looked for until the new stocks arrive in the spring.

Chemical plants, in an effort to meet the heavy demand for their products and to catch up with orders which have been delayed because of various adverse circumstances, are working three shifts daily.

Only current prices are available, as the price changes are noted daily. Some changes in prices have been made within the past few weeks, but these have been only to the extent of a cent or two. Spot stocks are few. Many bids have been made, with very few offerings. The coal situation has now righted itself in this district to a great extent and no further discontinuance of operations because of a fuel shortage is looked for, at least for the remainder of the winter.

Heavy Chemicals:—The market for heavy chemicals is firm with the demand strong. *Sodium bichromate* is quoted at 18½c. in carload lots and is very scarce. The price on this particular item has not changed within the last month. Some offerings have been made at 35@37c., but none has changed hands at that price. *Ammonium chloride* rules firm, with gray at 12¾c. and white at 16½c. No change was noted in the prices of this article in the past two weeks. Solid *caustic soda* is firm at $4.75 per cwt. f.o.b. Cincinnati. *Tin* is still very scarce and is quoted at 60c., an increase of 1c. over the quotation two weeks ago.

Coal-Tar Products:—A rise of a cent or two has been made in some products, with the market ruling firm. No spot stocks are available and in some instances stocks are sold up to April 1. *Benzol* is quoted at 41c., against 40c. two weeks ago. *Aniline oil* is selling at 37c., against 36c. two weeks ago; *aniline salts* is quoted at 41c., an increase of 1c. over the price of two weeks ago; *nitrotoluol* at 18c., there having been no price change over the quotation two weeks ago; *orthonitrotoluol* was selling at 27c. two weeks ago and has been increased to 28c.; *salicylic acid*, quoted at 92c., was quoted two weeks ago at 90c. *Benzoic acid* increased from $1.50 two weeks ago to $1.55.

Vegetable Oils:—The market for vegetable oils is very strong with no spot stocks. *Cotton oil* crude for February shipments did not increase, the quotation at 21¾c. two weeks ago ruling at this time. *Corn oil* continues active, with no price change at 21½c. in bbl. lots. *Menhaden fish oil* jumped 5c. on a gal., from $1.20 to $1.25. *Soya bean oil* in sellers' tanks is selling at 17¾c., against 17½@18c., with the demand strong. *Manila cocoanut oil* in sellers' tanks jumped to 19½@20c., against 18¾c., the price of two weeks ago. No price change was made in *linseed oil*, the present quotation being $1.79 in less than 5-bbl. lots.

Naval Stores:—The market is very firm. *Turpentine* in single barrels jumped to $2.03 over the price of $1.74. The market is very strong on this particular item, with no spot stocks, the supply being sold up to April. The market for *rosin* is very strong, with the prices on the increase, the latest quotation on F grade being $19, against $17.75 two weeks ago. *Raw white* is the same, at $22.35.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.60 – $0.65
Acetone	lb.	$0.16 –$0.20	.21 –
Acid, acetic, 28 per cent	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 –12.50	13.50 – 15.50
Boric, crystals	lb.	.14½– .15½	.15½– .16½
Boric, powder	lb.	.14½– .15	.15 – .16
Hydrochloric (muriatic), tech. 20 deg.	cwt.	2.50 –	2.60 – 2.75
Hydrofluoric, 52 per cent	lb.	.12 –	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½– .07
Molybdic, C. P	lb.	—	4.00 – 4.25
Nitric, 40 deg	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg	lb.	.06½– .07	.08 – .09½
Oxalic, crystals	lb.	.31 – .32	.32 – .40
Phosphoric, Ortho, 50 per cent solution	lb.	.09 –	.10 – .14
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 –22.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	22.00 –25.00	—
Sulphuric, 66 deg., drums	ton	—	—
Sulphuric, 66 deg., carboys	ton	—	—
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	25.00 –	30.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	32.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P	lb.	—	1.35 – 1.45
Tannic (tech.)	lb.	—	.42 – .55
Tartaric, crystals	lb.	—	.69 – .74
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	—	.76 – .78
*Alcohol, denatured, 190 proof	gal.	—	.71 – .73
Alum, ammonia lump	lb.	.04½– .05	.04½– .04¾
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾– .02	.02½– .02½
Aluminum sulphate, iron free	lb.	.02½– .03	.03½– .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½– .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	—	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½– .14	.13½– .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	.— –
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	—	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	—	.10½– .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride	ton	80.00 –85.00	100.00 –110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 –
Barium nitrate	lb.	.09½ .10½	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½– .04
Bleaching powder (see calcium hypochlorite)		—	—
Blue vitriol (see copper sulphate)		—	—
Borax (see sodium borate)		—	—
Brimstone (see sulphur, roll)		—	—
Bromine	lb.	.90 – .95	—
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	—	.04¾ .05
Calcium chloride, fused, lump	ton	20.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½– .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	—	2.50 – 3.75
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.05½–	.06 – .09
Carbon tetrachloride, drums	lb.	.10½– .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.75 –
Caustic potash (see potassium hydroxide)		—	—
Caustic soda (see sodium hydroxide)		—	—
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	—	1.50 – 1.55
Copperas (see iron sulphate)		—	—
Copper carbonate, green precipitate	lb.	—	.28 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.07½– .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		—	—
Epsom salt (see magnesium sulphate)		—	2.50 – 2.70
Formaldehyde, 40 per cent	lb.	—	.51 – .52
Glauber's salt (see sodium sulphate)		—	—
Glycerine	lb.	—	.24½– .26
Iodine, resublimed	lb.	—	4.10 – 4.30
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.00 –	1.20 – 1.75
Lead acetate, normal	lb.	—	.20 – .23
Lead arsenate (paste)	lb.	—	.13 – .17
Lead nitrate, crystals	lb.	—	.30 – .35
Litharge	lb.	—	.09½– .10½
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	—	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12 –	.15 – .16
Phosgene (see carbonyl chloride)		—	—
Phosphorus, red	lb.	—	.75 – .90
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	—	.56 – .60
Potassium bromide, granular	lb.	—	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 –
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.23 – .32	.35 – .42
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	—	.65 – .95
Potassium prussiate, red	lb.	—	1.10 – 1.20
Potassium prussiate, yellow	lb.	—	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	—
Rochelle salt (see sodium potas. tartrate)		—	—
Sal ammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake (sodium sulphate)	ton	18.00 –21.00	—
Silver cyanide	oz.	—	1.25 –
Silver nitrate	oz.	—	.81½– .82½
Soda ash, light	100 lb.	2.05 –	2.25 –
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.06¾– .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.20 – .21	.22 – .25
Sodium bisulphate (nitre cake)	ton	6.00 – 8.00	10.00 –
Sodium bisulphite	cwt.	1.80 – 1.90	2.00 – 2.10
Sodium borate (borax)	lb.	— .08	.08½– .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	—	4.35 – 4.50
Sodium hyposulphite	lb.	—	.03¾– .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	— .18
Sodium peroxide, powdered	lb.	—	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾– .04¼	.04¼– .05
Sodium potassium tartrate (Rochelle salt)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¼– .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½– .03	.03½– .04½
Sodium sulphate, crystals (Glauber'ssalts)	cwt.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	—	.05 – .06
Sodium sulphite, crystals	lb.	.03½–	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05¼–	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½–	.46 – .50
Tin oxide	lb.	.43 –	.60 –
Zinc carbonate, precipitate	lb.	—	.20 –
Zinc chloride, gran	lb.	.12¼–	.13½– .15
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.11¼– .12½	.13 – .15
Zinc oxide, dry American	lb.	—	.09½– .12
Zinc sulphate	lb.	.03½– .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.36
Aniline oil, drums extra	lb.	.34 —	.36
Aniline salts	lb.	.45 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.30
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.75 —	.80
Cresylic acid, 95-97%, dark, in drums	gal.	.72 —	.75
Cresylic acid, 50%, first quality, drums	gal.	.60 —	—
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.27 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.60 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12¾ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.55 —	.60
Salicylic acid, U.S.P.	lb.	.42 —	.50
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white, pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	.... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	.... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl.	280 lb.	$17.00 —	$17.50
Rosin E-I	280 lb.	17.85 —	18.40
Rosin K-N	280 lb.	19.75 —	22.50
Rosin W. G.-W. W.	280 lb.	22.50 —	24.25
Wood rosin, bbl.	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	.... —	1.97
Wood turpentine, steam dist.	gal.	.... —	1.70
Wood turpentine, dest. dist.	gal.	1.64 —	....
Pine tar pitch, bbl.	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl (500 lb.)	bbl.	15.00 —	15.25
Rosin oil, first run	gal.	.... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	.... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V.M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.47 —	$0.48½
Upriver coarse	lb.	.34 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.52 —	.54½
Ribbed smoked sheets	lb.	.50 —	.51
Brown crepe, thin, clean	lb.	.48	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23½ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.21 —	.21½
Cocoanut oil, Cochin grade, in bbls	lb.	.20½ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	$ .04½ —	$ .06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00 —	45.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C.	lb.	.... —	....
Shellac, V. S. O.	lb.	.... —	....
Shellac, Diamond I.	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	140.00 —	155.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	.... —	14.00
Fluorspar, gravel, f.o.b. mines	net ton	.... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	....
Pyrites, foreign, lump	unit	.17 —	....
Pyrites, foreign, fine	unit	.17 —	....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	....
Rutile, 95% TiO_2	lb.	.11 —	....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	....
Monazite, per unit of ThO_2	unit	42.00 —	....

* Government prices.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags, delivered	bbl.	$2.80
Lump lime, common, including container, at plant	300 bbl.	2.75
Common brick, delivered	M.	25.00
Yellow pine, 3x4 to 8x8, 20 ft. and under	M.	58.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago	M.	70.00
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis	M.	44.00
Roofings, tar felt (14 lb. per 100 sq. ft.)	ton	84.00
Roofings, tar pitch (in 400-lb. bbl.) carlots	ton	21.00
Roofings, asphalt pitch carlots	ton	34.00
Roofings, asphalt felt carlots	ton	88.00
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots		3.00
Roofings, slate-finished shingles, 100 sq. ft. carlots		7.25
Linseed oil, raw in barrels	gal.	1.80
Linseed oil, 5 gal. cans	gal.	2.00
Red lead, dry, 100 lb. keg	lb.	.14½
Red lead, in oil, 100 lb. keg	lb.	.16
Red lead, dry, 5 lb. cans	lb.	.16½
Red lead, in oil, 5 lb. cans	lb.	.17
White lead, dry and in oil, 100 lb. keg	lb.	.14½
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.14½
White lead, dry and in oil ,5 lb. cans	lb.	.16½

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Ridgeway Paper Stock Co., 1619 Ave. E., plans to construct a 100x250-ft. paper mill with a daily capacity of 50 tons. Estimated cost, $250,000. B. G. Ridgeway, pres.

California

PASADENA—The Throop College of Technology plans to build a physical laboratory building in connection with College on East California St. Estimated cost, $150,000. Bertram G. Goodhue, 2 West 47th St., New York City, archt.

Connecticut

WESTPORT—The Dolge Chemical Co. has awarded the contract for the construction of a 1-story factory, to Barney-Ahlers Constr. Co., 110 West 40th St., New York City. Estimated cost, $40,000.

Illinois

CHICAGO—Schmidt, Garden & Martin, archts., 104 South Michigan Ave., will soon award the contract for the construction of a 2-story, 50x250-ft. addition to the plant of the Chicago Solder Co., 218 North Union Ave. Estimated cost, $100,000.

Iowa

DES MOINES—The Hawkeye Tire & Rubber Co., 215 East 3rd St., has awarded the contract for the construction of a 3-story, 80x280-ft. factory, to John M. Benson, 422 V. M. B. Bldg. Estimated cost, $300,000.

Kansas

ELGIN—The North Amer. Refining Co. plans to build an oil refinery to refine the high-grade crude oil produced here. Estimated cost, $350,000.

Maryland

BALTIMORE—The Locke Insulator Co., Victor, N. Y., is having plans prepared for the construction of two buildings and twenty-four kilns for the manufacture of porcelain insulators, on Light St. and Ferry Bar, here. Estimated cost, $1,000,000.

CURTIS BAY (Baltimore P. O.)—The Kennedy Corp., Charles and Wells Sts., plans to build a plant here. Four open-hearth melting furnaces fired by fuel oil and seven annealing furnaces using powdered coal will be installed in same. J. P. Kennedy, pres. Noted Sept. 30.

Michigan

DETROIT—The Amer. Electrical Heater Co., Woodward and Burroughs Sts., has awarded the contract for the construction of a 1-story, 60x417-ft. factory and boiler house addition and a 23x32-ft. assembling room for electrical heating devices, on Commer and Dequindre Sts., to Conrad Keller, 210 Moran St., at $35,000.

New Jersey

EDGEWATER—The Barrett Co., 17 Battery Pl., New York City, has awarded the contract for the construction of a 2-story, 25x73-ft. laboratory building, here, with el 27x50 ft., to the Turner Constr. Co., 244 Madison Ave., New York City.

HOBOKEN—J. C. Schaeffler, archt. and engr., 40 West 32nd St., New York City, will receive bids about Feb. 16, for the construction of a 6-story, 135x135-ft. factory and a 3-story, 20x80-ft. foundry, for the White Metal Mfg. Co., 1006 Clinton St.

NEWARK—The Celluloid Co., 290 Ferry St., has awarded the contract for the construction of a 3-story, 40x50-ft. factory addition on Charles St., to Eustice Bros., 40 Clinton St.

TRENTON—The Union Electrical Porcelain Co., Hamilton and Clark Sts., plans to build a large porcelain manufacturing plant to replace the one recently destroyed by fire with a loss of $90,000. T. A. McKenzie, 1404 Greenwood Ave., pres.

New York

BALDWINSVILLE—The Morris Machine Wks. are in the market for a large oil-burning brass furnace. Address, L. L. Hofmann, secy. and treas.

CLAYTON—The Toggarts Paper Co., Sherman Bldg., Watertown, has purchased a 100-acre site at Steeles Point along the waterfront of the St. Lawrence River and adjacent to the New York Central R.R., and plans to construct a wood-preparing plant, etc., on same. Estimated cost, $100,000.

NEW YORK—J. M. Felson, archt. and engr., 1133 Bway., will soon award the contract for the construction of a 25x100-ft. factory addition at 12 West End Ave., for the Natl. Gum & Mica Co.

RYE—The city rejected all bids for the construction of sanitary sewers and sewage disposal units, involving 31,100 ft. of 8-in. and 580 ft. of 15-in. vitr. pipe sewers, etc. Estimated cost, $300,000. G. E. Hill, 45 7th Ave., New York City, engr. Work will be readvertised.

UTICA—The Utica Cutlery Co., 820 Hickory St., has awarded the contract for the construction of a 3-story, 55x200-ft. addition to its plant at Hickory St. and Wheeler Ave., to Griffith & Pierce, 618 Charlotte St. Estimated cost, $125,000.

Ohio

CLEVELAND—The Regar Brass Co., 1523 East 45th St., has awarded the contract for the construction of a 1-story, 24x42-ft. furnace building at East 45th St. and Superior Ave., to the Du Perow Constr. Co., Plymouth Bldg. Estimated cost, $7,000.

DAYTON—The Dayton Rubber Mfg. Co., West River St., plans to construct a 1-story, 70x200-ft. rubber manufacturing plant. Estimated cost, $35,000.

ST. BERNARD (Cincinnati P. O.)—The Jarecki Chemical Co. has awarded the contract for the construction of a 2-story, 150x500-ft. factory, here to the Austin Constr. Co., 16112 Euclid Ave., Cleveland. Estimated cost, $500,000.

WILLOUGHBY—The Thor Tire & Rubber Co., 802 Society for Savings Bldg., Cleveland, plans to construct a 1- and 2-story, 82x180-ft. rubber factory, on Main St. and New York Central R.R. Estimated cost, $150,000.

Oklahoma

FREDERICK—The Frederick Oil & Refining Co. has awarded the contract for the construction of a refinery, to A. H. Kruse. Estimated cost, $100,000.

MADILL—The city plans to improve the water-works, including the construction of a filtration plant, etc. Bonds for $410,000 were voted for this project. Johnson & Benham, Firestone Bldg., Kansas City, Mo., consult. engrs.

PAWHUSKA—The Osage Mutual Oil & Refining Co. plans to build an oil refinery, with a daily capacity of 1,500 bbl., on the Prairie along the Midland Valley Track. Estimated cost, $200,000.

Oregon

PORTLAND—The Oregon Brass Wks., 73 North 2nd St., have awarded the contract for furnishing and installing one 2,000-lb. capacity, and one 100-ton capacity electric steel furnaces, to the Detroit Electric Steel Furnace Co., 698 Hart St., Detroit, Mich. Estimated cost, $20,000.

PORTLAND—The Palmolive Co. plans to rebuild the 2-story, 100-ton capacity, copra mill which was recently destroyed by fire, and will install machinery for copra reduction and oil extraction in same. Estimated cost, $30,000.

Pennsylvania

JOHNSTOWN—The Lee-Strauss Co., formerly the Johnstown Chemical Co., 232 Levergood St., will soon receive bids for a 3- or 4-story, 55x100-ft. chemical plant and office building on Levergood St. Estimated cost, $150,000. Henry M. Rodgers, Trust Bldg., archt.

Rhode Island

WOONSOCKET—The Woonsocket Rubber Co., 87 Fairmount St., has awarded the contract for the construction of a 1-story, 40x50-ft. factory addition on Fairmount St., to the Fiske-Carter Constr. Co., 11 Foster St., Worcester, Mass. Estimated cost, $15,000.

Texas

STEPHENSVILLE—The A1-Tex Refining & Holding Co. has purchased a 20-acre site just outside of the city limits and plans to build a 2,500-bbl. capacity oil refinery on same. Estimated cost, $400,000.

Virginia

ROANOKE—The Bd. Educ. is having plans prepared for the construction of a 3-story school on Park St. A chemical laboratory will be installed in same. Estimated cost, $450,000. H. C. Richards, 1713 Sansom St., Philadelphia, archt.

Wisconsin

MILWAUKEE—The Pelton Steel Co., 672 Kinnickinnic Ave., is receiving bids for the constructon of a 1-story, 60 x 100-ft. foundry addition. Estimated cost, $35,000. Judell & Bogner, 1st Wisconsin Natl. Bank Bldg., archts. and engrs.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a joint meeting with the American Chemical Society and the Society of Chemical Industry, Feb. 6, 1920. On Feb. 27 another meeting will be held, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is Peace Uses for War Products.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16 to 19.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institution of Mechanical Engineers, Storey's Gate, Westminister, S. W. 1, London, England.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION will hold its convention at the Waldorf-Astoria Hotel, New York City, Feb. 26 and 27.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE SULLIVAN MACHINERY CO. announces the appointment of Arthur E. Blackwood, hitherto manager of its branch office in New York City, as vice-president, in charge of finance and accounting, with headquarters at Chicago. Louis R. Chadwick, for a number of years manager of the company's office at Spokane, Wash., has been appointed manager at New York City, 30 Church St., succeeding Mr. Blackwood.

THE NEW JERSEY ZINC CO. announces the contemplated construction of additional zinc oxide and lithopone plants to meet the growing demand for these products. The company plans to construct its plants at strategic geographical points so as best to serve its customers located in various parts of the country. Construction work will be commenced immediately on zinc oxide and lithopone plants in Colorado and Pennsylvania.

THE ALLIED MACHINERY CO. OF AMERICA recently opened at Center and Walker Sts., New York City, a permanent exhibit of the products of fifteen non-competing manufacturers. This allied machinery center occupies 30,000 sq.ft. of space and is designed to serve the need of both export buyer and domestic purchaser who may be interested in general construction machinery.

THE ASSOCIATED WELDING COS., INC., Brooklyn, N. Y., is the title of a new organization which has recently consolidated thirteen welding companies operating in different parts of the country. As a holding company it operates and manages a chain of welding service companies, each of which is conducted as a separate unit with its own organization of engineers. An illustrated pamphlet entitled "Electric Arc Welding" has just been issued by the company.

MARDEN, ORTH & HASTINGS, New York City, announces that its sales department of coal-tar intermediates has been separated from the main company and incorporated under the firm name of Calco Chemical Co. No change in the personnel has taken place and the new company will continue to occupy the same quarters.

THE BLAW-KNOX CO., Pittsburgh, announces that A. W. Ransom, formerly manager of the New England territory, with offices at Boston, Mass., has been transferred to San Francisco in the capacity of manager of the Pacific Coast territory, with offices in the Monadnock Bldg. O. A. Olstad, formerly with the New York office, has been made manager of the New England territory, with offices in the Little Bldg., Boston, Mass., succeeding A. W. Ransom.

THE FULLER ENGINEERING CO., Allentown, Pa., has entered into contract with the Trumbull Steel Co., Warren, Ohio, to remodel the pulverized coal plant of the latter. The new equipment will comprise two 57-in. dreadnaught gear-driven mills and a 5½-ft. x 42-ft. indirect-fired drier. The pulverized coal from the Fuller mills will be transported by the Fuller-Kinyon pumping system to the bins at the furnaces. Motor-driven screw feeders attached at the bottom of the bins will mix the coal dust and the air for injection into the furnaces.

THE UNITED STATES CAST IRON PIPE & FOUNDRY CO. announces the opening of an office in the Scollard Bldg., Dallas, Tex., in charge of T. W. Hanlon, Southwestern sales agent.

THE UNITED SMELTING & ALUMINUM CO., INC., of New Haven, Conn., announces the election of Frederick A. Merliss as vice-president and manager of sales. Mr. Merliss has been connected with the company for the past three years as assistant secretary, and his new appointment fills the place left vacant through the resignation of L. M. Brile, former vice-president and sales manager.

THE GENERAL CHEMICAL CO. has entered into a contract with the J. G. White Engineering Corp. covering the future designing, engineering and construction work incident to improvements and extensions to existing manufacturing plants, buildings, and other property, and in connection with any new projects or developments which may be undertaken from time to time. Two initial pieces of work, which are to be carried out immediately under the new arrangement, are the construction of a large warehouse at Pittsburgh, and improvements to the company's Delaware works near Marcus Hook, Pa.

THE QUIGLEY FURNACE SPECIALTIES CO., New York City, has been awarded a contract by the Inland Steel Co., Indiana Harbor, for the engineering work and installation of a complete milling plant of twenty tons hourly capacity with provision for extensions, compressed air distribution system for transporting pulverized fuel to furnace bins through small diameter standard wrought pipes, and the necessary fuel feed controllers, air supply system and burners. For the initial installation, powdered coal will be applied to sixteen sheet furnaces, sixteen pair furnaces, three continuous plate-mill furnaces, two continuous bar-mill furnaces and three slab-heating furnaces. Arrangements are also being made for an extension to the boiler plant and other departments.

THE ALUMINUM CASTINGS CO., Cleveland, Ohio, announces the change of its name to Aluminum Manufacturers, Inc.

THE CLINTON-WRIGHT WIRE CO. has acquired the Wickshire Steel Co., and the combination will be known as the Wickshire-Spencer Steel Corp.

K. TEKN. HOGSKOLANS MATERIALPROVNINGSANSTALT announces that from Jan. 1, 1920, it has been organized as a state institution of Stockholm, Sweden, under the name of Statens Provningsanstalt.

GANNET, SEELYE & FLEMING, consulting engineers, of Harrisburg, Pa., have established Southern headquarters in Randolph Bldg., Memphis, Tenn.

THE PERFECT PRODUCTS CO. is establishing a manufacturing plant at 674 South Main St., Memphis, Tenn., for the production of automobile and furniture polish, automobile top and fabric dressing and shellac.

THE BAKER LABORATORIES, of Dallas, Tex., have established a manufacturing plant at 166 North Front St., Memphis, Tenn. This company manufactures toilet goods and dye products for all classes of leather. George W. Baker is president and W. K. Baker secretary.

THE COMBUSTION ENGINEERING CORP., New York City, has enlarged its facilities for handling business in the Philadelphia territory. The office of the company in this territory is located in the Lincoln Bldg., and W. C. Stripe, formerly of its Pittsburgh office, becomes manager. Associated with him on the selling force are C. L. Bachman, recently returned from military service abroad, and formerly manager of the Chicago office of this company, and E. F. Knehnle, formerly in the New York City office.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., is now devoting more floor space to the industrial electric heating department, which includes electric space heaters, soldering irons, linotype pot heaters, metal melting pots, immersion water heaters, circulation water heaters, etc.

JOSEPH T. RYERSON & SON, Chicago, and the CONRADSON TOOL MACHINE CO., Greenway, Wis., have recently formed an association for the sale of machine tools which will be marketed under the trade name of "Ryerson-Conradson."

THE QUIGLEY SYSTEM of preparing and burning powdered coal has been selected by the Philadelphia Rapid Transit Co. for its Mt. Vernon St. power station. This plant at present requires twenty 375-hp. Babcock & Wilcox water tube boilers, but with powdered coal firing the necessary power will be secured by using only ten boilers. By means of compressed air, pulverized coal will be transported through small diameter wrought pipes from an adjacent milling plant to the present coal bunker, which will be partitioned into ten sections, each section supplying coal individually to its corresponding boiler. The fuel is not mixed with air in transport, but travels through the pipes in compact masses. The equipment from milling plant to burners is entirely enclosed and dust tight. The change from hand fired to powdered coal will be made without interruption of service; and the new installation will be completed during the coming summer.

THE HIRSCH LABORATORIES, INC., is the name under which Dr. Alcan Hirsch has incorporated his laboratory. The company's office is in the Chemists' Bldg., 50 East 41st St., New York City, where it has been for the past eight years, but the laboratories and experimental plant have been removed to 593 Irving Ave., Brooklyn, N. Y. The officers of the new corporation are: Alcan Hirsch, president; Marx Hirsch, vice-president, and Harry W. Wolff, general manager.

HERVEY J. SKINNER, formerly of A. D. Little, Inc., announces the opening of an office in the Garden Bldg., 248 Boylston St., Boston, Mass., as a consulting chemical engineer. Particular attention will be paid to pulp and paper problems and the development of processes and their commercial application.

THE NATIONAL FOREIGN TRADE COUNCIL, India House, Hanover Sq., New York City, has published a pamphlet of interest to those engaged in export business. It defines the meaning of export quotations and the responsibility falling upon the seller and the buyer in each case and it also contains some general recommendations for the standard American export practice.

THE BIRMINGHAM COKE & BYPRODUCT CO., Birmingham, Ala., has completed its byproduct coke plant which was started under the direction of the Ordnance Department during the war. Work began in September, 1918, but on the signing of the armistice in November all work was discontinued. Work was again begun by the War Department April 1, 1919, and the plant is to be taken over April 1, 1920, by the Birmingham Coke & Byproduct Co. The plant has now a daily capacity of 825 tons of coke, 400 gal. of toluol and 11¼ tons of ammonium sulphate.

THE YARNALL-WARING CO., Philadelphia, Pa., has opened a branch office in the Builders' and Traders' Exchange, Penobscot Bldg., Detroit, in charge of Walter G. Heacock, as branch manager.

Manufacturers' Catalogs

THE BAUSCH & LOMB OPTICAL CO., Rochester, N. Y., has issued a booklet entitled "What Lens Shall I Buy?" This booklet is intended to furnish information which will assist the purchaser in the proper selection of a photographic lens.

HOLZ & CO., INC., New York City, has issued a leaflet describing the Holz universal photomicrographic and macrographic metallographic bench model 1920.

THE PENNSYLVANIA SALT MFG. CO., Philadelphia, is distributing a booklet listing its heavy chemicals.

THE WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa., has published a 50-page illustrated bulletin on the application of electricity to the metallurgical and chemical industries. Among the subjects treated at considerable length are the use of electric furnaces in ferrous and nonferrous metallurgy, industrial heating and the manufacture of such materials as carbide, electrolytic processes for the fixation of nitrogen and the precipitation of suspended matter in gases. The catalog contains information that will be suggestive of a variety of applications of electricity.

WESTINGHOUSE, CHURCH, KERR & CO., INC., New York City, has issued a folder entitled "Shops." It gives actual illustrations of industrial plants and describes what a shop is.

THE NELSON VALVE CO., Philadelphia, Pa., announces a new book just received from the press, entitled "Nelson Valves." This 156-page book illustrates and describes the many different types, which include bronze, iron and steel valves in gate, globe, check and non-return patterns, in fact, a type for every class of service found in power plant work, industrial establishments and large building construction.

THE WORTHINGTON PUMP & MACHINERY CORP., New York City, has issued an attractive 116-page book on "Condensing Apparatus," which is well illustrated and described. There are four sections, which include: surface condensers, with auxiliaries and pumping equipment; high vacuum surface condensers and equipment; jet and barometric condensers; useful information, condensation. This book also contains useful tables, notes and general information.

THE TECHNICAL PRODUCTS CO., INC., 501 Fifth Ave., New York City, calls attention to a catalog entitled "The Economist," in which are listed the surplus and idle equipment recently purchased at various plants. The material includes equipment of every sort used in the chemical and allied industries and is ready for immediate shipment.

THE KOPPERS CO., Pittsburgh, Pa., is issuing a 68-page bulletin on byproduct coke and gas oven plants, benzol recovery plants, motor fuel recovery plants, tar distilling plant, and ammonia recovery apparatus which it has designed and built. Many illustrations of actual installations are given, together with descriptive matter.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

ALAN G. WIKOFF
Assistant Editor
L. W. CHAPMAN
Western Editor
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 22 — New York, February 11, 1920 — *Number* 6

The Report of the British Nitrogen Products Committee

ONE of the revelations of the World War was the unpreparedness of the allied nations in the matter of nitrogen fixation. Not only did the beginning of the war find the principal English-speaking nations without a nitrogen-fixation industry and depending on Chile for sodium nitrate, but the war ended before either Great Britain or the United States had brought to completion their plans for the production of synthetic nitrates on a large scale. Germany alone developed her Haber process from insignificant proportions at the beginning of the war to an industry of great magnitude before hostilities ceased. True, with Germany it was a more vital matter than with the Allies, as the latter could still obtain some supplies of Chilean nitrate. In order to augment this supply Great Britain had, before the end of the war, considered the establishment on a large scale of the calcium cyanamide process, and on a development scale of the synthetic ammonia and ammonia oxidation processes. The United States had practically completed a similar program.

With the end of the war developments ceased abruptly and neither Great Britain nor the United States has made more than nominal progress since that time. As a consequence the plans of either nation are of the greatest importance to the other, reflecting as they do the best possible thought on the subject. The British Nitrogen Products Committee, appointed in June, 1916, to consider the establishment in Great Britain of some of the newer processes for fixing atmospheric nitrogen, has recently published its final report, and while a copy has not yet reached this office, we are enabled to review the salient features of the report from an abstract appearing in a late issue of the *Chemical Age* (London).

The recommendations of the Committee are significant in view of the program actually under way in the United States at the time of the Armistice. Calcium cyanamide is apparently recognized as the most likely fixed-nitrogen product that can be made on a commercial scale without further research or experimentation. The Committee recommends the establishment without further delay of a plant using this process on a scale sufficient to yield 60,000 tons of cyanamide per annum. The synthetic ammonia process and the oxidation of ammonia are recognized as yielding the greatest promise for the future, and the Committee recommends the establishment forthwith of the synthetic process "on a commercial unit scale and its expansion as rapidly as possible" to a production of 10,000 tons of ammonia per annum. Likewise, the ammonia oxidation process should be established on a scale sufficient to yield about 10,000 tons of nitric acid per annum.

With reference to power, the Committee's conclusion points quite logically to hydro-electric developments as the cheapest source on a large scale. Of more than ordinary interest is the Committee's conclusion that the present state of our knowledge on the application of low-temperature carbonization of coal as a preliminary to power production, in order to conserve ammonia and other byproducts, is not sufficiently encouraging to warrant the establishment of plants on a large scale.

Undoubtedly the development of a nitrogen-fixation industry in Great Britain, as in the United States, is vital to the national welfare. Great Britain's Committee is of the opinion that its development will require the active support of the Government. A similar question confronts the United States, and it will be necessary in the near future for our own Government to decide what its policy will be toward nitrogen-fixation in its relation particularly to the fertilizer industry in peace times. The report of the British Committee undoubtedly will be studied with profit as soon as copies are available for distribution in this country.

Industrial Research And New Technology

UP TO comparatively modern times the progress of industrial development was slow. Industrialists were confined mainly to the results of their own limited observations or to those of their immediate associates, and it was thus only by means of empiricisms, ideas unaided by even approximate theoretical conceptions, that any advancements were made in the industrial arts. There were no scientific or technical publications that carried knowledge to and fro through the isolating factory walls that secluded these men. They toiled alone; passed on their art through apprenticeship and left it practically as they had received it from their master. They were jealous minded, secretive and generally indisposed toward any changes being made in their art.

In recent times the progress of some of the industrial arts, through the aid of research and our present system of scientific co-operation, has been nothing less than revolutionary as well as exemplary for those still continuing to tread around on the same old spot where they started. The modern achievements in mechanics, electricity and chemistry as fruits of research need no elucidation here. But in order to show our readers some actual indication of the scope for the application of research to almost every variety of industry, we publish in this issue a brief exposition of the work now being carried on at the Mellon Institute. A year or two ago the administration of the Institute made an extensive inquiry to determine what expenditures were being made for research in the various industries of this country. Twenty million dollars was decided to be approxi-

mately the amount, one-half of which was expended in industrial laboratory investigations and the remainder on engineering developments.

Compared with other items to be found in our national budget, this research cost seems to have been kept at too conservative a figure, especially when it is considered from the point of view of what the credit column of this account would show if it were possible to assign a monetary figure to it. It is believed that a yearly return of at least $100,000,000 would not be too optimistic an estimate of it.

Industrial research is performed for gain, and to be properly evaluated should be run on sound business principles. This means that it should be charged for what it receives and credited for what it yields. Its expenditures should be so gaged that maximum gains will be obtained. To accomplish this, executive talent of the first order is required. If this were done, there is no doubt that it would be much more appreciated by the captains of industry, to whom only the balance sheets from their accounting departments are to be taken as navigating guides.

Carbon and Molybdenum As Producers of Flakes in Steel

PRACTICALLY all the evidence on flakes brought out at last winter's meeting of the American Institute of Mining and Metallurgical Engineers can be harmonized with the hypothesis that aside from deep-seated shrinkage cracks or strain cracks in ingots, the so-called flake—or its first cousin woody structure—in a finished piece is due to the presence of oxidized impurities of extreme tenuity. Several American metallurgists have expressed the opinion that flakes probably would be found in commercial steel of almost any composition if transverse testing would be regularly done, and with but two or three notable exceptions would not subscribe to the suggestion that the chemical specification was of determining weight in causing flakes. The French metallurgist J. J. COHADE, of Le Creusot, is a firm believer in the latter as being a very important factor, and his paper before the fall meeting of the British Iron and Steel Institute cites explicitly his experience that molybdenum or high carbon-nickel analyses engender woody fractures solely by virtue of the chemical composition. Woody structure thus appears in charges much less difficult to work sensibly free of inclusions than similar analyses lower in the objectionable elements but treated to give comparable tensile strengths.

English metallurgists were apparently as chary of accepting this conclusion as are their American brethren. For instance, in the discussion of Mr. COHADE'S paper Sir ROBERT HADFIELD and Dr. W. H. HATFIELD agreed that the quality of steel was largely influenced by the furnace and casting temperature, Dr. WALTER ROSENHAIN seconding them with the statement that high hearth heats and long high annealing will eliminate woody structures. In detail T. M. SERVICE notes that good armor required a high working temperature—and here he agrees with Mr. COHADE—a careful adherence to chemical specification, and a very fluid slag during the boil eventually to exclude solid non-metallic impurities. Steel cast at 1,560 deg. C. would therefore be much better than that cast at the more usual heat of 1,420 deg., while high forging temperature further aided in the production of superfine metal. E. H. SANITER, on the other hand, gave the opinion that woody structure was due to a state of strain existing in the steel, while W. H. DICKINSON thought that the original structure of the ingot was responsible, and that the effect of invisible inclusions was most important, the latter conclusion being supported by Dr. J. E. STEAD. Dr. GIOLITTI and COSMO JOHNS united in emphasizing the idea that while inclusions were doubtless responsible for defective transverse tests, the result was due not so much to the presence of the inclusion as to its effect on the surrounding metal.

Thus, much dissent was expressed to the hypothesis that carbon, nickel or molybdenum is a flake producer *per se*. Mr. COHADE himself probably aims to emphasize not so much the danger of carbon in steel as the effect chemical composition plays on segregation, since at the outset he quotes the first of four causes of woody structure as "mostly from the presence of non-metallic inclusions," and in the body of his paper he says of defective high-nickel steel that "it appears probable to the author that the improvement due to a lower percentage of carbon is the result of less segregation around the dendritic crystals formed during solidification, owing to the greater speed with which this takes place."

Apparently, in the case of carbon and nickel, segregation is again the culprit, so the difference between the author and his critics is less real than apparent. Perhaps, although Mr. COHADE is silent on this point, molybdenum acts as a litterer or a dispersing agent, as a very antithesis of scavengers or flocculators such as manganese or titanium; and its hesitant acceptance by meticulous tool-steel makers is due to this fact unconsciously rather than to a series of transverse tests.

Bribery of Dyers In Textile Mills

THE Federal Trade Commission gives out the news that complaints have been made against the United Chemical & Color Co., of New York, Andreykovicz & Dunk, Inc., of Philadelphia, the Arkansas Distributing Co., F. Bredt & Co., the New York Color & Chemical Co., the Franklin Import & Export Co., and the Heller & Merz Co., all of New York, alleging as follows: "That the respondents have been giving and offering to give to employees of both their customers and prospective customers, and their competitors' customers and prospective customers, without the knowledge or consent of their employers, sums of money" (and in some cases "and other gratuities") "as an inducement to influence their employers to purchase or contract to purchase from the respondents, dyestuffs, chemicals, etc., or to influence such customers to refrain from dealing or contracting to deal with competitors of respondents."

These are charges and not findings. So far as certain of the parties named are concerned we are convinced that if any efforts at bribery were made it was without the sanction of the men at the head. But that is not the affair of the Federal Trade Commission. Its duty is to try these complaints impartially, and, if it finds still in existence any continuations of the old habit of bribing the dyers, to call down the penalty of the law upon the offenders.

For many years this has been an infernal nuisance to the textile industry. It is a mean, underhanded trick, and its practice was very widespread. The color agent had to deal with the dyer, to teach him to use the dyes, to "make it right with him," and to leave

him satisfied. The easy way is to give him a rebate which is charged to the consumer—and the dyer is used to it. Without doubt a considerable number of these precious crooks declare that everybody else is offering these presents, and of this the salesman is finally persuaded. Bribery was a standard feature of German commercial practice, "and," as an old dyesalter said, "they didn't even know it was wrong. The rest of us did—but we bribed the dyers all the same."

We know of one concern that has laid down the law to its entire force that under no circumstances or provocation shall any kind of so-called "gratuity" be paid, and we understand that a goodly number of others hold to the rule. To break it is to offend against the law and to encourage dishonesty. There is nothing in the practice of the dyer's art to make him less dependable than other men except this German tradition, and if dyers as a class are so poor in spirit that they cannot stand up against it we hope that manufacturers and dealers will be made to find it unprofitable to give in to them. The whole country has a business reputation to make in some things, and to bear in all things, and it will not do to let a lot of hold-over dyers with itching palms jeopardize its fair name.

Maybe the textile industry will see a light some day and induce textile chemists to supervise their tinctorial work instead of working by the rule-of-thumb methods of some boss dyer who learned his trade and his cupidity in secret from some one no better than himself. If a chemist indulges in such practices he is guilty of unprofessional conduct and there is abundant warrant to expel him from any learned society.

Business Men For Exalted Positions

In proportion to one's labour, eminences are gained; and he who seeketh eminence passeth sleepless nights.
Whoso seeketh eminence without labouring for it, loseth his life in search of vanity.

WELL applied, indeed, are the words of the Arabian poet to the conduct of life in these times, and most aptly fitted to the career of the present-day politician. There is a call for men who study and know the factors that influence our economic and industrial life. Business men are needed in administrative government positions from the President down. The most hopeful prospect is HERBERT HOOVER.

Wages and Hours In Steel Industry

THE 10 per cent wage advance to common labor, announced by the United States Steel Corporation as effective February 1, may be readily interpreted as indicating that the Steel Corporation has no present intention of eliminating the twelve-hour shift, which now applies to something like 20 per cent of the total number of men employed in the iron and steel industry. It is easily recognized that were the elimination of the twelve-hour shift feasible in other respects, it would be necessary to compromise matters with the men involved by paying them a larger rate per hour for the smaller number of hours of employment provided, and the time when the employer is disposed to accept a higher labor cost or feels that the workmen require an improvement in their condition is the natural time for such a compromise.

Under the rate for common labor that obtained in the iron and steel industry from August 1, 1918, to February 1, 1920, 42 cents an hour, and with the "eight-hour basic day" established October 1, 1918, the man who is on duty twelve hours is paid fourteen times the hourly rate, while with the same rate for an eight-hour day he would be paid for eight hours' time, or only 58 per cent as much. Obviously, such a change would make an impossible condition for the man. Under the expiring rate, a man working twelve hours and being paid for fourteen hours' time received $5.88, making $11.76 for two men, to complete the twenty-four-hour cycle. A straight 10 per cent wage advance increases this to $12.94. The same sum distributed to three men, thus leaving the labor cost unchanged, would give $4.31 to each man, this being 27 per cent decrease in the day's earnings instead of 42 per cent, therefore constituting a long step toward a compromise.

In order to employ three men in place of two an extra man must be found, and the Steel Corporation management was evidently of the opinion that this would be difficult if not impossible, while it is fair also to presume that it was known that the men individually do not wish the change, that as a rule they prefer to work the long hours and receive the correspondingly greater pay. Such conclusions are important, since there is no reason to doubt either that the Steel Corporation desires to be fair with its workmen or that it is very well informed as to labor conditions and the attitude of the men.

The incident furnishes no ground for a conclusion that abolition of the twelve-hour day is to be postponed forever. We are in a transitionary condition. There is a shortage of labor in the sense that there are more jobs seeking men than there are men seeking jobs. There is much reason to doubt whether there is a shortage of ability on the part of the workers in the United States, taken as a whole, to do the work that is seeking to be done. Probably the time will come when men individually will be willing to work harder, and then the iron and steel industry may be able to obtain more men.

In another sense there is a transitionary condition. The common labor of the iron and steel industry has been very largely foreign born in the past, and the supply of such labor is practically shut off. Eventually men with different ideas as to the length of time they are willing to be on duty will have to be employed to operate the blast furnaces and steel mills. Those men may prefer to work eight hours for eight fourteenths, or ten hours for eleven-fourteenths, as much money as for twelve hours. Were such a time to come the problem would solve itself with no effort by employers.

There is no occasion to fear that at any time in the future there will be a protracted shortage of labor in the iron and steel industry such as would prevent the furnishing of supplies desired by consumers. The amount of labor involved in making a ton of finished rolled steel is so small relative to the industrial value of the steel that it will always be commercially feasible for the iron and steel industry to bid the prices necessary to obtain the labor. A large amount of labor is required in the consumption or employment of steel. In case of competition for labor, the typical consumer of steel is more likely to find his own labor cost prohibitive than to find the cost of the steel prohibitive, if enhanced only by the necessary increase in the labor cost of producing that steel. Market conditions never remain unchanged long enough to enable the economic law to work out the result.

Readers' Views and Comments

The Eventual Retort Plant for the Distillation of Oil Shales

To the Editor of Chemical & Metallurgical Engineering

SIR:—In a recent article entitled "The Eventual Retort Plant for the Distillation of Oil Shales," by Louis Simpson (CHEM. & MET. ENG., vol. 22, p. 71), there appears the following staggering statements:

"It is, however, now known that to obtain the recovery of the maximum yield of nitrogen as ammonia gas, every particle of the spent shale should be exposed to a temperature of 1,125 deg. C., or 2,060 deg. F. It is also known that a decrease of comparatively few degrees of temperature will result in a very large and entirely disproportionate decrease in the yield, while an increase in temperature over the critical temperature increases the yield only slightly."

I seriously doubt the veracity of those assertions. According to Ramsay and Young, ammonia commences to decompose into its elements at about 500 deg. C. under the most favorable circumstances, and on passing the gas through a porcelain or iron tube the decomposition is *complete* before 800 deg. C. is reached, the actual temperature being about 780 deg. C. The temperature of 1,125 deg. C., mentioned by Simpson as the most favorable for a maximum ammonia yield, would disintegrate the NH_3 molecule with great violence, and it would be impossible for the elements (N_2 and H_2) to recombine to any appreciable extent under the conditions he assumes, because of the peculiar physical nature of the equilibrium represented by the equation

$$N_2 + 3H_2 \leftrightarrows 2NH_3.$$

This reaction is exothermic, therefore a high temperature will inevitably shift the equilibrium to the left, and the absence of pressure aids this decomposition, because the formation of ammonia is attended by a contraction in volume, while its decomposition proceeds with an increase in volume. This is merely an application of the principle of Le Chatelier. (See also F. Haber, *Zeit. für Etektrochemie,* vol. 16, p. 244.) Even under the most favorable conditions, hydrogen and nitrogen combine to ammonia very slowly, unless the velocity of the reaction is increased by the use of a catalyst. Hence it is self-evident that the physical conditions which Simpson suggests as ideal would play havoc with the ammonia molecule, and make the yield of this product practically zero. ARTHUR J. FRANKS.

Colorado School of Mines,
Golden, Col.

To the Editor of Chemical & Metallurgical Engineering

SIR:—The reaction cited by A. J. Franks is doubtless correct, so far as the decomposition of *pure* ammonia is concerned, but the problem, in the case criticized, is different and involves the claimed decomposition of ammonia, diluted in steam and other gases.

Dowson claims that at low temperatures only a small percentage of steam decomposes, and it is only with the decomposition of steam that the formation of ammonia, when treating oil shales, becomes possible.

The ammonia produced by the decomposition of steam, in the presence of nitrogen, does not remain subjected to the high temperatures needed to secure the decomposition of the steam used, the combination taking effect in the presence of an excess of steam and of other gases.

Since the war, German chemical literature teems with information as to the influence of steam and other gases upon this and similar combinations of gases.

Were Mr. Franks' ideas correct in practice, it would be possible to secure a maximum recovery of ammonia only through the use of a very great excess of steam. The Scotch practice demonstrates, and demonstration is safer to follow than any theory, which, as in this case, may be incorrectly applied, that there is something not sound in Mr. Franks' contention.

Whether the 1,125 deg. C., mentioned by me, be too high a temperature or not is really of small consequence at this moment. It is known that the Scotch retort could not stand up against the high temperature required for a maximum yield of ammonia, so it was necessary to devise a plant that would stand up. If my plant will stand up against 1,125 deg. C., and a temperature much lower than 1,125 deg. C. is required, so much the better. The chemical reaction employed is not different from that used in Scotland for many years, with more or less success, so that a plant that will satisfactorily endure the highest temperatures used in the Scotch retort, and even higher, and which is so designed that the heat can be regulated and also applied more regularly and intimately, must of a necessity be an improvement. LOUIS SIMPSON.

Ottawa, Canada.

Resistance of Absorption Tower Packing to Gas Flow

To the Editor of Chemical & Metallurgical Engineering

SIR—In my paper on "Resistance of Absorption Tower Packing to Gas Flow," printed in your number of Dec. 24-31, an error occurs on page 766.

You have printed formulas 1 and 2 as:

$$p = \frac{ks^2}{v}$$

and $s = a$

respectively, whereas they should read:

$$p = ks^2$$

and $s = \frac{v}{a}$

Wilmington, Del. FRED C. ZEISBERG.

Cellulose Symposium

To the Editor of Chemical & Metallurgical Engineering

SIR:—Will you let me make the correction of the little slip made on page 708, vol. 21, of CHEMICAL & METALLURGICAL ENGINEERING? In this you report me as saying that "the art of hydration of paper making fiber has not yet been discovered." Of course the art of hydration by mechanical means has been known for a long time, but I was endeavoring to point out the desirability of substituting the use of chemicals to replace part of the long mechanical treatment now necessary in the manufacture of such papers as grease-proof and glassine. My conclusion was that although many suggestions have been made, no one has succeeded in making the chemical hydration of wood pulps a commercial success. W. P. COHOE.

New York, N. Y.

Hoover for President

To the Editor of Chemical & Metallurgical Engineering

SIR:—In accordance with the instructions of the Joint Council of Engineers of San Francisco, I have the honor to transmit to you copy of a resolution hereto attached, favoring the "Hoover for President" movement. It is the intention of the Joint Council, in forwarding this letter and its accompanying resolution to engineering organizations throughout the United States, to arouse engineers generally to the importance of having for our next Chief Executive of the nation a man of proved administrative ability, unquestioned integrity and absolutely free from partisan politics.

Engineers can well appreciate the exceptional fitness of Mr. Hoover for President, and through their organizations are in a position to form the nucleus of a non-partisan movement to improve materially the running of the biggest business organization in the world—the Government of the United States. C. H. SNYDER,
Secretary Joint Council.

The following is the resolution unanimously adopted by the Joint Council of Engineers of San Francisco, Jan. 13, 1920:

> Whereas there is at this time a strong and widespread sentiment for Herbert C. Hoover for President of the United States as an independent candidate, free from political deals and pre-election pledges; and
>
> Whereas Mr. Hoover, by his work in Europe, has shown executive and administrative abilities of the highest order, particularly fitting him for handling both the economic problems of reconstruction at home, and our relations with other nations; and
>
> Whereas the Joint Council of Engineers of San Francisco has a patriotic duty to perform at this time, not only as representing engineers, but also as a representative body of American citizens; be it therefore
>
> *Resolved*, That the Joint Council of Engineers of San Francisco, representing 2,000 engineers in the Bay district, indorses Herbert C. Hoover for President and invites the engineering bodies of the United States to join with it in forming an organization to further Mr. Hoover's election, and in such other activities as will insure the affairs of the nation being handled on an efficiency and non-partisan basis, and be it further
>
> *Resolved*, That copies of this resolution be sent to all engineering organizations and technical journals throughout the United States, and that such other steps be taken as will further the movement of "Hoover for President."

Spring Meeting of the American Electrochemical Society

Plans for the meeting of the American Electrochemical Society in Boston, April 8, 9 and 10, are maturing rapidly and give promise of an excellent meeting. Joint sessions will be held with the American Institute of Electrical Engineers on the subject of electric-furnace alloys and power for electrochemical purposes. A symposium on the regular program will cover the subject of colloid chemistry. Among the trips already planned is one to the General Electric Co.'s plant at Lynn, to inspect the manufacture of the tungar rectifier and the kenetron tube. Headquarters will be at the Copley-Plaza Hotel.

Chemical Warfare Service

No change was made by the Committee on Military Affairs in the Chemical Warfare section of the Army reorganization bill when it was reported to the Senate. The exact language drafted by the sub-committee in providing for a separate Chemical Warfare Service is part of the bill which is now before that body.

A.I.M.E. Annual Meeting

A CIRCULAR has been issued giving the program of the 121st meeting of the American Insitute of Mining & Metallurgical Engineers, to be held in New York City, Feb. 16 to 19, 1920. Programs of interest to metallurgists will be held as follows:

Non-Ferrous Metallurgy, Institute of Metals Division, Tuesday, Feb. 17, 10:30 a.m. Papers to be presented: Intercrystalline Brittleness of Lead, by H. S. Rawdon; A Peculiar Type of Intercrystalline Brittleness of Copper, by Henry S. Rawdon and S. C. Langdon; Relationship of Physical and Chemical Properties of Copper, by Frank L. Antisell.

Milling and Smelting Session, Tuesday, Feb. 17, 2 p.m. Papers to be presented: Volatilization in Assaying, by Frederic P. Dewey; Reverberatory Furnace for Treating Converter Slag at Anaconda, by Frederick Laist and H. J. Maguire; Coal Pulverizing Plant at Nevada Consolidated Copper Smelter, by R. E. H. Pomeroy; Milling Plant of the Alaska Gastineau Mining Co., by E. V. Daveler.

Iron and Steel Sessions, Wednesday, Feb. 18, 10 a.m., and 2 p.m. Papers to be presented: Blast-Furnace Flue Dust, by R. W. H. Atcherson: Manufacture of Semi-Steel for Shells, by Frank E. Hall; An Experiment in One-Piece Gun Construction, by P. W. Bridgman; Tensile Properties of Boiler Plate at Elevated Temperatures, by H. J. French: Microstructure of Iron and Mild Steel at High Temperatures, by H. S. Rawdon and Howard Scott; Physical Changes in Iron and Steel Below the Thermal Critical Range, by Zay Jeffries; Graphitization of White Cast Iron, by R. S. Archer; Application of the Microscope to the Malleable-Iron Industry, by Enrique Touceda.

Alloy Steels Session, Wednesday, Feb. 18, 2 p.m. Papers to be presented: The Coefficient of Expansion of Alloy Steels, by John A. Mathews; Critical Ranges of Some Commercial Nickel Steels, by Howard Scott; Forgeability of Iron-Nickel Alloys, by T. D. Yensen.

Among other papers included in the program are the following: Rise and Decline in Production of Petroleum in Ohio and Indiana, by J. A. Bownocker; Petroleum Resources of Kansas, by Raymond C. Moore; Rôle of Bed-Rock in the Distribution of the Hydrocarbons, by M. M. Monte-Flores; Water Displacement in Oil and Gas Sands, by Roswell H. Johnson; Oil Fields of Kentucky and Tennessee, by L. C. Glenn; Petroleum in the Philippines, by W. D. Smith; A Résumé of the Pennsylvania-New York Oil Field, by R. H. Johnson and Stirling Huntley; Petroleum in the Argentine Republic, by Stanley C. Herold; A Foreign Oil Supply for the United States, by George Otis Smith; Petroleum Resources of Great Britain, by A. C. Veatch; Geologic Distillation of Petroleum, by Bailey Willis; International Aspects of the Petroleum Industry. by Van H. Manning; The Composition of Petroleum and Its Relation to Industrial Use, by C. F. Mabery; Low-Temperature Carbonization of Coal, by S. W. Parr and T. E. Layng; Examination of Ores and Metals in Polarized Light, by Fred E. Wright.

Registration will begin, as usual, at 9 a.m. at the Institute headquarters. Lunches will be served daily at the Engineering Societies' Building. The smoker, which has become an institution, will be held for the members and male guests on Monday evening—during this time the ladies will attend a theater party. Tuesday evening the banquet will take place, while Thursday

an excursion will be taken to the Bush Terminal, Brooklyn.

Institute of Metals Division members are requested to make their headquarters at the Hotel Seville, Madison Ave. and 29th St. This hotel served the Division nicely last February. It will be glad to do so again this year and the members of this Division find special advantages in being together.

The ladies who are visiting the meeting with members are especially invited to attend the luncheons, the banquet, and other functions which have been arranged by the Ladies' Committee for each day of the meeting. An Entertainment Committee from the Ladies Auxiliary, headed by Mrs. Arthur S. Dwight, has prepared a very attractive program which will insure them a pleasant stay.

Bill to Prohibit Export of Helium

Exportation of helium is prohibited without special permit in the draft of the bill which has been submitted to Congress by the Secretary of the Navy. The President is authorized by the bill "to prescribe appropriate rules and regulations to govern the exportation of helium." Exportation of that gas without such a permit is to be punishable by imprisonment for not more than 5 yr. and not less than 1 yr., or by fine of not less than $5,000, or both. Secretary Daniels in recommending the adoption of the measure wrote to the chairman of the Interstate and Foreign Commerce Committee as follows:

"The sources of supply of helium in the United States are not numerous and the quantity obtainable is very much limited. This gas is non-inflammable and is consequently of inestimable value for balloons of all kinds and especially for those of the dirigible types that the Navy Department is endeavoring, under authorization by Congress, to develop and bring to a state of greatest efficiency.

"It is manifest therefore that the public interests imperatively require conservation of the supply of this gas, as the demand for it abroad is insistent and great enough to consume, in all probability, within a short time the available supply in this country.

"The accompanying draft of a bill would admit of the control of the supply of this gas so that the interests of the Government would be given the maximum of protection so far as affected by this matter."

Criticism of Government Expenditures at Muscle Shoals

Government nitrate plants at Muscle Shoals, at Toledo, and at Cincinnati came in for particularly severe criticism at a hearing Feb. 3 before the Graham committee of the House of Representatives. The author of the more serious charge of inefficiency in the handling of the Muscle Shoals project is Fred H. Wagner of Johns Hopkins University. Mr. Wagner formerly was a Lieutenant Colonel in the Ordnance Department and from July, 1918, to May, 1919, was Director of Operations at Muscle Shoals. Patriotism was forgotten at Muscle Shoals, Colonel Wagner asserts. Extravagance not only was permitted but was encouraged, he says. Among points brought out by Colonel Wagner was the fact that a number of former New York City officials held some of the more prominent official positions connected with the Muscle Shoals work. These officials, whom he named, formerly were connected with the New York Fire Department, Street Cleaning Department, and other municipal activities which were in no way connected with the chemical industry.

Colonel J. W. Joyes of the Nitrate Division of the Ordnance Department was called before the committee to explain the purchase of a limestone quarry at Waco, Ala., thirty miles from the Muscle Shoals plant. It had been charged that this action on the part of the Government had put private enterprise engaged in lime industries out of business. Colonel Joyes explained that the purchase was necessary in order to have an absolutely reliable source for limestone.

Hugh L. Cooper, who was connected with the construction of the Keokuk dam, with a large plant at Niagara Falls and other important projects, testified to the effect that he had been recalled from service in France to make an examination of the Muscle Shoals project and had spent three months there. He made recommendations as to changes which were adopted. He expressed the opinion that with a free hand he could have built the Muscle Shoals plant in three years. The Government's estimate was six years. He also stated that four or five years probably will be required to complete the Muscle Shoals plant. He explained the difficulties involved in a 24-hr. use of power as necessary in the production of nitrate as compared with the 10-hr. period for which power is required for industrial purposes in the area supplied by the Keokuk power plant.

The Government is likely to lose nearly $15,000,000 if the Toledo (Ohio) nitrate plant should be salvaged at this time, is the opinion of Henry G. Tyrrell of New York, who also appeared before the committee. Mr. Tyrrell is a member of a firm of plant appraisers. He attempted to appraise both the Toledo and Cincinnati plants for the Government. Before the work was completed he was recalled to Washington and is still awaiting orders which never came. He attributes his separation from the work to the fact that his figures differed so widely from those of the War Department. He also stated that his efforts to appraise these plants were hampered by the failure of the officials to cooperate. He expressed the opinion to the committee that both the Toledo and Cincinnati plants were in unsuitable locations, as is the picric acid plant at Little Rock. At the time these locations were chosen it was done to satisfy certain influential interests as well as to scatter the plants to avoid congestion.

Institution of Mining and Metallurgy Awards Medals

The following awards have been made by the Institution of Mining and Metallurgy (London):

Gold Medal of the Institution (premier award) to H. Livingstone Sulman, M.Inst.M.M., in recognition of his contributions to metallurgical science, with special reference to his work in the development of flotation and its application to the recovery of minerals.

"The Consolidated Gold Fields of South Africa, Ltd.," Gold Medal to William Henry Goodchild, M.Inst.M.M., for his papers on "The Economic Geology of the Insizwa Range" and "The Genesis of Igneous Ore Deposits."

"The Consolidated Gold Fields of South Africa, Ltd.," Premium of Forty Guineas to Dr. Edward Thomas Mellor, M.Inst.M.M., for his paper on "The Conglomerates of the Witwatersrand."

A Compendium of Chemical and Physical Constants

ONE important outcome of the war is the recognition that the United States of America must take a more active part in scientific work than ever before. America has done wonderful things in chemistry, physics and other branches of science, but in spite of this she has not been accorded recognition as a scientific nation. What is more, America serenely accepted the world's estimation and made no effort to get her just dues. This fact we accepted so absolutely that no teacher of the science thought his education complete unless he received a degree after taking a course of study in some foreign university. And many a man has gone to get a foreign education which might or might not be better than that which he could have obtained in this country, simply for the éclat which a foreign diploma gave him. Few non-scientific people realize that the best and most complete works on chemical and physical constants are written in German. To be sure, these are woefully out of date in many respects and they are perhaps known as much for the vast amounts of fundamental knowledge which is missing as for what is contained therein. Much of the knowledge contained therein is incorrect and many divergent values are given without any critical comment to enable the searcher to pick the right one. They are poorly indexed and abominably compiled. But in spite of all these drawbacks and many others which might be mentioned, they are still the most complete source of information gathered in one volume. Being written in German they are hard to understand and American industry because of this fact obtains only a fraction of the matter available therein.

German Literature an Aid to Allies in the War

A fact which is not generally known is that during the war the colleges, universities and the industries were combed for copies of Landolt and Börnstein's Tabellen, and that hundreds of these works were in daily use in the Army, Navy, Airplane and Medical Departments, to say nothing of those used by the Council of National Defense, National Research Council, Shipbuilding and Explosive Departments and many other departments too numerous to mention here. Many Germans figure that it was their literature that defeated them in this war.

It is proposed to issue a critical compendium of chemical and physical constants, which shall be up to date and correct; and which shall contain such new constants as can be determined before the time of publication as well as many which have been determined but which are not now generally available.

Decision to Publish Tables

At a meeting of the Inter-Allied Chemical Conference held in London, July 14-17, 1919, there was formed an International Union of Pure and Applied Chemistry, and it was voted that "Critical tables of physical and chemical constants shall be published in the United States and there shall be created an American publication committee charged with the general organization and the prosecution of the work."

At the meeting of the International Research Council held in Brussels on July 22, 1919, the International Union of Pure and Applied Chemistry became the Chemical Section of the International Research Council. The vote in regard to the publication of critical tables of physical and chemical constants was confirmed by the Chemical Section and by the Physical Section.

Board of Trustees Appointed Here

This work has been undertaken by the National Research Council in co-operation with the American Chemical Society and the American Physical Society. The business arrangements are to be in the hands of a board of three trustees: Mr. Hugh K. Moore, chairman, (appointed by the National Research Council); Mr. Julius Stieglitz, (appointed by the American Chemical Society); Mr. Edward P. Hyde, (appointed by the American Physical Society). By a vote of the National Research Council, these gentlemen have been authorized to raise by subscription $100,000 and as much more as may be found necessary in order to meet the probable deficit which will result from carrying out the task assigned to the United States by the International Research Council.

Aid Asked in the Tremendous Task

It will be seen that America has undertaken a tremendous task. All our colleges have certain information which they can impart. There is a vast amount of knowledge in the research laboratories of the industries. It will be the duty of those in charge to collect and tabulate all this information. Not only this, but an effort will be made to obtain from the business concerns of the country a list of the physical and chemical constants which they require in their business and as far as possible have these determined and included in the work. The information contained therein will be of immense value to all industries using chemical or physical processes.

It is hoped that when manufacturers are approached for funds they will contribute liberally. It is not only good business to support this movement, but it is a patriotic duty. How can the United States hope to be a leader in scientific development, if everyone has to go to foreign publications for information?

In fact, it appears already as though even this information will no longer be all available, since it is reported that there is a movement on hand to prevent the exportation of any more German scientific literature. It is therefore becoming increasingly important that the United States should not only be self-sustaining in regard to this matter, but should take the leadership.

Civil Service Examinations

The Civil Service Commission announces the following examinations:

Associate physicist qualified in physical metallurgy, for men only, at salaries ranging from $2,000 to $2,800 a year. Applications will be received until further notice.

Assistant physicist qualified in physical metallurgy, for men and women, at salaries ranging from $1,400 to $1,800 a year. Applications will be received until further notice.

Pyrotechnic engineer. Duties will be to assist in development of design, test and manufacture of military pyrotechnics, and, in addition, will be those of an observer and firer from aircraft. Salary: Grade 1, $2,400 a year; Grade 2, $3,600 a year. Apply on Form 1312 before Feb. 17.

Proposed Substitute for Dye Licensing System

WHILE the last word has not been heard in the controversy over the licensing of dye imports, it seems certain that the main objections of the opponents of this plan have been met by the modifications now under consideration by the sub-committee. The sections referring to the licensing system in the original Longworth bill[1] have been striken out and replaced by the United States Tariff Commission's plan. The final wording is still uncertain, as Joseph H. Choate, Jr., has suggested certain changes.

Changes in Dutiable List

The following articles have been removed from Group III., sec. 500, that is, the finished product group, for which a duty of 45 per cent ad valorem is provided:

Natural alizarin and natural indigo, and colors, dyes, stains, color acids, color bases, color lakes, leuco-acids, leuco-bases, indoxyl and indoxyl compounds obtained, derived or manufactured in whole or in part from natural alizarin or natural indigo; natural methyl salicylate or oil of wintergreen or oil of sweet birch; natural coumarin.

In place of these natural products the following higher sugars have been substituted:

Adonite, arabinose, dulcitol, galactose, inosite, inulin, levulose, mannitol, mannose, melezitose, raffinose, rhamnose, sorbitol, xylose, and other of the higher saccharides required for scientific purposes.

Tariff Commission Plan

The new section 504 provides that no article on the dutiable list shall be imported into the United States unless the Tariff Commission shall determine that such article (or a satisfactory substitute) is not obtainable in the United States on reasonable terms as to quality, price and delivery, and that the article is required for use by an actual consumer in the United States. In addition, Mr. Choate proposes that the Tariff Commission prepare, after investigation, a list, to be known as the importable list, of such products as may be found by it to fulfill the above requirements for admission to import.

The phrase "reasonable terms as to price" for any article is defined as the lowest price, for the time being, which, in the judgment of the Tariff Commission, shall be sufficient to insure the maintenance in the United States of the production of such article by an efficient plant operating on a substantial commercial scale.

Suggestions as to Procedure

All details as to practice and procedure are to be determined by the Tariff Commission. Mr. Choate suggests that such rules and regulations shall be so framed as to prevent the importation of any article in quantities sufficient to discourage manufacture of the same in the United States, or to provide any consumer with supplies from any source exceeding his needs for six months in advance, or to cause an accumulation in the United States of more than a six months' supply for the country as a whole.

Extension of War Trade Board Licenses

Notwithstanding the prior termination of the present war the provisions of the trading with the enemy act are to be continued for ninety days after the date of the taking of effect of this act and all individual licenses issued by the War Trade Board section of the State Department during this period are to remain in effect. At the end of this period all records, etc., relating to individual import licenses for articles on the dutiable list are to be turned over to the Tariff Commission.

For the purpose of enforcing this act, the Tariff Commission has the right to demand from manufacturers, dealers and importers sworn statements as to production, stocks on hand, cost of production, price, etc. Such information shall be confidential, of course, and shall not be published except in the form of tables, averages and summaries which shall not disclose the operations of individual domestic manufacturers.

[1] H. R. 8,078; Sec. 503(a) to 503(d) inclusive, Sec. 504. The bill passed the House of Representatives Sept. 26, 1919, and was referred to the Senate Committee on Finance Sept. 29, 1919.

American Chemical Society, Chicago Section Meeting

The January meeting of the Chicago Section of the American Chemical Society was held at the City Club, Jan. 16. The principal speaker of the evening was Dr. Clarence W. Balke, who spoke to the members on the metallurgy and manufacture of tungsten.

Dr. Balke covered at considerable length the process of manufacture employed at the Fansteel Products Co.'s works in North Chicago, a full description of the operation of which was published in the Jan. 7 issue of Chemical & Metallurgical Engineering.

New York Section, A. I. M. E., Elects Officers

At the regular February meeting of the New York Section of the American Institute of Mining and Metallurgical Engineers held on Feb. 4, the following officers were elected for the ensuing year: Chairman, E. P. Mathewson; vice-chairmen, William Y. Westervelt and D. M. Liddell; treasurer, E. L. Gruver; members of the executive commitee, S. H. Ball and A. F. Keene.

The subject of the meeting was Foreign Trade. The speakers were G. A. O'Reilly, of the Irving National Bank, and V. Gonzalles, of the Mercantile Bank of the Americas, and Dr. John F. Crowell, of the R. G. Dun Co.

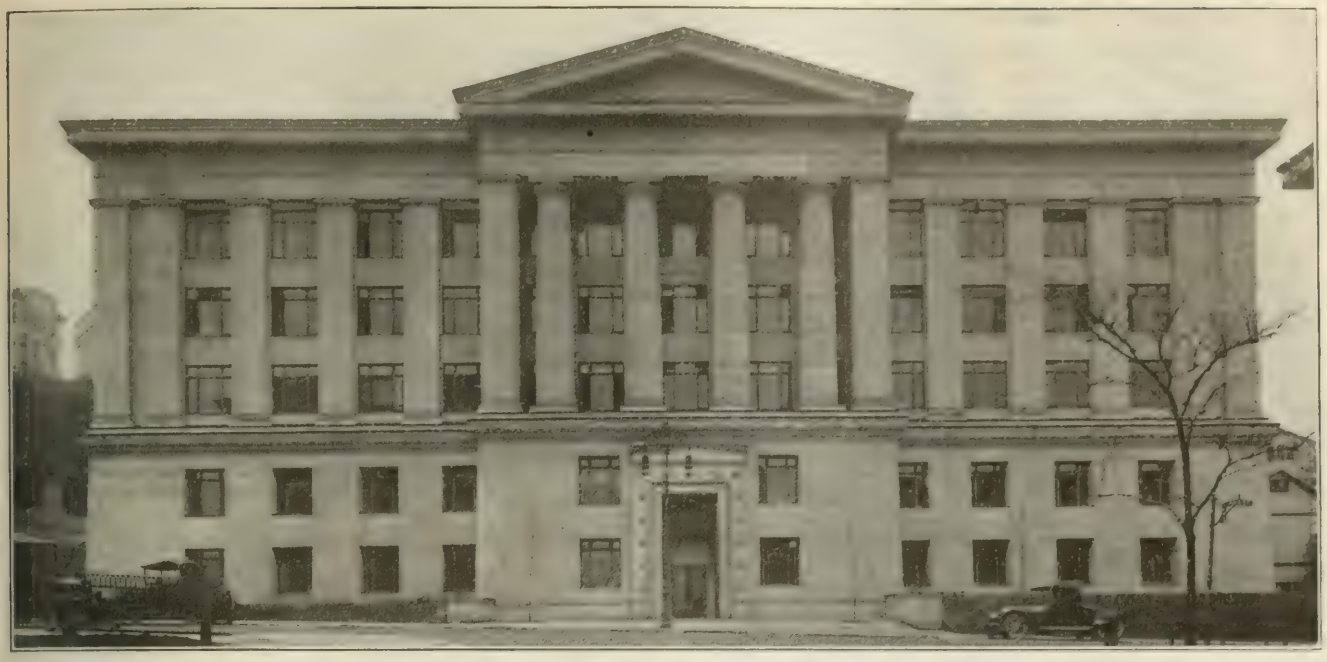
Stretched Wire Apparatus for Measuring Thermal Expansions

An unfortunate piece of printers' pi was dished up to the readers of A. W. Gray's article on the above subject in Chemical & Metallurgical Engineering of Nov. 26-Dec. 3, 1919, prepared during the printers' strike. The matter immediately preceding the first subtitle on page 668 should read:

"Molybdenum repeats better than most substances, and is, therefore, well suited for exhibiting the reliability of expansion apparatus.

"The precision easily attainable with stretched wire expansion apparatus is also well illustrated by the routine practice of plotting to a large scale the deviations of individual measurements from the quadratic which best represents an entire series. This method is useful not only for adjusting observations, but also for locating transition regions with precision, as can be seen by examining the deviation curves published by Merica and Schad."

On page 670 the word "or" in line 16 of the first paragraph should have been "of." In the seventh line of the last paragraph of this section the fraction "$\frac{5}{4}$" is omitted before the words "the expansion of *AJ*."



MELLON INSTITUTE OF INDUSTRIAL RESEARCH

Industrial Research at the Mellon Institute

A Concise Account of the Fellowship System of Industrial Research—Developments in Bread, Laundering, Refractories, Dental Cements, Magnesia Insulation, Insecticides, Protected Metals, Paper Containers, Flotation, and Testing of Leather Belting

By WALLACE SAVAGE

BEING inquisitive to know just what the accomplishments were that had created the great repute in industrial circles of the Mellon Institute of Industrial Research in its brief eight years of activity in Pittsburgh, the writer made a survey of the pertinent literature. Reviewing backwards, the first clue was found in "Some Present-Day Problems of Chemical Industry."[1] Here was listed a selection of problems such as are taken at the Institute for investigation, together with a few preliminary general remarks on the methods of industrial research. Being in quest of solved problems, "The Industrial Fellowships of the Mellon Institute"[2] was scrutinized next. The progressive growth in the number of industrial fellowships and fellows, together with the increase in contributions, shown

TABLE I. ANNUAL RECORD

March to March	Number of Fellowships	Number of Fellows	Amounts Contributed
1911–1912	11	24	$39,700
1912–1913	16	30	54,300
1913–1914	21	37	78,700
1914–1915	21	32	61,200
1915–1916	36	63	126,800
1916–1917	42	65	149,100
1917–1918	42	64	172,000
1918–1919	47	77	238,245

in this report, as recorded in Tables I and II, was certainly excellent evidence of the merits of the industrial fellowship system, in even a greater measure than the founder, the late Dr. Robert Kennedy Duncan, had ever predicted in his writings.[3] However, after examining the indexes of several of the publications especially representing industries having fellowships, it soon became apparent that the reports on the findings were voluminous as well as widely scattered, and that the most convenient source for the desired information was to be had by direct interview with the directors and the industrial fellows of the Institute.

Organization and Administration

In the spring of 1913, Andrew W. and Richard B. Mellon gave a sum of money which was sufficient to erect a substantial home, purchase a large amount of equipment and supply an annual income of $65,000. At present about $250,000 are received from the fellowship donors, making the total available funds $315,000 per annum. While the Institute is operated as a part of the University of Pittsburgh, it is independent financially and under its own management. The functions of the administrative organization are shown in the chart.

In establishing an industrial fellowship, an agreement is made between the donor and the director of the Institute, in which the donor agrees to furnish a stated amount of money, the expenditure of which shall be limited to his problem and for which he shall receive exclusive title to any results obtained. Assignments to all patents on inventions made during and germane to the fellowship are made by the fellow to his donor. The

[1] Bacon and Hamor, *J. Ind. Eng. Chem.*, vol. 11, p. 470.
[2] Bacon, *J. Ind. Eng. Chem.*, vol. 11, p. 371.
[3] "The Chemistry of Commerce" and "Some Chemical Problems of Today."

TABLE II. INDUSTRIAL FELLOWSHIPS IN OPERATION, 1919

Numbers and Names of Industrial Fellowships	Industrial Fellows, Names and Degrees	Foundation Sums and Dates of Expiration
117—Window Glass	(Fellow to be appointed)	$3,000 a year. Bonus: $2,000.
127—Collar	H. D. Clayton (B. A., Ohio State University)	$2,800 a year. June 14, 1919.
129—Illuminating Glass	A. H. Stewart (B. A., Washington and Jefferson College)	$2,100 a year. October 1, 1919.
145—Soap	(Fellow to be appointed)	$2,000 a year.
150—Enameling	R. D. Cooke (M. S., University of Wisconsin)	$2,600 a year. April 1, 1919.
151—Leather Belting	P. G. McVetty (M. E., Cornell University), senior fellow	$4,900 a year. April 1, 1919.
	R. H. Edson (B. A., Clark College)	
152—Refractories	R. M. Howe (M.S., University of Pittsburgh), senior fellow	$7,000 a year. May 1, 1919.
	B. M. Burchfiel (B.A., Southwestern College). E. N. Jessop (B.S., University of Pittsburgh). S. M. Phelps (assistant).	
153—Canning	M. R. Daughters (M.A., University of Nebraska), (second fellow to be appointed)	$6,000 a year. May 1, 1919.
154—Paper	Howard Curtis (B.A., Washington and Jefferson College)	$2,175 a year. June 1, 1919.
155—Protected Metals	J. H. Young (Ph.D., Ohio State University)	$3,000 a year. June 1, 1919.
156—Physiological Research	K. K. Jones (M.S., Kansas State Agricultural College)	$4,000 a year. August 1, 1919.
157—Dental Products	C. C. Vogt (Ph.D., Ohio State University)	$2,000 a year. July 1, 1919. Bonus: Royalty on sales.
158—Leather soling	C. B. Carter (Ph.D., University of North Carolina)	$3,500 a year. June 1, 1919.
159—Copper	C. L. Perkins (B.S., New Hampshire College)	$5,400 a year. July 1, 1919.
	R. E. Sayre (M.S., University of Wisconsin)	
160—Oil	W. F. Faragher (Ph.D., University of Kansas), senior fellow	$10,000 a year. Sept. 1, 1919.
	W. A. Gruse (Ph.D., University of Wisconsin)	Bonus: $10,000.
161—Glass	R. R. Shively (Ph.D., University of Pittsburgh)	$4,000 a year. Sept. 1, 1919.
162—Gas	J. B. Garner (Ph.D., University of Chicago), senior fellow	$7,500 a year. Sept. 15, 1919.
	H. B. Heyn (B.S., University of Wisconsin).	
163—Aluminum	E. O. Rhodes (M.S., University of Kansas), senior fellow	$6,500 a year. Sept. 15, 1919.
	R. B. Trusler (B.S., Syracuse University).	
164—Alloy	O. E. Harder (Ph.D., University of Illinois)	$3,500 a year. Oct. 1, 1919.
165—Coffee	C. W. Trigg (B.S., University of Pittsburgh)	$2,250 a year. Oct. 1, 1919. Bonus: 2 per cent of gross profits.
166—Food Container	F. W. Stockton (B.A., University of Kansas)	$5,000 a year. Oct. 16, 1919.
167—Magnesia	M. S. Mason (M. S., University of Illinois)	$6,000 a year. Jan. 1, 1920.
	R. H. Heilman, assistant (University of Pittsburgh)	
166—Yeast	Ruth Glasgow (M.S., University of Illinois), senior fellow	$15,000 a year. Nov. 1, 1919.
	Grace Glasgow (M.S., University of Illinois). G. S. Bratton (B.A., University of Tennessee). F. M. Hildebrandt (Ph.D., Johns Hopkins University). W. H. Randall, assistant (George Washington University).	
169—Copper	G. A. Bragg (B.S., University of Kansas), senior fellow	$6,000 a year. Nov. 1, 1919.
	J. W. Schwab (B.S., University of Kansas).	
170—Household Utilities	F. F. Rupert (Ph.D., Massachusetts Institute of Technology)	$5,000 a year. Nov. 1, 1919.
	E. R. Edson (B.A., Clark College).	
171—Asbestos	A. F. Shupp (Ph.D., University of Pittsburgh)	$3,500 a year. Nov. 1, 1919.
172—Silicate	M. G. Babcock (M.S., Iowa State College)	$2,500 a year. Dec. 1, 1919.
173—Fiber	J. D. Malcolmson (B.S., University of Kansas)	$3,000 a year. Nov. 15, 1919.
174—Glycerine	R. K. Brodie (M.S., University of Chicago)	$5,000 a year. Nov. 15, 1919.
	Melvin DeGroote (B.Ch.E., Ohio State University)	
175—Light Metals	P. V. Faragher (Ph.D., Massachusetts Institute of Technology)	$4,000 a year. Dec. 1, 1919.
176—Fuel	J. G. Davidson (Ph.D., Columbia University)	$5,000 a year. Jan. 1, 1920.
177—Toilet Articles	(Fellow to be appointed)	$3,500 a year.
178—Silverware	H. E. Peck (B.S., Clarkson Memorial College of Technology)	$2,500 a year. Dec. 11, 1919.
179—Organic Solvents	L. M. Liddle (Ph.D., Yale University), senior fellow. H. W. Greider (M.S., University of Kansas)	$5,600 a year. Jan. 1, 1920.
180—Keratin	B. A. Stagner (Ph.D., University of Chicago)	$4,000 a yr. Jan. 1, 1920. Bonus: $5,000.
181—Synthetic Resins	(Senior fellow to be appointed). A. E. Coxe (B.S., University of Chicago)	$5,000 a year. Dec. 23, 1921.
182—Byproducts Recovery	Walther Riddle (Ph.D., University of Heidelberg). H. E. Gill, assistant (University of Pittsburgh)	$3,000 a year. Jan. 1, 1920.
183—A, Organic Synthesis	G. O. Curme, Jr. (Ph.D., University of Chicago), senior fellow. H. R. Curme (Ph.D., University of Pittsburgh). J. N. Compton (M.S., Columbia University). C. O. Young (Ph.D., University of Pittsburgh). E. W. Reid (M.S., University of Pittsburgh).	$32,400 a year. Jan. 1, 1920.
183—B, Organic Synthesis	H. A. Morton (Ph.D., University of Pittsburgh), senior fellow	
	C. J. Herrly (B.S., Pennsylvania State College)	
184—Coke	F. W. Sperr, Jr. (B.A., Ohio State University), advisory fellow	$7,020 a year. Jan. 1, 1920.
	O. O. Malleis (M.S., University of Kansas)	
	L. R. Office (B.S., Ohio State University).	
	H. S. Davis (Ph.D., Harvard University).	
185—Insecticides	O. F. Hedenburg (Ph.D., University of Chicago)	$3,500 a year. Jan. 1, 1920.
186—Fertilizer	H. H. Meyers (B.S., University of Pennsylvania)	$4,000 a yr. Jan. 5, 1920. Bonus: $5,000.
187—Glue	R. H. Bogue (M.S., Massachusetts Agricultural College)	$2,500 a year. Jan. 5, 1920.
188—Distillation	David Drogin (M.S., University of Pittsburgh)	$3,000 a year. Jan. 18, 1920.
189—Laundry	H. G. Elledge (M.S., University of Pittsburgh)	$5,000 a year. Feb. 15, 1920.
	Alice L. Wakefield, assistant (B.S., Margaret Morrison).	
190—Bread	H. A. Kohman (Ph.D., University of Kansas), senior fellow	$10.000 a year March 1, 1921.
	Roy Irvin (M.S., University of Kansas)	Bonus: $10,000.
	R. J. Cross (B.A., Leland Stanford Jr. University).	
191—Fruit Beverages	H. A. Noyes (M.S., Massachusetts Agricultural College)	$3,000 a year. March 1, 1920.

fellow and the directors are granted open access to the donor's factory and the co-operation of its operating staff. Reports on the findings of the research can be published with the consent of the company at any time or after three years from the completion of the fellowship work by permission of the director upon the decision that such publicity would not unduly injure the interests of the donor.

The Institute in its relation to a fellowship has two important functions. It brings into association a body of men having a wide variety of knowledge in pure and applied science and furnishes them with extraordinary facilities for augmenting and applying the same. While interconsulting among the fellows is largely done through the directing staff, free direct intercourse on scientific matters is permitted. The potency of this aggregation of specialists increases with the number of fellowships and the variety of industries represented by them. At the conclusion of a research, the donor of a fellowship often will have available the services of a man of training superior to that obtainable in the university or technical school and immediately adaptable to his particular requirements. The Institute is producing industrial specialists of its fellows, in the increased ability of whom the community will eventually be more benefited than by the most successful conclusion of any of their researches.

Industrial Fellowships

Industrial fellowships are usually founded by individual companies, but there are at present nine important association fellowships. These are shown in Table III. It is the intention of the administration to encourage this class of donors, because the benefits derived from their type of investigations will normally have the widest distribution.

Where the research involves more work than can be performed by one fellow, a sufficient staff, known as a multiple fellowship, is appointed, responsible through a senior fellow to the administration.

ADMINISTRATION
H. S. Coleman W. A. Hamor E. W. Tillotson
R. F. Bacon E. R. Weidlein D. S. Pratt

A very brief description showing the accomplishments of six of the association fellowships and four of the company fellowship investigations will now be given as affording examples of the work done at the Institute.

Laboratories[4], outside unit plants and experimental equipment will not be described further than can be done by the accompanying selection of illustrations.

Bread Fellowship

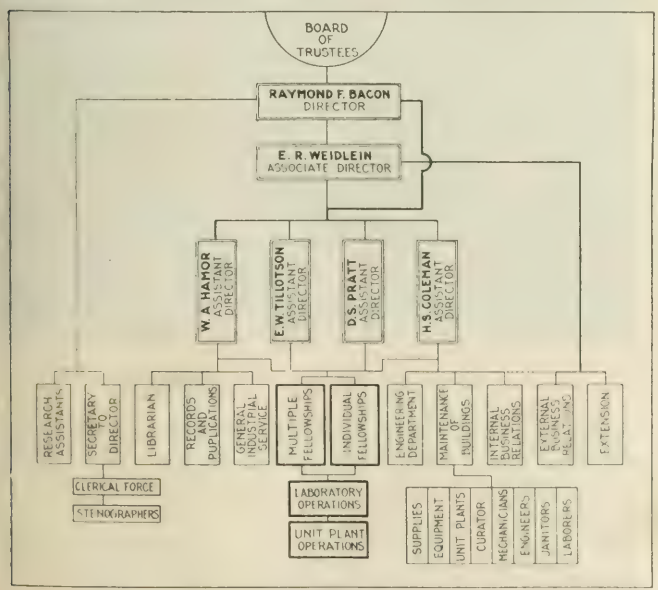
During the pioneer days of the industrial fellowship system at the University of Kansas, Dr. Henry A. Kohman isolated and grew a pure culture of spores concerned in the fermentation of "salt-risin" bread. This was very noteworthy, as it was the first scientific contribution of importance to the ferment bread-leavening industry. Since the introduction of these spores, "salt-risin" bread has been steadily increasing in commercial importance. Less than ½ per cent of the weight of the bread stock is lost in this spore-leavening process, which, when compared to the 5 per cent loss in ordinary yeast leavening, will be readily acknowledged by any one acquainted with baking finances to be of vast economic importance. While nothing has been accomplished toward elucidating the enzyme action of the spore, its products have been found to be mainly edible organic acids, such as lactic, and gases consisting of one-third carbon dioxide and two-thirds hydrogen. Dr. Kohman now markets these spores in quantity lots to the bakery trade.

In 1911, after reading Dr. Duncan's chapter on "Bread" in "Some Chemical Problems of Today," George S. Ward, of the Ward Baking Co., of New York, decided to establish a multiple fellowship and find out whether science could improve on the art of bread making as it had been passed on after the lifelong and collective efforts of hundreds of generations of bakers.

[4] "Description of the New Building of the Mellon Institute," Hamor, *J. Ind. Eng. Chem.*, vol. 7, p. 333.

TABLE III. ASSOCIATION FELLOWSHIPS

	Companies	Foundation Sum
Leather belting	40	$4900
Refractories	84	7000
Canning	71	6000
Leather soling	60	3500
Magnesia products	4	6000
Asbestos	10	3500
Fiber board containers	20	3000
Insecticides	9	3500
Laundry	2500	5000



ADMINISTRATION CHART

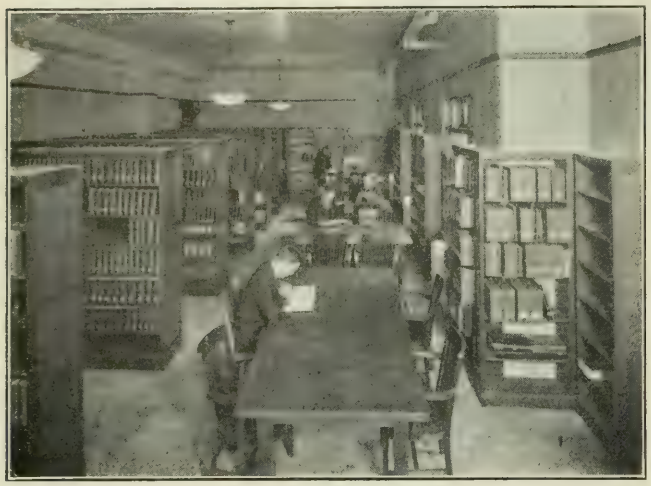
FELLOWS' ROOM

Dr. Kohman, already being the recognized genius in applying science to this industry, was chosen to take the fellowship.

Within a short time "Arkady" yeast food was evolved. In the old process of leavening, the yeast derived its nourishment mainly from the soluble sugar, mineral salts and protein contents of the dough. Considerable time appeared to be lost in the breaking down of the proteins by the yeast, so Dr. Kohman experimented with ammonium salts as a substitute for this complex source of nitrogen. The yeast thrived and generated the leavening carbon dioxide in a much more efficient manner. The brewing industry for generations had known that lime salts were an important tonic,

so Dr. Kohman studied their application and found that they were of great value. Hints taken from the chemical fertilizer industry did not prove so profitable, with the result that potash and soluble phosphates were found to contribute nothing. The wheat flour carried a sufficient content of these latter salts, while the others, though present, were in insufficient amounts adequately to supply the appetite of the yeast.

After Dr. Kohman had mastered the yeast-feeding problem, he found that it was possible to hasten the aging or maturing process. This was believed to be an



LIBRARY AND READING ROOM

oxidation phenomenon, wherein the leavened dough cell walls became more viscid and elastic. A small addition of potassium bromate was eventually found to give the desired oxidation necessary to the aging process. The most efficient mixture of salts so far determined has been found to be 100 g. of ammonium chloride, 240 g. of calcium sulphate and 3 g. of potassium bromate to the 200 kg. of flour used. The decrease in the amount of sugar lost in leavening fermentation is about 27.5 lb. per ton of flour. Only half as much yeast is required, so it can be said that the cost of leavening bread with yeast has been cut in two by the discovery and adoption of "Arkady" yeast food.

Laundryowners' National Association Fellowship

About one-half the laundry companies in the United States, representing a business of at least $150,000,000, through their Association, are the donors of the laundry multiple fellowship. Harvey G. Elledge, assisted by Miss Alice L. Wakefield, has given individual attention to numerous problems as they have arisen in the plants of the Association throughout the country. Poor textiles and dyes nearly always do not impressively come into evidence until they have been laundered. An accompanying photomicrograph, Fig. B, illustrates what to the unaided eye would pass for silk cloth. The large cotton filling threads and the few bushed out unspun silk fibers make a combination which is almost as delicate as a spider web. A shirt made of this material failed to survive intimate contact with soap and water even when carefully laundered by hand.

A fading dye does not give as serious trouble as a mixed blend, one important member of which is not fast. The owner of what was a blue shirt can rarely be made to be contented with the delivery of the same article washed out to some other color. More serious trouble arises when the fabric has been tendered in dyeing, for then the oxycellulose formed passes into the soapsuds emulsion along with the soiling materials. Fig. A represents a blue bandana handkerchief, having white dots, which were made by removing the dye by printing with stripping salts. Failure to wash out these corrosive salts promptly, if at all, permitted the formation of non-fibrous oxycellulose, and, when the handkerchief was laundered, the product looked as though it had received pretty rough treatment.

Such occurrences, becoming more and more common in these days of higher prices and lowered production, have given to the laundry fellowship the added purpose of educating the public to the necessity for discrimination in purchasing, which is the only method that can successfully eliminate the present condition of unfair prejudice against the power laundry. This purpose, in connection with the original object of investigation of the actual problems of conducting a power laundry in so far as they are related to chemistry, has opened a field which, when it has been fully developed, shall have increased the store of chemical and industrial information many-fold. One of the most useful of the recent accomplishments of the laundry fellowship has been the working out of standard washroom formulas. These scientific procedures are now in use in the laundries of the Association membership.

Refractories Manufacturers' Association Fellowship

Two and one-half years ago, the Refractories Manufacturers' Association founded a multiple fellowship at the Institute for the main purpose of developing standard tests to be used in the specifications of refractories. Simple tests that could be interpreted to or would directly indicate the properties of a refractory in actual use were very much desired. A fuller understanding of the purpose of the tests and a discontinuance of mis-

TYPICAL SMALL LABORATORY

application of them in many specifications of consumers were also sought. Incidentally, it was believed that improvements in refractory products would be a sequel to better methods of testing.

Raymond M. Howe and a staff of three are amply meeting the expectation of the donors of the fellowship. They have aided much in clearing up the variation of

AISLE OF LABORATORY SUPPLY ROOM

fusion with respect to time of heating and under loads. Slag penetration and abrasion, spalling and changes in volume under reheating are all being kept under consideration. At present the clay silicates form too complicated a system for their properties to be resolved to and conceived by a few fundamental physical laws. Whatever advance is made in this direction will first be associated with simpler materials such as magnesia and silica products. In the case of magnesia, extensive investigations have been required to develop a domestic product having the properties of that formerly imported. The effect of the basic fluxes such as lime, iron oxide, etc., on the slaking, slagging and general stability in use was sufficiently determined to give the data required for the production of satisfactory magnesia products from domestic magnesite.

The most outstanding among the industrial contributions of this fellowship is an improvement in manufacturing auger machine-made brick. While such firebrick find wide commercial application because of their uniformity and density, they are sometimes regarded with skepticism because of a more or less laminated structure. These laminations are the result of the center of the clay column moving faster than the exterior, due to the resistance caused by the surface of the die. It has been found that this lamination may be removed by repressing the soft unburned bricks on edge, thus overcoming the prejudice of the mason who has trouble in accurately breaking a laminated brick, retaining the economy of the process, and extending the application of such bricks to larger fields.

The Dental Products Fellowship

The Lee S. Smith & Son Manufacturing Co. was not satisfied with the opaque dental cements in general use up to 1915 and desired to manufacture a translucent tooth-like product, highly resistant to physical and chemical action. Dr. C. C. Vogt was chosen to work on that problem at the Institute. The non-translucent cements used prior to the completion of Dr. Vogt's work consisted of an opaque aggregate of metal oxides, such as zinc, etc., bonded together by insoluble translucent phosphate salts, formed by the reaction between the basic aggregate and phosphoric acid. Dr. Vogt's problem ultimately simmered down to producing a basic translucent aggregate. By fusing his metal oxide with fluxes such as feldspar, silica and fluorides, he was eventually able to get just such a translucent basic aggregate as he desired. Considerable investigating was required to select the best formulæ and to meet all the specifications. The nation-wide adoption of the cement by the dental profession within the last three years is ample testimony of the success of this fellowship.

Magnesia Association Fellowship

Reliable heat data on insulation materials, especially 85 per cent magnesia, are required to enable manufacturers to know what a given investment in insulation materials will net them on their fuel account. In 1918 Glen D. Bagley and R. H. Heilman held the fellowship, and during the present year M. S. Mason and Mr. Heilman have proceeded with the investigation.

The method of procedure is to measure the electrical energy input required to maintain a given temperature difference between the test pipe and the air in the room. The pipe is heated by means of three separate electric heating coils which are arranged end to end within the pipe. When the thermocouples in the pipe wall indicate that the center and the end sections are at the same temperature, there is no longitudinal flow of heat within the pipe. Under such conditions the energy supplied to the center section of the pipe must flow radially through the covering of the center section and be lost by radiation and convection. From the heat equivalent of the electrical energy supplied to the center section, the loss per unit area of pipe surface can be calculated. The investigation will be continued to find how these losses are affected by variations in covering and ranges in temperature upon exposure under all possible factory conditions. Excellent sets of curves showing heat losses, steam costs and economical sizes of magnesia insulation have been put out by the association under whose auspices the research work is being carried out.

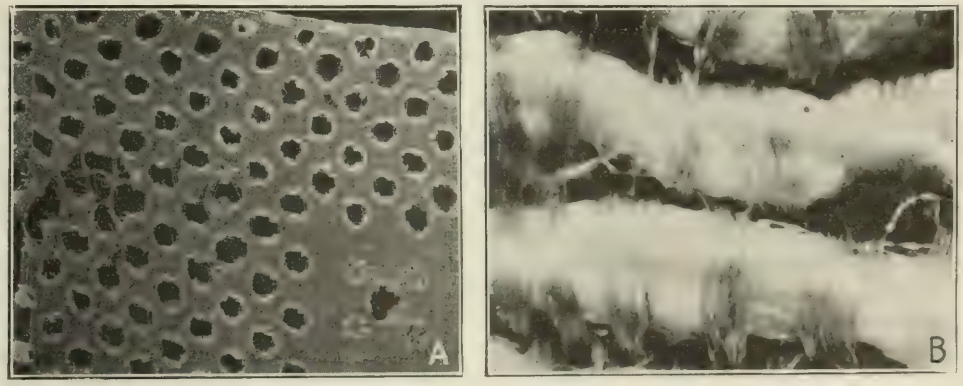


FIG. A. COTTON TENDERED WITH STRIPPING SALTS. FIG. B. UNIQUE COTTON-SILK WEAVE

The Rex Insecticide Fellowship

A number of arsenates and arsenites have been manufactured by various companies for insecticidal purposes, but the arsenates of lead and of calcium have proved to be the best. The former may be used on all

kinds of foliage, but the latter should not be used on stone fruits, although it may be used on other foliage, and especially in combination with lime-sulphur solution.

The Rex Spray Companies, desiring to improve their products and to manufacture other insecticides, became the donors of this fellowship. Dr. Oscar F. Hedenburg, industrial fellow, has made considerable progress with their problems during the past two years.

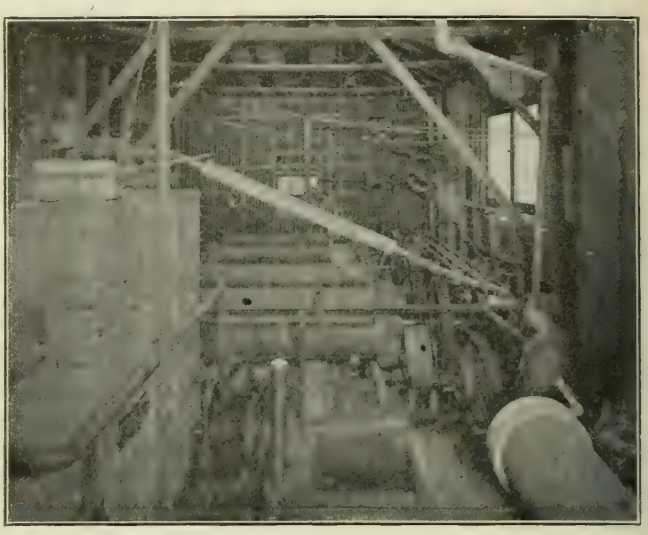
Arsenate of lead has been in use for a number of years. All brands are guaranteed to contain 30 or 31 per cent of arsenic oxide, As_2O_3, and may contain up to 32 per cent. Arsenate of lead must not contain more than 1 per cent of soluble arsenic, calculated as As_2O_5.

Since nearly all arsenate of lead is used in suspension in water, that product which remained in suspension the longest time, or which settled the most slowly, has been regarded the most satisfactory. Besides this property, adhesion to the foliage and spreading or covering power have been considered of great value.

As a result of work in connection with this fellowship, an arsenate of lead has been produced which exhibits to an unusual degree the properties mentioned above. It has been named "NuRexform" dry arsenate of lead. From suspension in water it separates only after standing several hours. It is so finely divided that the agitated suspension has a "silky" appearance. When sprayed onto a surface, it covers it uniformly, and, after the water has evaporated, the dry deposit cannot be washed off by a heavy flow of water. Even when a sulphide solution, such as lime-sulphur solution, is added to the suspension, this arsenate of lead darkens very little and the stability of the suspension is hardly affected. Other arsenates of lead, when treated thus, become flocculated and almost black, and as a result the property of suspension is lost. As applications for patents have only recently been filed, a more detailed account cannot be given at present.

The destructiveness of the cotton boll weevil made extensive research of effective control necessary. This work was carried on by the Government at the Delta Laboratory, Tallulah, La. Dusting cotton plants with calcium arsenate five times during the season was found to give the most effective control. An important demand for calcium arsenate was created without giving the various producers much advance notice.

UNIT PLANTS



UNIT PLANT—TUBE MILL INSTALLATION

Dr. B. R. Coad, in charge of the work, set the following requirements for calcium arsenate to be used in boll weevil control:

Not less than 40 per cent As_2O_5.
Not more than $\frac{3}{4}$ per cent soluble As_2O_5.
Density, 17 to 22 lb. per cu.ft.
80 to 100 cu.in. per lb.

The legal limit for soluble arsenic oxide is 1 per cent. The soluble arsenic value measures the tendency of an arsenate to destroy the plant tissue.

Research on this fellowship has made it possible to produce a fine, white calcium arsenate containing less than $\frac{1}{2}$ per cent of soluble arsenic, and some batches have shown only a trace of soluble arsenic.

Production of calcium arsenate containing soluble arsenic below the legal limit has been the greatest difficulty experienced by manufacturers. The manufacture of calcium arsenate with soluble arsenic far below the legal limit is a distinctive advance.

The Protected Metals Fellowship

A prominent manufacturer of a sheet steel building material which is coated with rust-proofing layers of asphalt and asbestos felt experienced great difficulty in preventing the coated sheets from sticking together, especially when they were subjected to any considerable pressure. On this account, the material could not be piled either during storage or shipment, without taking considerable risks.

Dr. J. H. Young found the solution of the problem within thirty days after the inception of the work. He obtained from cellulose an economical surfacing material, which adhered well to the asphalt coating as well as giving the desired break in contact between the asphalt surfaces.

The Container Club Fellowship

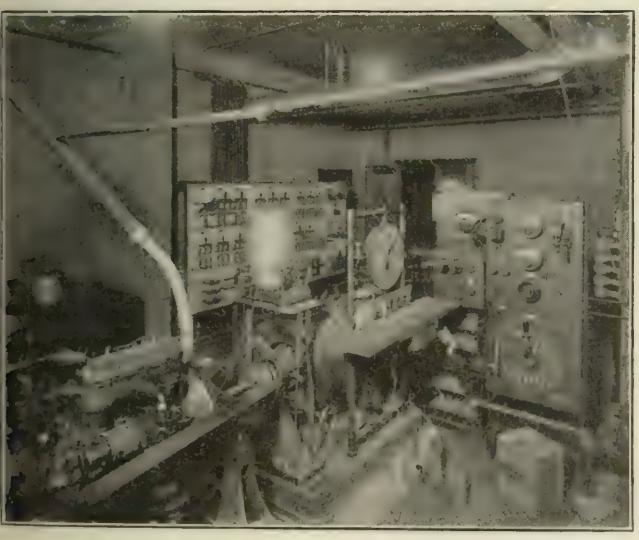
The recent advent of the Webb paper and box tester was due to the unreliability of the Mullen test on corrugated fiber board. The manufacturers experienced great difficulty with the railway testing laboratories on this account. J. D. Malcolmson has spent the last year in perfecting the Webb instrument with its various attachments. A small perforated foot fitting the corrugation is so arranged that perfect support is given to the fiber, the true breaking strength of which is then measured by the perforating force of the plunger. Each wall is measured separately and the strength of the

board is arbitrarily taken as the sum of the walls. Many of the instruments are now in operation and specifications are being drawn calling for its use. The tester is so calibrated that it gives Mullen figures on paper. A tensile strength attachment is provided so that the test figures of the Schopper instrument can also be obtained with it. A small pocket tester has also been perfected, which is intended for the use of inspectors in catching shipments that are suspected of being under specifications.

The adhesives and other raw materials used in the manufacture of boxes from the corrugated board have been considerably improved. The viscosity of waterglass has been found to rise enormously with the addition of sodium chloride. This is important in reducing the alkalinity and amount applied to obtain adhesion. Recommendations have been made to have the heavy fibers of the boards belted crosswise so as to give a maximum lateral strength. Up to the present ordinary tape has been used in strapping the boxes. This has the stronger cords running lengthwise and is designed to give high tensile strength. Resistance to lateral tears is required of box tape, so a special weave has been worked out that should prove more satisfactory than the tape now in use.

Copper Flotation Fellowship

The Institute has been studying the subject of flotation for about six years. In the beginning a great deal of attention was devoted to the theory of the froth process which was then in a very confused state. As



MOTOR FUEL POWER TESTING EQUIPMENT

one result of this investigation into the mechanism of the process, the great effectiveness of alphanaphthylamine and a few closely related compounds as flotation agents for the sulphide copper in the low grade disseminated ores of the Southwest was discovered by the late Dr. H. P. Corliss. In the opinion of J. M. Callow, perhaps the foremost authority on flotation in this country, this discovery marked the greatest single improvement in the art since its introduction into the United States.

The discovery of alphanaphthylamine also opened up a whole new field for research. Recently the work of the fellowship, carried on by C. L. Perkins and R. E. Sayre, has been largely confined to the study of this field, with results which will one day constitute a very interesting chapter in the story of the development of the flotation process.

The Leather Belting Fellowship

The Leather Belting fellowship was founded for the purpose of investigating the comparative power-carrying capacities of leather and substitute belts and to obtain definite scientific data in reference to the transmission of power by belts. For this work a complete belt testing outfit, consisting of two 100-hp. Sprague electric dynamometers, was installed at the Institute. One of these machines is arranged to operate as a motor and the other as a generator. These machines operate on 220 volts d.c. and are so connected that the output of the generator is pumped back into the line, thus making it necessary to draw on the outside source of power only to the extent of making good the losses in the machines. The fields of both machines are mounted on ball bearings to permit them to turn freely about the armature axis. The torque of the fields is indicated on dial balances through a system of levers. The dials and lever systems are so arranged that the dial reading multiplied by the r.p.m. divided by 1000 equals the horsepower. Connected to each armature shaft is a revolution counter and by the manipulation of a single switch both are either started or stopped through the medium of a magnetic clutch. By this arrangement it is possible to measure the slip of a belt to an accuracy of $\frac{1}{10}$ of 1 per cent. Since April, P. G. McVetty has been testing out all types of belting material.

Principles Applied in the Administration of All Fellowships

The principles applied in the administration of the investigational activities of the Mellon Institute of Industrial Research are much the same as those followed in any other effective business. It is general experience of mankind that if it is wished to get any work well done, the way to go about it is to select competent men, extend them the largest liberties compatible with order and hold them responsible for the attainment of the desired results.

To illustrate: The industrial fellowships of the Mellon Institute are placed in charge of research chemists and engineers selected solely by reason of their special fitness for the conduct of the investigatory work concerned, and these men are accorded the privilege of being the autocrats of their own destinies within the limits of the foundation sums of their industrial fellowships. In addition, every industrial fellow receives the constant advice and collaborative support of an administrative staff which is constituted of experts in scientific research. As stated by the Carnegie Institution of Washington, whose departments of research are similarly operated, the principle applied to the incumbents of all industrial fellowships is "autonomous freedom and reciprocal accountability."

No attempt has been made to offer the reader data on which to base a comparative opinion on research as commonly performed in company laboratories and under the fellowship system as cited above. The former does not lend itself readily to brief treatment because of its extreme variation in ways, means and results. However, from such information as has been made generally known concerning isolated plant and laboratory research work, it may be stated with confidence that the fellowship system is more certain, economical and speedy in attaining results.

Classifying Organic Compounds by the Prager-Jacobson System

By Donald W. MacArdle

OF THE various methods which have been proposed for the classification of organic compounds, only one, that of Richter, assigns to each compound a place determined solely by its formula. In the Richter system, the ultimate elementary composition of the substance is the criterion; this lays the system open to the grave objection that similar compounds, as ethane and propane, are in different sections, while such dissimilar compounds as allyl alcohol, propionic aldehyde, and acetone are grouped together because their empirical formulas are the same, C_3H_6O. To provide a system which shall avoid this defect, but which shall be sufficiently comprehensive to include all known organic compounds, Prager and Jacobson, the chief editors of the fourth edition of Beilstein's Handbook, have developed a method differing in many points from any heretofore proposed. The fundamental rules of this system form the introduction to the first volume of the Handbook, on which the present article is based.

Main Divisions

If we assume that in a compound all atoms or radicals, other than hydrogen atoms, directly attached to carbon, except such as form cyclic complexes, are replaced by an equivalent number of hydrogen atoms, we obtain the "stem nucleus" of the compound. Thus the stem nucleus of (1) aminochloracetic acid ($NH_2CHCl.COOH$) is ethane (CH_3CH_3); (2) of picric acid [$C_6H_2(NO_2)_3OH$] is benzene (C_6H_6); (3) of furfuraldehyde ($C_4H_3O.CHO$) is methyl furane ($C_4H_3O.CH_3$); (4) of methyl ethyl ether ($CH_3CH_2.O.CH_3$) is $C_4H_8 + CH_4$, etc. The stem nuclei are the first consideration in the systematic arrangement of compounds, and are divided into three groups; (I) Acyclic stem nuclei, in which the carbon atoms are united entirely in chain arrangement (examples 1 and 4 above); (II) isocyclic stem nuclei, in which carbon atoms are united in ring formation, and which have only carbon atoms for ring components (example 2); (III) heterocyclic stem nuclei, in which carbon atoms are united in ring formation not only to other carbon atoms, but also to polyvalent atoms of other elements; in this group would fall not only compounds like example 3, but such cyclic compounds as succinic anhydride, phthalimid, lactones, etc.

To these three main divisions of the system, acyclic, isocyclic and heterocyclic, a fourth division is added to include naturally-occurring organic products of incompletely known structure, such as rubber, starch, chlorophyll, etc., or complex mixtures like petroleum.

Principle of Latest Position in the System

If a compound has stem nuclei belonging to two or more main divisions, as, for example, phenyl ethyl ether ($C_6H_5.O.C_2H_5$), whose stem nuclei are C_6H_6 and C_2H_6, the compound falls in the same main division as the one of its component stem nuclei which in the system comes last. Accordingly, phenyl ethyl ether would be treated not with ethyl compounds in the first main division, but with phenyl compounds in the second. This "principle of latest position in the system" applies throughout for all such cases which arise not only in assignment to main divisions, but in further classification into classes, sub-classes, rubrics, etc.

In the case of heterocyclic compounds a complication arises not met with among acyclic or isocyclic compounds, due to the presence in the stem nuclei of atoms other than carbon and hydrogen. This makes necessary an arrangement of these compounds into "heteroclasses," according to the kind and number of the heteroatoms (that is, the atoms in the ring other than carbon atoms). Compounds containing one or more oxygen atoms are treated first, then those with nitrogen heteroatoms, and finally heterocompounds containing both oxygen and nitrogen. In all cases arising throughout the system, derivatives of sulphur and selenium are grouped, whenever possible, with the corresponding oxygen derivatives; thus mercaptans follow alcohols directly, and thiophenes follow furanes. Sulphonic and selenic acids have, of course, no corresponding oxygen derivatives; their place in the system will be shown presently.

Formation of Classes Within the Main Divisions

Alteration of the stem nuclei may take place by the replacement of one or more of the hydrogens attached to the carbon atoms by "inorganic" atoms or radicals (by "inorganic" is meant elements other than carbon and hydrogen). The most important of these inorganic elements are fluorine, chlorine, bromine, iodine, oxygen, sulphur and nitrogen. The halogens appear almost always as single atoms replacing a single hydrogen, but atoms of the three latter elements, by combination with each other and with hydrogen, give rise to a very considerable number of substituent radicals, such as OH, SH, SO_3H, NH_2, NO, NO_2, $NH.NH_2$, N_3, etc. It will be noticed that certain of these radicals contain one or more hydrogen atoms; these hydrogens may in turn be replaced by other atoms or groups, and thereby the number of derivatives greatly increased. These radicals containing hydrogen atoms are known as *functioning substituents*. Seven of the substituents, however—F, Cl, Br, I, NO, NO_2, N_3—do not contain hydrogen and so cannot undergo further substitution. For this reason they are called *non-functioning substituents*. Compounds containing non-functioning groups are considered substitution products of the compounds in which the non-functioning groups are replaced by hydrogen (or hydroxyl—see below); $NO_2CH_2CH_3$ is derived directly from CH_3CH_3; $ClCH_2CH_2OH$ from CH_3CH_2OH, etc., and these substitution products are included in the same class as the parent substance.

Rôle of Functioning Substituents

The functioning substituents, on the other hand, furnish the basis for the establishment of classes within the main divisions. The group -OH, for example, characterizes the class of hydroxy-compounds (alcohols and phenols); the group $-NH_2$ the class of amines. These classes are in turn divided into sub-classes according to whether the characteristic group appears in the molecule once or several times, whether as the sole functioning group or in conjunction with other dissimilar groups.

In the division of hydroxy-compounds it will be noted that when several hydroxy-groups are present, there are two distinct possibilities of arrangement. The hydroxyl groups may be attached to different carbons,

as in ethylene glycol ($CH_2OH.CH_2OH$) and pyrogallol [$C_6H_3(OH)_3$], or they may be attached to the same carbon, as in the compounds $RCH(OH)_2$, $RR'C(OH)_2$, $RC(OH)_3$. Compounds of this type are highly unstable, but by the splitting off of water they yield the aldehydes, ketones, and carboxylic acids, RCHO, RR'CO, RCOOH, compounds of great importance. It would be obviously unsuitable to consider these groups of compounds as polybasic alcohols; instead the groups =CO and -COOH are included in the list of functioning substituents which determine classes, forming respectively the carbonyl derivatives and the carboxylic acids.

Compounds which have a functioning group and one or two other functioning or non-functioning groups attached to the same carbon atom are considered derivatives of the carbonyl-compound or carboxylic acid which results from the replacement of these substituents by hydroxyl, with subsequent splitting off of water. Thus $CH_3CH(NH_2)(Cl)$ is a derivative of CH_3CHO, and $CH_3C(NH_2)(Cl)_2$ of CH_3COOH. The same rule is followed in the case of nitrogen bound by two or three valences to carbon: e.g., $CH_2CH{:}NH$ is a derivative of CH_3CHO; $CH_3C \vdots N$ is a derivative of CH_3COOH. However, when two or three non-functioning groups are attached to the same carbon without at the same time a functioning group being attached, this rule does not apply. For example, CH_2Cl_2 is a derivative of methane rather than of formaldehyde; $CH_3CBr_2(NO_2)$ is a derivative of ethane rather than of acetic acid.

Following these rules, and in particular the "principle of latest position in the system" mentioned above, the main divisions are divided into classes according to the functioning group present. In the complete system there are twenty-eight classes, as follows: (1) Stem nuclei; (2) hydroxy derivatives; (3) carbonyl derivatives; (4) carboxylic acids; (5-7) acids of sulphur and selenium; (8-22) nitrogen derivatives, such as amines, hydroxylamines, azo compounds, etc.; (23-28) compounds with direct bonding of carbon to polyvalent inorganic elements, as phosphine, cacodyl, etc.

Division of the Classes Into Sub-Classes

In the first and second main divisions and in each heteroclass, the first class is that of stem nuclei (in the acyclic and isocyclic divisions these are the hydrocarbons). These stem nuclei are divided into sub-classes (homologous series) arranged according to decreasing saturation; the homologous series are in turn divided into rubrics arranged in order of increasing number of carbon atoms. The series C_nH_{2n+2} would have the rubrics CH_4, C_2H_6, C_3H_8, etc.; under the rubrics the individual isomers are taken up. The arrangement of the isomers is based on a few simple rules, for the discussion of which space is not available here.

With the second class begins the series of classes characterized by functioning groups; the sub-classes are here determined by the number of functioning groups present. Thus the sub-classes of this group would be monohydroxy derivatives, dihydroxy derivatives, trihydroxy derivatives, etc. Each sub-class is in turn divided into homologous series, and these into rubrics, as in the case of the stem nuclei.

In the third class a further complication is introduced: The combination of the characteristic functioning group of the class with the functioning groups of previous classes; in addition to simple carbonyl compounds we must consider in the third group compounds containing both =CO and -OH. Such compounds with mixed functions are always included after all the compounds containing only the single type of functioning group (with, of course, their non-functioning derivatives). In the fourth class the sub-classes would be monocarboxylic acids, dicarboxylic acids, etc., hydroxycarboxylic acids (these and the following sub-classes are arranged in the order of increasing number of oxygen atoms), carbonyl-carboxylic acids, and hydroxy-carbonyl-carboxylic acids; the sub-classes are divided as before.

Index Compounds and Their Derivatives

In the division of the classes into sub-classes, homologous series, etc., we come finally to the individual compounds which are the true representatives of the class. These are known as "index compounds," and are followed directly by such of their derivatives as are not, according to the rules previously stated, considered as index compounds to be treated elsewhere. The derivatives are of three types: (1) Functional derivatives, resulting from the alteration of the functioning group; (2) substitution products of the stem nucleus or functioning group by non-functioning substituents; (3) derivatives resulting from the replacement of functioning oxygen by sulphur or selenium.

The arrangement of derivatives of the second type (substitution products) is according to the following order of substituents: F, Cl, Br, I, NO, NO_2, N_2. For each index compound derivatives containing fluorine alone come first, then that with one chlorine atom (with fluorine derivatives), with two chlorine atoms (with fluorine derivatives), etc. This procedure may be briefly expressed in the rule: "First combination of the new substituent with all that precedes it, then multiplication of the new substituent, with combinations as before."

Derivatives of the first type (functional derivatives) are considered as being formed by "anhydrosynthesis"; that is, by coupling of the functioning group (if carbonyl or carboxyl, in the hydrated form) with organic compounds containing hydroxyl attached to carbon, or with inorganic hydrogen-containing compounds, the coupling taking place with the splitting out of water. The component reacting with the index compound is known as the coupling compound. Such an alteration of the functioning group of the index compound is known as an *alteration of the first degree.* If the coupling compound is capable of undergoing similar substitution, alterations of the second, third, and higher degrees are possible. In the arrangement of derivatives of an index compound, if the first degree is considered higher than the second, the second higher than the third, etc., the rule may be stated that a new derivative of a higher degree is taken up only after all the lower degree derivatives of the preceding compound of the same degree have been included.

If a functioning group can undergo simultaneously more than one first degree alteration, as in the amino group, with two replaceable hydrogens, or the hydrated carboxyl group [$-C(OH)_3$], the same rule for arrangement in the system is followed as in the case of substitution products: First combine, then multiply.

In the case of a compound with two functioning groups, if the groups are the same, a first degree alteration is made in one group (the order of the sub-

stituents being the same as the order in the series of compounds with hydroxyl attached to carbon), all derivatives of this given; then the same substitution made in the other group, all alterations of the first group given, etc. If the groups are different, the one standing earlier in the list of functioning groups is caused to undergo all possible substitutions, the other group remaining unchanged; then a first degree alteration of the second group is made, and the complete series of substitutions of this compound given, and so on.

For a full explanation of how a given complex compound is located in this system, reference must be made to the complete exposition of the system in the Handbook. Suffice here to say that the method used is the reverse of the anhydrosynthesis; the compound is considered as being resolved into its component index compounds (or their substitution products) by hydrolytic splitting, and by the constantly-used "principle of latest position in the system" the compound is located under one of its hydrolysis products.

Space is also lacking here for a summary of the rules for the arrangement in the system of compounds of easily altered structure (tautomeric substances, pseudo-acids and pseudo-bases, etc.), of diphenylmethane and triphenylmethane dyestuffs, and of a few other less important types.

In a work like Beilstein, which in the fourth edition includes more than 150,000 compounds, the system of arrangement must of necessity be complex and subject to a considerable number of more or less arbitrary rules; for a person who makes frequent reference to the Handbook no summary of the system of arrangement can take the place of a careful study of the introduction to vol. 1 (pp. 1-46), in which the system is explained in detail, with numerous examples to clear up obscure points; if the present article assists in the understanding of the introduction, or serves as a passable substitute to occasional users of the Handbook, its purpose will have been accomplished.

Semet-Solvay Co.,
Syracuse, N. Y.

Diagrammatic Outline of Arrangement of Organic Compounds

in

Beilstein's "Handbuch der Organischen Chemie"

(Fourth Edition)

Acyclic Compounds

Hydro-Carbons	Hydroxy Comp'ds	Carbonyl Compounds: Simple Carbonyl Compounds	Carbonyl Compounds: Hydroxy Carbonyl Compounds	Carboxylic Acids: Simple Carboxylic Acids	Carboxylic Acids: Hydroxy Carboxylic Acids	Carboxylic Acids: Carbonyl Carboxylic Acids	Sulphur Acids: Sulphinic & Sulphonic Acids	Sulphur Acids: Functional Derivatives	Amines: Simple Amino Compounds	Amines: Hydroxyl & Carbonyl Deriv's	Amines: Amino Acids	Nitrogen Comp'ds	Metallic Comp'ds
Methane and homologues, with non-functional derivatives; Olefines, Acetylene Series	Alcohols, Ethers, Mercaptans Glycol, Glycerine	Formaldehyde, Acetone Acrolein, Glyoxal	Glycolaldehyde, Aldol, Monosaccharides	Formic Acid, Acetic Acid, Acrylic Acid, Oxalic Acid	Carbonic Acid, Lactic Acid, Tartaric Acid, Citric Acid	Glyoxalic Acid, Aceto-Acetic Acid, Glycuronic Acid	Methyl-Sulphuric Acid	Sulpho-Acetic Acid, Isathionic Acid	Methylamine, Allylamine	Amino Ethyl Alcohol, Amino Acetone	Glycine, Aspargic Acid	Hydroxylamines, Azo- & Diazo-Com'ds, etc.	Phosphine, Grignard Comp'ds
2—15	16—70	71—151		152—322			323—331		332—379			380—400	401—449

Isocyclic Compounds

Cyclohexane, Cyclopentadiene, Benzene, Naphthalene	Menthol, Phenol, Benzyl Alcohol, Naphthol, Resorcinol	Camphor, Benzaldehyde, Acetophenone, Quinone	Salicylic Aldehyde, Benzoin, Alizarin	Benzoic Acid, Cinnamic Acid, Camphoric Acid, Phthalic Acid	Salicylic Acid, Mandelic Acid, Gallic Acid	Benzoyl-Formic Acid Phthalaldehydic Acid	Benzene-Sulphonic Acid	Phenol- and Naphthol-Sulphonic Acids, Alizarin-Sulphonic Acid, Sulphobenzoic Acid	Aniline, Benzylamine, Phenylene Diamine, Benzidine	Aminophenol Amino Benzaldehyde	Anthranilic Acid Amino Salicylic Acid	Phenylhydroxylamine, Azobenzene, Azoxybenzene	Compounds of P, As, Sb, Bi, Ca, Mg, Hg, Pt, etc.
450—498	499—608	609—890		891—1504			1505—1591		1592—1928			1929—2251	2252—2358

Heterocyclic Compounds

Heterocompounds with	one	oxygen atom	2360—2665	Heterocompounds with	three	nitrogen atoms	3794—4008
" " "	two	" atoms	2666—2950	" " "	four or more	" "	4009—4187
" " "	three	" "	2951—3006	" " "	oxygen and one	" "	4188—4483
" " "	four or more	" "	3007—3031	" " "	" two	" "	4484—4669
" " "	one	nitrogen atom	3032—3457	" " "	" three or more	" "	4670—4719
" " "	two	" atoms	3458—3793				

Organic Compounds of Uncertain Structure Found in Nature 4720—4877

The division of the Isocyclic Compounds into Classes and Sub-Classes is the same as of the Acyclic Compounds. The numbers under each Class indicate the sections included therein. The whole work is divided into 4877 sections and will appear in fifteen volumes. The first volume includes sections 1—151.

Woody Structures of Fractures of Tranverse Test-Pieces Taken From Certain Special Steels*

Observations Seem to Indicate That Acid Open-Hearth Metal Is Less Liable to Give Woody Fractures, While Molybdenum and High-Carbon Nickel Steel Give Poor Transverse Tests by Virtue of Their Chemical Composition

By J. J. COHADE†

IT IS sometimes found in transverse tensile tests that the elastic limit and the breaking strain are practically the same or only slightly lower than n the longitudinal direction of the piece. On the ther hand, contraction and elongation are lower. mpact test bars withstand a smaller number of blows; otched bars withstand, section for section, fewer ilogrammeters, and the bent layers break at a lower ngle. At the same time, the fracture-surfaces are treaked with parallel lines resulting from the intersec- ion of that surface with surfaces parallel with the axis iven to the structure of the metal during forging. For his reason such fractures are described as "woody ractures."[1]

Origin of These Streaks

These streaks may result:

1. Mostly from the presence of non-metallic inclu- ions.
2. Much less frequently from numerous tiny blow- oles.
3. From the chemical composition of the metal.
4. From overworking.

We will leave aside the influence of working, which as been very minutely and very completely dealt with y Mr. Charpy.[2] If exception be made of the second ause enumerated above, the three other causes inter- ene simultaneously in all steels and make it difficult o separate the particular influence of each on the esults.

Presence of Non-Metallic Inclusions

The author will not dwell on the formation of non- netallic inclusions in steels, which has been explained y many metallurgists, and, more especially and with nuch care, by Dr. McCance.[3] The influence of such nclusions on defective transverse results, and there- ore on woody fractures, cannot be doubted. There is ometimes found, during the manufacture of gun steel arried out with every precaution and yielding very xcellent results, an occasional cast of normal composi- ion giving poor results and woody fractures. If these e examined under a magnifying glass there will enerally be seen more or less greenish inclusion stains, longated in the direction of the streaks. In cases here a simple examination with a lens does not suffice, microscopic examination of a small sample of the netal, after polishing and slightly etching, will reveal bnormal amounts of non-metallic inclusions. There will be seen on the surfaces of tensile test-pieces which have given these defective results, slight cracks or, at least, faint depressions. If the bar be broken carefully, by bending, at these points, inclusions will be found.

The formation of streaks in fractures, owing to the influence of inclusions, is easily explained. The original globules, more or less ovoid in form, become flattened and elongated parallel with the direction of the flow of the metal during forging. When the steel is subjected to a tensile stress perpendicular to this direction, it cannot elongate at the points at which these inclusions are found, for at these points fracture has already taken place. What occurs is as though the bar had a series of internal parallel notches preventing the elongation of the neighboring metal and fracture takes place suddenly, passing from one notch to the next and producing the typical stepped fracture which is described as "woody" and which characterizes these steels.

Presence of Numerous Tiny Blowholes

Tiny blowholes which have not been welded up during forging will similarly form planes of separation parallel with the direction of the working of the metal and play exactly the same part as inclusions.

Chemical Compositions of the Metal— Molybdenum Steels

The author was much struck in 1894 with the influence which the chemical composition of the metal might exercise on the defective results of transverse tests with woody fractures.

A series of molybdenum steels were studied in the form of small ingots cast from crucibles. The results having been very satisfactory, it was decided to run some charges in a 10-ton basic open-hearth furnace in order to ascertain what difficulties their furnace manufacture might present and to cast ingots of sufficient size to investigate their different possible applications.

One of these casts (No. 930) had the following composition:

	Per Cent		Per Cent
Carbon	0.360	Phosphorus	0.016
Silicon	0.041	Manganese	0.420
Sulphur	0.017	Molybdenum	0.470

The metal was therefore very pure and was prepared with great care.

One of the ingots was made into a gun tube. All the tensile test-pieces cut transversely gave low contractions and elongations, and woody fractures. The first impulse was to attribute this lack of success solely to the presence of oxides, or other non-metallic inclusions, inevitable when working by basic open-hearth.

It was possible, however, that the molybdenum itself

*A paper presented before the 1919 autumn meeting of the ron and Steel Institute, (British).

†Le Creusot Works.

[1] See Chem. & Met. Eng., vol. 20, pp. 216, 271 and 342.

[2] "Influence of Hot Deformation on the Qualities of Steel," *Engineering*, (London), Sept. 20, 1918, vol. 106, p. 310.

[3] *J. Iron and Steel Inst.*, 1918, No. 1, p. 239. See also H. Styri, Chem. & Met. Eng., vol. 20, p. 342.

might intervene, and to clear up this question the laboratory experiments were resumed. Two small ingots of 10 kg. each were made in the crucible, one with molybdenum and the other without. Their composition was as follows:

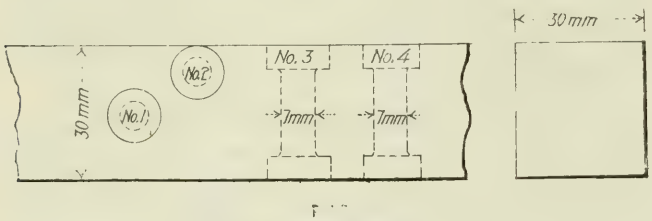
	With Molybdenum per Cent	Without Molybdenum per Cent
Carbon	0.300	0.450
Silicon	0.170	0.190
Sulphur	0.016	0.020
Phosphorus	0.029	0.026
Manganese	0.120	0.420
Molybdenum	0.530	nil

These small ingots, which were square in section (80 x 80 mm.) were transformed, by forging, into square bars 30 x 30 mm., and annealed at 900 deg. and cooled in air.

After cropping 4 per cent from the bottoms a piece 260 mm. long was cut longitudinally from each and two test-bars 13.8 mm. in diameter and 100 mm. long between punch marks were machined from them. They gave the following results:

	Elastic Limit per Sq.mm. Kg.	Tensile Strength per Sq.mm. Kg.	Elongation per Cent
With molybdenum	57.3	71.6	16.3
Without molybdenum	37.2	65.5	19.0

A length of 150 mm. was cut from the continuation of the bars which furnished the above test-pieces, quenched in water from 900 deg. C., and annealed at



LOCATION OF TEST-BARS

600 deg. C. Small transverse bars were also taken, as shown in the sketch (Fig. 1). Nos. 1 and 3 were at right angles to each other and followed the axis of the bar; Nos. 2 and 4 were similarly at right angles to each other and cut in such a manner that their heads were tangential to the side surfaces. The results of the tensile tests are given in Table I.

TABLE I. TESTS ON MOLYBDENUM STEEL

Description of the Bars		Tensile Strength Kilograms per Sq. mm.	Appearance of the Fractures.
Molybdenum steel	No. 1	96.6	Fine lines; low contraction
	No. 2	105.7	Lines hardly visible; fairly good contraction
	No. 3	94.0	Fine lines; low contraction
	No. 4	106.0	Lines hardly visible; fairly good contraction
Steel without molybdenum	No. 1	90.5	No lines, good contraction
	No. 2	92.3	No lines, good contraction
	No. 3	89.3	No lines, good contraction
	No. 4	91.9	No lines, good contraction

The elongation, owing to the dimensions of these bars, being meaningless, has not been given.

It will be seen that the ordinary steel gave no streaks, whereas all the molybdenum steel bars presented them. They are barely appreciable in the bars cut from the edges, although they actually exist; they are much more marked in the bars cut along the axis. The dimensions of the ingots being very small and the test-pieces having been cut from the portion corresponding with one-third of the ingot, it was hardly probable that the difference between the results was due to segregation; it might rather be attributed either to the differences in crystallization—needle-shaped along the edges, equiaxial in the center portion—or simply to some slight porosity of the latter. It will be noted later that microscopic examination of these small samples showed that the metal was practically free from inclusions.

It would therefore appear highly probable that molybdenum, even in small quantities, intervenes to accentuate the bad results of transverse tests.

Attempted Improvement of Molybdenum Steel

These tests can be grouped into three categories:

1. Modification of the structure of the ingot by more rapid cooling.
2. Modification of the structure by forging at a higher temperature.
3. Modification, after forging, by reheating and quenching.

First Group

Two small molybdenum steel ingots, of the same dimensions and practically of the same composition as the foregoing, were cast, after melting in crucibles, one in the ordinary way and one into an ingot mold plunged into water. The transverse fracture of these two ingots within 40 per cent of the bottom was very sound; that of the ingot cast into the water-cooled mold revealed bacillus-like crystallization going right through to the center, whereas in the other ingot this structure only occupied a superficial zone about 15 mm. thick. After forging the portions representing the 40 per cent lower ends of the ingots, a length of 150 mm. was cut from the bar, and this piece was quenched, annealed and transverse test-bars cut from it as previously described. The fractures of the pieces along the edges showed very fine, barely perceptible lines; those of the central bars were better marked; in spite of the difference in the crystallization the results were identical in both ingots, which shows that the difference in the results given by test-pieces along the edge and those from the center in the previous tests cannot be attributed to this cause, and was probably due to a slight degree of center porosity produced during solidification.

Second Group

An ingot from basic open-hearth cast No. 930, to which reference has previously been made, was cropped 40 per cent from the top, after which a slice 120 mm. thick was taken and divided into four portions, as shown in Fig. 2. The treatments to which each part were submitted were as follows:

Slab No. 1 was water-quenched from 1,050 deg. and then forged between 950 and 800 deg.

Slab No. 2 was water-quenched from 1,050 deg. and then forged between 1,100 and 950 deg.

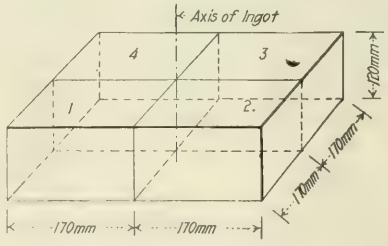


FIG. 2

SUBDIVISION OF INGOT 930

Slab No. 3 was given the same treatment as No. 2 above.

Slab No. 4 was unquenched but forged between 1,100 and 950 deg.

The slabs, which were originally 170 x 170 x 120 mm., were reduced by

forging to flats, 200 mm. long and 35 mm. in section, their length being parallel with the 120 mm. side—that is to say, with the axis of the ingot. Tensile test-bars were then cut in the directions of the thickness and width of the flats and the results obtained gave rise to the following observations:

First, quenching prior to forging effected no improvement.

Second, the fractures were "woody" whether forging was carried out between 1,100 and 950 deg. or between 950 and 800 deg.; except that the streaks were less marked in regard to the bars from slabs forged between 1,100 and 950 deg.

Third, the differences were fairly marked according to the position from which the test-pieces were cut. Those corresponding with the edges of the ingot were better than those corresponding with parts in the neighborhood of the centers.

Thus, with this ingot, of fairly large dimensions, the same peculiarities occur as in the small ingots of crucible steel cast in the laboratory.

Third Group

The test-bars were cut transversely from a 75-mm. gun tube forged from an ingot of cast 930, which furnished the slabs described above. They were divided into two groups. Those of the first set were quenched in water from temperatures of 780, 850, 1,000, 1,100 and 1,170 deg. respectively, as soon as the pyrometer showed that the required temperature had been reached. Those of the second group were treated the same way except that the temperature was maintained for one hour before the bars were quenched.

All the fractures showed lines; a slight improvement was, however, detected in the bars kept at between 1,100 and 1,170 deg. for an hour before quenching.

To conclude, it would appear that forging at a high temperature, and that quenching after keeping at a high temperature, will both improve the results, although this improvement is insufficient.

Tests on Various Special Steels

During the years 1894 to 1898 a large number of special steels had to be examined transversely in the laboratory, and the conclusion was arrived at that good results could be obtained—the fractures being free from streaks—when the carbon percentage did not exceed 0.25, even with fairly high percentages of the special elements, reaching, for example, in the case of nickel, as much as 7 per cent.

As a result of these conclusions a certain number of casts were made from an open-hearth furnace, some on a basic lining and others on an acid lining. Those made by the basic process showed few or no lines, but side by side with test-bars giving good fractures were others showing small whitish stains, oval and in all probability identical with the defect which has recently been described in various English and American reviews under the name of flakes, which prevented such steels being accepted as suitable metal for guns.

The casts from the acid open-hearth made with all the precautions observed in gun manufacture, such as much slower working of the charge and charging in several relays, gave on the contrary excellent results. Table II gives those obtained on a 75-mm. gun tube forged from an ingot of the first cast made under these conditions. Test-pieces were 13.6 mm. in diameter and 50 mm. long, cut transversely in the middle thickness.

The composition of this cast was: Carbon, 0.24 per cent; silicon, 0.216 per cent; sulphur, 0.022 per cent; phosphorus, 0.031 per cent; manganese, 0.43 per cent; and nickel, 5.55 per cent. The average working was 3:4.

This composition showed that the upper limit of 0.25 per cent fixed for the carbon may be raised to 0.30

TABLE II TESTS OF NICKEL STEEL FROM ACID OPEN-HEARTH

Treatment	Location of Specimen	Elastic Limit*	Tensile Strength*	Elongation, per Cent	Reduction of Area†
Annealed after forging at 900 deg.	Front	42.7	61.0	24.5	0.460
	Back	43.0	61.3	24.0	0.453
Quenched in water at 900 deg. C. and again quenched at 620 deg.	Front	61.0	82.5	19.0	0.389
	Back	57.7	79.5	23.5	0.468

NOTE—All fractures were what is known in England as "half-cup."

*In kg. per sq.mm.

†$(S - S^1) \div S$

and, even with 5 to 6 per cent of nickel, yield excellent fractures.

A fact that supports the foregoing contention on the subject of the upper limit of the carbon is the following:

During the war tests were made of six breech sleeves from abroad for 155-mm. guns. Five of these pieces had a composition closely agreeing with the above: Carbon, 0.25 per cent; silicon, 0.25 per cent; manganese, 0.50 per cent; nickel, 3.60 per cent; and chromium, 0.80 per cent. They yielded excellent fractures.

The composition of the sixth was: Carbon, 0.34 per cent; silicon, 0.32 per cent; manganese, 0.70 per cent; nickel, 2.76 per cent; and chromium, 0.115 per cent. These bars gave the same elastic limits and tensile strengths as the previous ones, but the elongations and reductions of area were much smaller and the fractures were woody.

Transverse Tests on Nickel Steels

The upper carbon limit of about 0.30 need not be kept to as long as the percentage of nickel does not exceed 2.5 per cent. Thus some hundreds of gun-steel casts have been made at Creusot by the acid process with carbon percentages of 0.35 to 0.50 and with 1.8 to 2.4 per cent of nickel, with excellent results when tested in a transverse direction. With more than 2.5 per cent of nickel, however, it is necessary to diminish the carbon in order to avoid woody fractures. This fact appears to the author a strong argument in favor of the hypothesis put forward, namely, that defective transverse results and correspondingly woody fractures may arise, not only owing to the presence of inclusions or blowholes or to overworking, but also owing to the chemical composition of the metal.

It can indeed hardly be doubted that if it be possible to make two casts by the acid open-hearth process, and with every imaginable precaution, one with, for example, 0.25 per cent of carbon and 4 per cent of nickel, and the other with 0.40 per cent of carbon and 4 per cent of nickel, it is more difficult to avoid oxidation and the presence of inclusions in the former than in the latter, yet, however, the former will give good transverse fractures and the second will give streaky fractures even when the treatment has been adjusted so as to give in both instances the same tensile strength on testing.

The latter condition is necessary to afford comparisons, as it may often be found that a steel which in the annealed state does not show a streaky fracture will show streaks once quenching has increased its tenacity. It appears probable to the author that the improvement due to a low percentage of carbon is the result of less segregation around the dendritic crystals formed during solidification, owing to the greater speed with which this takes place.

Improvement of High Carbon-Nickel Steels

The program of these experiments was drawn up in order to investigate the influence of percentages of carbon above 0.30, the end temperature of forging, the coefficient of working, and the position of the test samples with regard to the ingot. With these objects, four ingots of 130 x 130 mm. section, and weighing about 75 kg. each, were cast from the crucible furnaces of the steelworks, the lower ends of the ingots being smaller than the tops. Their composition is shown in Table III.

TABLE III. COMPOSITION OF NICKEL INGOTS

No. of Cast	Carbon per Cent	Silicon per Cent	Sulphur per Cent	Phosphorus per Cent	Manganese per Cent	Nickel per Cent
919	0.320	0.272	0.026	0.039	0.480	3.22
924	0.330	0 280	0.026	0.037	0.440	3.30
1004	0 451	0 257	0.030	0.037	0.500	3.25
1005	0.434	0.224	0.028	0.041	0 490	3.22

Forging

These ingots were forged under a 2,000-kg. hammer. The ingots from casts 919 and 1,005 underwent three reheatings at between 1,075 and 625 deg. C. The other

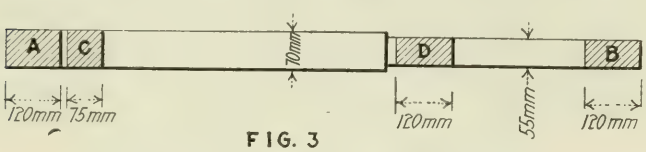


FIG. 3

TEST-PIECES FROM NICKEL FORGINGS

two were forged in five heats at temperatures between 1,050 and 600 deg. Table IV shows the dimensions of the pieces after forging as well as the percentage crops top and bottom.

TABLE IV. FORGINGS FROM NICKEL INGOTS

Cast	Bottom Crop, per Cent	Coefficient of Working 1:4, mm.	Coefficient of Working 1:7, mm.	Top Crop, per Cent
919	6.6	880	540	33.6
924	5.9	870	530	32
1004	5.6	860	460	32.5
1005	5.4	870	400	29.8

After forging the four rounds were annealed at 950 deg. and air-cooled. From each end of each round, a piece 120 mm. long was cut, marked A and B (see Fig. 3). The pieces taken from the bottom end were drilled along their axes with a hole 20 mm. in diameter, and those from the top end with a hole 10 mm. in diameter, in order to secure approximately the same thickness of metal and to be able to obtain smaller bars.

In casts 919 and 924 only, there were then cut, about midway along the length but on the portion reduced to 55 mm., a sample D, 120 mm. in length, and from the bottom end a sample C, 75 mm. long, which was reforged to 55 mm. The forging down was carried out at the same temperature as the first forging, that is to say, between 950 and 625 deg. for the round from cast 919 and between 1,000 and 900 deg. for the round from cast 924. The lengths obtained were like the previous ones bored with 10-mm. holes.

By acting thus it was possible to determine:

First, the influence of the carbon by comparing the results of the tests of the lengths:

A. Casts 919 1005	A. Casts 924-1004
B. Casts 919-1005	B. Casts 924-1004

These lengths have, in each series, undergone the same amount of working and the same method of forging. They likewise occupy the same relative positions in the ingot. The percentage of carbon is the sole difference between them.

Second, the influence of the end temperature of forging, by comparing the results of the tests of the lengths:

A. Casts 919-924	D. Casts 919- 924
B. Casts 919-924	A. Casts 1005-1004
C. Casts 919-924	B. Casts 1005-1004

These lengths had, so far as each series was concerned, undergone the same amount of work; they occupy the same relative positions in the ingot and have practically the same percentages of carbon. They differ solely in respect to the end temperatures of forging.

Third, the influence of the amount of working, by comparing the results of the tests of the lengths:

A and C in cast 919	A and C in cast 924

These lengths have the same carbon percentages and have undergone, in pairs, the same method of forging and occupy the same relative positions in the ingots. The amount of work they have undergone is their sole difference.

Fourth, the influence of the relative positions of the samples in the ingots, by comparing the results of the tests of lengths:

C, D and B in cast 919	C, D and B in cast 924

These lengths have the same carbon percentages; have undergone—as regards each cast—the same method of forging, and have undergone the same amount of work. Their positions, in respect to the ingots, are their sole differences.

All the lengths forged to 55 mm. were machined down to 50 mm., and the 70 mm. lengths were machined

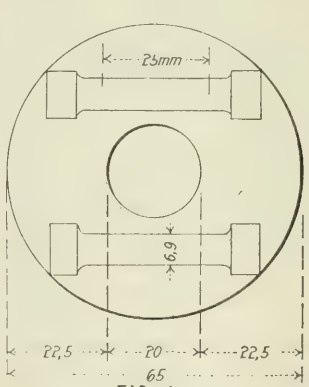


FIG. 4

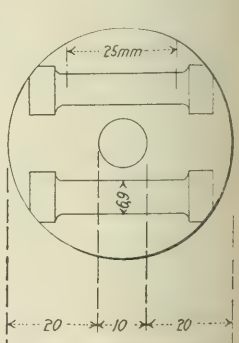


FIG. 5

METHOD OF CUTTING TRANSVERSE TEST-BARS

down to 65 mm., after which they were again annealed at 850 deg. and air-cooled. From each of them a rod 12 mm. thick was then cut for testing before quenching. Each rod furnished two tensile test bars 6.9 mm. in diameter and 25 mm. in length between punch-marks (homologous with those 13.9 mm. in diameter and 50

TABLE V. TESTS ON HIGH NICKEL-CARBON STEELS

No. of Cast	Composition: Carbon	Composition: Nickel	End Temperature of Forging	Treatment of Bars	Tensile Tests: A. Bottom. Working 1 : 4 — Elastic Limit	Tensile Strength	Elongation, Per Cent	$\frac{S-S1}{S}$	Fracture	C. Bottom Working 1 7 — Elastic Limit	Tensile Strength	Elongation, Per Cent	$\frac{S-S1}{S}$	Fracture	D. Center Working 1 7 — Elastic Limit	Tensile Strength	Elongation, Per Cent	$\frac{S-S1}{S}$	Fracture	B. Head Working 1 7 — Elastic Limit	Tensile Strength	Elongation, Per Cent	$\frac{S-S1}{S}$	Fracture
919	0.320	3.22	625°–700°	Heated to 850°, then cooled in air	45.5	66.8	22.4	0.318	0	39.3	62.3	21.2	0.183	2	40.8	65.3	18.4	0.232	2	48.1	65.5	16.0	0.220	2
					43.6	66.1	24.0	0.416		40.5	64.7	21.2	0.237		40.5	64.7	18.4	0.213		48.0	65.4	16.8	0.296	
924	0.330	3.30	925°		43.7	66.3	25.6	0.456	0	40.2	64.5	24.0	0.362	1	40.6	63.6	16.0	0.235	2	43.8	65.2	16.0	0.196	3
					42.4	66.3	23.2	0.392		41.2	64.2	21.2	0.255		39.5	63.8	16.8	0.180		44.0	65.4	16.0	0.194	
1004	0.451	3.25	900°–925°		48.9	76.7	21.6	0.300	1											52.0	76.0	16.8	0.245	2
					50.7	77.3	23.2	0.270												50.2	77.4	13.2	0.207	
1005	0.434	3.22	625°–700°		47.8	67.8	20.8	0.298	1											49.4	69.5	12.8	0.192	3
					48.2	68.8	20.0	0.273												47.3	69.0	14.8	0.184	
919	0.320	3.22	625°–700°	Tempered in oil at 875°, then tempered in water at 640°	60.7	75.5	19.2	0.275	3	61.8	78.0	14.8	0.240	2	59.3	76.8	19.2	0.263	3	59.2	75.3	22.0	0.406	1
					60.2	74.8	13.2	0.138		61.6	77.7	13.2	0.241		60.9	77.1	14.8	0.208		59.0	74.6	23.2	0.424	
					* 58.4	74.5	16.0	0.247	3											* 60.4	76.2	15.0	0.232	3
					58.4	74.6	16.0	0.247												60.4	76.2	13.6	0.232	
924	0.330	3.30	925°		57.0	73.0	18.0	0.198	2	59.4	74.2	20.4	0.358	1	58.8	75.0	19.6	0.243	3	58.8	73.5	20.0	0.267	2
					57.5	72.5	20.0	0.292		58.2	73.1	13.6	0.257		59.4	74.3	13.6	0.213		58.4	73.4	19.6	0.283	
1004	0.451	3.25	900°–925°		70.0	86.2	18.8	0.358	1											70.5	81.5	8.0	0.071	5
					72.0	88.0	18.0	0.320												67.8	76.7	7.2	0.063	
1005	0.434	3.22	625°–700°		54.7	74.9	13.2	0.193	3											71.7	88.0	12.0	0.126	4
					53.4	74.7	16.4	0.245												72.2	88.3	15.2	0.243	

*Tests made on a second bar. Strengths in kg. per sq.mm.

mm. long between punch-marks). These bars were cut as shown in Figs. 4 and 5.

The rods were subsequently quenched in oil from 875 deg., and in water from 640 deg. A fresh rod 12 mm. thick was taken from each sample and sliced as before.

The accompanying Table V sums up the results of these tests. In the column headed "fractures" the figures 0, 1, 2, 3, 4 and 5 have been used to signify the relative proportion of streaks. Those marked 0 show none; those marked 5 reveal the most.

By instituting the comparisons as already described, so that in each instance there is but one variable, it is found:

First, as regards the influence of the carbon: In eight examples five are favorable to the less highly carburized casts; one gives identical results in both cases, and two favor the more highly carburized casts. It may therefore be concluded, as before, that from the point of view of the test results it is advantageous to reduce the carbon percentage.

[EDITOR'S NOTE:—These figures are compared in Table VI. The author's comparison apparently has to do with the condition of the fracture. Averaging the figures, it appears that increasing carbon from 0.325 to 0.442 per cent increases the elastic limit of an annealed bar 4.4 kg. per sq.mm., increases the ultimate 6.9 kg. per sq.mm., decreases the elongation 2.1 per cent, the contraction 6.5 per cent, and increases the number of streaks in the fracture by about one-tenth. In tempered bars, the higher carbon increases the elastic limit 7.8 kg. per sq.mm. and the ultimate 8.2 kg., decreases the elongation 4.7 per cent, and the contraction 6.5 per cent and increases the number of streaks by about one-fifth.]

Second, as regards the influence of the end temperature of forging, it is found that out of twelve instances six favor high finishing temperatures, three are identical both as to high or low finishing temperatures, and three favor low temperatures. From this the conclusion can be drawn that it is preferable to finish the forging at as high a temperature as possible.

[EDITOR'S NOTE:—The figures again are compared in Table VII. It appears that in annealed bars decreasing the temperature of forging from 925 to 700 deg. C. leaves the elastic limit and condition of fracture practically unchanged, but decreases the tensile strength, the elongation and the contraction slightly. In tempered bars the results cover a wider range, but their average is nearly negligible, except that the number of streaks is increased about 10 per cent.]

TABLE VI. EFFECT OF CARBON

Bars	Elastic Limit	Tensile Strength	Elongation	Contraction	Fracture
Annealed bars:					
A 919 — A 1005.	— 3.4	— 1.9	+ 2.8	+0.081	—1
B 919 — B 1005.	— 0.4	— 3.7	+ 2.6	+0.070	—1
A 924 — A 1004.	— 6.8	—10.7	+ 2.0	+0.139	—1
B 924 — B 1004.	— 7.2	—11.4	+ 1.0	—0.031	+1
Average	— 4.4	— 6.9	+ 2.1	+0.065	—0.5
Tempered bars:					
A 919 — A 1005.	+ 5.4		+ 1.3	+0.008	
B 919 — B 1005.	—12.2	—12.6	+ 4.8	+0.139	—2
A 924 — A 1004.	—13.8	—14.3	+ 0.6	—0.094	+1
B 924 — B 1004.	—10.6	— 5.7	+12.2	+0.208	—3
Average	— 7.8	— 8.2	+ 4.7	+0.065	—1

TABLE VII. EFFECT OF END TEMPERATURE OF FORGING

Bars	Elastic Limit	Tensile Strength	Elongation	Contraction	Fracture
Annealed bars:					
A 919 — A 924.	+ 1.6	+ 0.1	—1.2	—0.057	
B 919 — B 924.	+ 4.1	+ 0.2	+0.4	+0.063	—1
C 919j — C 924.	— 0.8	— 0.9	—1.4	0.098	+1
D 919 — D 924.	+ 0.6	+ 1.3	+2.0	+0.014	
A 1005 — A 1004.	— 1.8	— 8.7	2.0	+0.001	
B 1005 — B 1004.	— 2.7	— 7.5	1.2	0.038	+1
Average	+ 0.2	— 2.6	—0.6	0.019	+0.2
Tempered bars:					
A 919 — A 924	+ 2.2	+ 2.0	2.9	0.018	+1
B 919 — B 924	+ 1.2	+ 2.2	—1.4	+0.048	
C 919 — C 924	+ 2.9	+ 4.2	3.0	0.068	+1
D 919 — D 924.	+ 1.0	+ 2.4	+0.4	0.008	
A 1005 — A 1004	—17.0	—12.3	3.6	0.120	+2
B 1005 — B 1004	+ 2.8	+ 9.1	+6.0	0.117	—1
Average	— 1.1	+ 1.3	0.8	0.004	+0.5

Third, in regard to the amount of working the results are indecisive. There are two instances where the 1: 4 working is advantageous and two instances where it is the reverse. The author believes this to arise from the small number of tests and, more especially, from the small dimensions of the ingots. [See Table VIII, by the Editor.]

Fourth, from an examination of the results from the bottom, the center and the head of the ingots it results that the bottom portion is distinctly better. The difference between the other portions is inappreciable. [See Table IX, by the Editor.]

Fifth, it should likewise be noted that, generally speaking, the fractures are more woody after quenching than in the annealed bars. Thus, the tests, before quenching, on test-pieces from the bottoms of ingots worked 1: 4 show no streaks, although they show them after quenching and annealing.

Conclusions

To sum up: What this investigation brings out is that forging finished at a high temperature improves the results of transverse tests, although it does not do so sufficiently. Hence, if very good results be sought it is preferable to diminish the percentage of carbon to below 0.30 per cent, if the percentage of nickel has to be increased in order to obtain the necessary tensile strength after quenching.

In addition to the part played by non-metallic inclusions, blowholes and amount of working, in giving bad results in transverse tests of forged parts, it is necessary to take into consideration the chemical composition of the steels and particularly of the percentage of carbon. When this is below 0.30 per cent, and better still below 0.25 per cent, good results are obtained if the metal has been properly made, even when adding a sufficiently high percentage of special metals to secure very high tensile strength after quenching and annealing. This rule applies up to steels which have undergone a 1: 8 working, but the author has no experience of higher coefficients of working.

TABLE VIII. EFFECT OF PER CENT REDUCTION

Bars	Elastic Limit	Tensile Strength	Elongation	Contraction	Fracture
Annealed bars:					
A 919 — C 919.....	+4.7	+2.9	+2.0	+0.157	—2
A 924 — C 924.....	+2.3	+1.9	+1.8	+0.116	—1
Tempered bars:					
A 919 — C 919.....	—2.3	—3.0	+2.1	—0.013	+1
A 924 — C 924.....	—1.6	—0.8	+2.0	—0.063	+1
Average.....	+0.8	+0.2	+2.0	+0.049	—0.2

\+ Represents advantage of 1 : 4 over 1 : 7.

TABLE IX. EFFECT OF LOCATION IN INGOT

Bars	Elastic Limit	Tensile Strength	Elongation	Contraction	Fracture
Annealed bars:					
C 919 — B 919.....	—8.1	—2.0	+4.8	—0.048	.....
C 924 — B 924.....	—3.2	—0.9	+6.6	—0.113	—2
Tempered bars:					
C 919 — B 919.....	+1.9	+2.2	—4.4	—0.083	.....
C 924 — B 924.....	+0.2	+0.2	—2.8	+0.033	—1
Average.....	—2.3	—0.1	—1.0	—0.053	—0.8

It is not necessary to lower the carbon in nickel steels so long as the percentage of nickel is below 2.5. Very good results are indeed obtained with percentages of carbon reaching 0.5, as has been shown by numerous tests on steel manufactured for ordnance.

It would appear that the transverse tests are improved if the forging of the ingot be wholly carried out at a high temperature, but this improvement is insufficient when the maximum results are required in transverse strength, for example, in the case of steel for guns.

The different tests described in this paper, having been carried out at different times and over a prolonged period, lack the co-ordination they might have possessed had they been carried out as a whole. For this the author offers his apologies.

Growth of Research Associations in England

The formation of combinations or associations of specific trades for the purpose of research work under the British Government's plan, whereby $4,866,500 is made available for industrial research, continues to become more frequent. Research associations have been formed in connection with chocolate, cocoa, sugar, confectionery, jam, boot and shoe and allied trades, cotton, sugar, iron, motor and allied manufactures, photographic materials, portland cement, woolens and worsteds, scientific instruments, india rubber and tires, linen, and glass industries. The scientific and industrial research department has given its sanction to the formation of similar associations for refractory materials, non-ferrous metals, and Scottish shale oil. Other trades or industries whose applications have been made for the department's approval include launderers, electrical and allied industries, and makers of aircraft. Silk manufacturers, leather trades, master bakers and confectioners, and manufacturers of adhesives have under consideration details of proposed associations.

Before any association can come under the government scheme, the approval of the scientific and industrial research department must be obtained, and subsequently a license must be secured from the Board of Trade. The associations must be national in character and include the bulk of the manufacturers in any specified industry. A legal status is obtained through registration as a company under section 20 of the companies consolidation act, 1918. The associations are limited by guarantee of a nominal sum and may not divide profits; but the contributions of firms, being regarded as business costs, are exempted from income tax. The general scheme is to provide £1 from the department for every £1 subscribed by members up to five years after organization; but should an association's expenditure exceed £6,000 a special arrangement may be agreed to.

At present, the largest associations are those of the cotton and woolen industries. In the cotton association, growers, spinners, manufacturers of loom and knitted fabrics, dyers, bleachers, and finishers are combined; all sections of the woolen trades are represented in the association of woolen industries. With a view to improving supplies of wool, a conference has recently taken place between the woolen association and the Scotch, Welsh, and English sheep breeders.

Origin of the British National Physical Laboratory

At the recent Bournemouth meeting of the British Association for the Advancement of Science, the treasurer, Prof. John Perry, stated that the National Physical Laboratory, the scene of researches of which the importance to the nation during the war cannot be overestimated, had its origin in the Kew Observatory, which was maintained by the Association from 1842 to 1872.

A New Cyanide*

Description of the Process for Converting Calcium Cyanamide to a New Cyanide in a Modern Sodium Chloride Solution—Early European Developments—Recent American Achievements—Products and Production—Applications

By W. S. LANDIS

ABOUT thirty years ago the new use of cyanide in the gold industry brought to the attention of the chemical world the necessity of producing this material on a larger scale than previously, and at the same time of finding cheaper methods of preparation if the compound was to have an extended use. American, French, English and German chemists attacked the problem most energetically, and from their work arose the present-day processes, with which, as far as they have become commercially practicable, you are probably familiar.

Two German chemists, working on the barium carbonate process about twenty years ago, attempted to supplant the expensive barium salt with a cheaper calcium salt, and obtained a new product, cyanamide, which afterward formed the basis of development of the well-known cyanamide process. To a certain extent they were disappointed at the outcome of their work, as the new product, calcium cyanamide, had little in common with the object of their search, and after its discovery they sought for many years to convert cyanamide into cyanide. Their first patents on this transformation of cyanamide into cyanide were taken out eighteen years ago, these patents covering a process of fusing crude cyanamide with common salt in the proportions preferably of one part of cyanamide to two parts of sodium chloride. The mixture of cyanamide and sodium chloride was to be heated to fusion and until foaming of the mass ceased, which operation was reported to require from ½ to 1 hr. The resulting product was reported to contain cyanide of calcium, but no analyses were given.

In attempting to carry out this process on a commercial scale, apparently they met with a great deal of difficulty. I visited their plant in 1914 and found a great many types of equipment had been installed at one time or another, none of which had worked successfully, and the cyanide plant had been closed down and abandoned for several years.

Types of Equipment Tried and Abandoned

The earliest type of apparatus consisted of a row of iron crucibles set in a gas-fired furnace with the top flush with the roof of the furnace. These crucibles were about 48 in. deep and 20 in. in diameter and had been made at various times of cast iron, cast steel and welded soft steels. In operation salt was melted in the pot and cyanamide was then stirred in and the whole mass kept fused for a suitable length of time. The transformation efficiencies were extremely low, but no actual record of the same was made public.

The next development consisted in setting two iron crucibles side by side in the furnace. In one crucible they charged salt and melted it, and in the second they charged cyanamide and heated it to redness. Molten salt was ladled from the first crucible to the second, and when a proper quantity had been added the whole mass was kept melted until by chemical analysis the maximum yield of cyanide had been attained. The contents of the pot were then ladled out and cast into slabs.

The enormous amount of hand labor involved in this operation rendered it commercially impracticable, and a new equipment replaced the old. A revolving furnace was constructed with an enlarged melting hearth midway between the tires. Salt was melted in this hearth and tapped into an iron ladle and conveyed to a crucible containing red hot cyanamide. This operation was also unsuccessful in that there was considerable wear and tear on the salt-melting furnace, and further, great care had to be exercised in pouring the molten salt onto the heated cyanamide, as the initial reaction was very violent and the pot frequently boiled over.

The maintenance of the externally heated crucible at the required high temperature became quite burdensome, and a new type of furnace was developed in which an iron pot, provided with a spout, was set into a fuel-fired furnace. This pot was built of welded flange steel. It was 3 ft. deep and 2½ ft. in diameter. There was also provided an electrode 5 in. square hung on a chain block in line with the axis of the pot so that it could be lowered into the fused mass. In this way a single-phase furnace using about 40 volts and 1,200 amp. was made in a setting also provided for initial fuel firing. In operating, cyanamide was charged into the bottom of the pot and heated to redness by the fire underneath. Salt was melted in the rotating furnace previously described and was slowly poured into the electric furnace at such rate that no very violent reaction ensued. The carbon electrode was then lowered, the current turned on, and the whole mass kept heated electrically until the reaction was complete. The cyanide was tapped through the spout and cast into slabs.

This furnace and process were not successful—the efficiency of nitrogen transformation was very low and the final product contained a comparatively small percentage of cyanide. I was informed, however, that the same type of furnace was being used successfully in another part of Germany, where the salt was melted electrically, and there was being turned out in this second plant a grade of product containing 40 per cent equivalent potassium cyanide at an efficiency of nitrogen transformation of over 90 per cent. I accordingly visited this other plant and was much surprised to find there an entirely different type of apparatus in use.

Uneven Heating Cause of Low Efficiency

At this second place I found they had tried the combined fuel-fired and electric furnace just described, and had come to the conclusion that the uneven distribution of electric energy throughout the bath caused very uneven heating of its contents, which was believed to be the cause of the poor efficiency obtained from the process. The iron pot would last only two or three runs, due to cracking, and they had abandoned this type of apparatus for a resistance type of electric furnace built

*Read at the meeting of the New York Section of the American Electrochemical Society, Jan. 23, 1920.

of brick. This improved furnace was of the tilting type with a rectangular hearth and arch roof and lined with magnesite brick. The side walls were formed of carbon blocks and electrically connected with a source of current. In practice these blocks were short-circuited with a rod of carbon, and salt was thrown into the furnace and melted around the rod, thus establishing a path of current between the side electrodes. The furnace was then filled with salt. Cyanamide was added to the melted bath and the heating continued until, as shown by chemical analysis, the maximum content of cyanide had been formed, when the molten bath was poured out and cast into slabs. I witnessed several operations of this furnace and found that the furnace produced about 400 kg. of molten product in from 3 to 4 hr. The apparatus used about 21 volts and 2,800 amp. The equivalent potassium cyanide in the final product ran from 8½ to 17½ per cent in the various runs and the nitrogen transformation efficiency from 40 to 75 per cent. During the last run I witnessed, the furnace became blocked with a white spongy material and all operations were abandoned.

It is thus apparent that in the fifteen years elapsing between the initial experiment and my visit the Germans had been able to do little or nothing with the process of transforming cyanamide into cyanide. They had tried out many types of furnaces, none of which was successful in any marked degree, and had produced only a small amount of product of comparatively low grade and at great inefficiency. They were firmly convinced that it would be necessary to use more than two parts of salt to one part of cyanamide in order to make reaction take place at all and that for smooth working at least three parts of salt to one of cyanamide was absolutely necessary, also premixing of the charge was wrong chemically and must not be used. On the basis of these mixtures the final product should test between 15 and 20 per cent of equivalent potassium cyanide. There were many theories and ideas advanced on the subject, but I could find no comprehensive chemical study of the process and little information of scientific value. In fact, the outlook for this transformation was most discouraging.

Resistance Furnaces Tried in America

In the late fall of 1916 there was a sharp advance in the price of cyanide in this country and a great shortage in the available supply. The gold and silver mills of the continent faced a serious situation, and finally one of the large users of the material came to the American Cyanamid Co. with a request that it endeavor to co-operate in producing the necessary requirements of this material. With the discouraging report on the German process in hand and no time available for experimental work, the outlook was not particularly bright, but the problem was attacked and a plant was designed and equipped, using resistance furnaces of a modified design, and the older German procedure was altered somewhat with the hopes of obtaining results at least as good as the Germans had anticipated.

This plant was put into operation at Niagara Falls late in December, 1916. It was provided with five resistance furnaces of a tilting type and two salt-melting furnaces of fixed type. While completing the salt-melting furnaces, the resistance furnaces were put into operation as combined salt-melting and reaction units. They were very much larger than the German furnaces and the design and construction were quite new. They functioned extremely well as such furnaces go, considering the complicated operation. The time of an operation, including salt melting and reaction, was reduced to about 2½ hr., and the salt-melting furnaces were never used for their intended purpose.

Salt, charged cold, was first melted by adding it directly to the hot furnace, the heated walls conducting sufficient current to start the melting. Into this bath of molten salt cyanamide was fed by hand, the bath stirred up with an iron rod, and as soon as all the cyanamide was in, the furnace was tapped by pouring into chill cars. After cooling, the cake was broken up and loaded into caustic soda drums, which formed the shipping container of the final product. Later it was tapped directly into the shipping drums.

Improvements in the Process

The process was somewhat troublesome to carry out. The life of the low-grade magnesite brick lining, the only kind then obtainable, was at most six weeks. It then became so conducting, due to the iron content of the bricks being reduced by the cyanide and through its absorption of the cyanide itself, that relining was necessary. Further, the addition of the cyanamide had to be slow and cautious, as considerable foaming took place during the reaction and the contents of the furnace would frequently boil over. The first great improvement was the discovery that the addition of a very small amount of calcium carbide to the furnace would entirely stop the foaming. This permitted the cyanamide addition to be made very quickly, and the power input was, therefore, increased to obtain the additional melting speed. I had learned in Germany that the furnace men over there were of the very fixed opinion that at no time should the temperature of the bath rise above 960 deg. C. or decomposition of cyanide would result. Due to an accident to the electrical system at Niagara one of the furnaces received an undue amount of electrical power in one of the runs and the temperature shot up several hundred degrees above the limit set by the Germans, yet most excellent results were obtained. All furnaces were, therefore, operated at the highest possible temperature, and as a result within three months of the starting of the plant the Cyanamid Co. not only maintained a daily production rate of nearly four tons of sodium cyanide but had carried on experimental work which had enabled it to dispense entirely with the salt-melting furnace as well as some of the reaction furnaces, to cut down the time of reaction to half, to avoid foaming, and further to increase the test of the finished material up to approximately 24 per cent equivalent sodium cyanide.

New Type of Furnace Tried

The unsatisfactory performance of the tilting furnace led the company to experiment with a new type using a suspended electrode and the combination arc-resistance method of heating. The success following this development enabled it to abandon the numerous small-resistance furnaces and concentrate its efforts in a single unit and at the same time obtain a very greatly improved product. After a short period of development there was constructed at Niagara a single-phase furnace with conducting hearth and a single suspended electrode. This furnace started with an initial capacity of ten to twelve tons of product per day running about 28 per cent sodium cyanide equivalent, but it is now operating at nearly thirty tons of product per day aver-

aging 36½ per cent equivalent sodium cyanide. Additional furnaces are in process of construction.

Rapid Development of the Industry

The development of the industry has been quite rapid. In 1917 there was produced approximately 2,187,000 lb. equivalent of 100 per cent sodium cyanide. In 1918 this grew to 2,350,000. In 1919 a very considerable revision of the process and equipment was made, and as a consequence the plant operated only seven months, during which period it produced at the rate of over 4,000,000 lb. of NaCN per year. The quality of the product started at about 14 per cent equivalent sodium cyanide in January, 1917, and in August, 1919, ran uniformly between 36 and 37 per cent equivalent sodium cyanide. Material running as high as 50 per cent equivalent sodium cyanide has been produced and there have been shipped several carloads running around 45 per cent, of which I shall speak more later.

The process and apparatus used for manufacturing this product have been extensively described in the many United States and foreign patents covering the process. Essentially, cyanamide, salt and calcium carbide are mixed together and continuously fed to a single-phase furnace designed so that it has a very small cubical capacity as compared with the power input. Melting is extremely rapid and the fused product is removed from the furnace almost continuously to a cooling device, which instantly chills the product. This is necessary to prevent reversion of the initial reaction, whereby calcium cyanamide plus its contained carbon is converted into cyanide. The proportions of cyanamide and salt vary with the product to be made.

In 1917 operations were started with two parts of salt to one part of lime nitrogen and gradually decreased in salt content until, in making the present standard 36 to 37 per cent product, more cyanamide than salt is being used. The large furnace has been successfully operated with proportions as low as two parts of cyanamide to somewhat less than one part of salt, and the experimental furnace with no salt whatever.

The Product and Its Application in the Cyanide Process

The resulting product is marketed in the form of small thin scales of a grayish black to shiny black appearance, and the standard grade, known as Aëro Brand Cyanide "Grade X," contains between 36 and 37 per cent equivalent sodium cyanide. This method of expressing its composition is used because it is sold on the basis "per lb. of sodium cyanide equivalent." A constitutional analysis of the material has so far proved impossible of execution, but evidence points to the fact that it consists of a mixture of calcium cyanide, sodium chloride and free lime, with fractions of a per cent each of calcium carbide, calcium cyanamide, and other minor impurities obtained from the ash of the coke used in cyanamide manufacture. The product known as Aëro Brand Cyanide "Grade XX" contains about 45 per cent equivalent sodium cyanide—the cyanogen being actually present as calcium cyanide—a slightly higher percentage of free lime and a materially lower percentage of salt than the X grade.

As to the use of this material, it has found an enthusiastic reception in the mining industry. Being made from cyanamide, one of the cheapest forms of combined nitrogen, and common salt, its cost of manufacture and its selling price are materially less than the purer forms of cyanide hitherto on the market. The use of caustic soda drums for packing has cut down the expensive item of metal containers forced upon the early industry.

Use in the Precious Metal Industry

The first of this cyanide made in 1917 went into the precious metal industry after a short series of laboratory tests in which it was demonstrated that it would dissolve gold and silver with equal efficiency to the 98 per cent grade then in the market, and that the accumulation of soluble salts due to the cyclical use of solutions in the mill would not prove troublesome. In mill operations the drums were opened and the cyanide placed in a revolving tumbler which dissolved it in water, thus giving an opportunity for any acetylene produced to be evolved outside of the mill solutions. Containing as it does a small amount of insoluble material, part of which is carbon, difficulty with precipitation due to the presence of this carbonaceous material was feared, and the solutions were therefore filtered before passing into the mill circuit. Experimental work quickly determined that the carbonaceous residue had no precipitating effect upon cyanide solutions of the precious metals, and this early practice of presolution was quickly abandoned and from then to the present time the new cyanide is dumped directly into the mill circuit.

The presence of a small amount of sulphur in the cyanamide is carried through into the cyanide as a sulphide. Difficulty was feared with the presence of this sulphide, but several years' experience has shown that the aëration as employed in the cyanide mills quickly oxidizes these sulphur compounds and renders them harmless. As a result no trouble has been experienced from its sulphur content.

In the gold industry, where the cyanide consumption per ton of ore is comparatively small, no difficulty has ever been experienced with the accumulation of soluble salts. In the silver industry, where cyanide consumptions of not over 5 lb. equivalent potassium cyanide per ton of ore are experienced, they have similarly had no trouble from accumulation of the soluble salts, but where consumptions are considerably above that figure certain difficulties have made themselves known in several of the silver mills. The calcium chloride obtained from double decomposition of calcium cyanide and sodium chloride acts as a precipitating agent and greatly assists in the settling of the mill solutions. Its accumulation in such a solution, however, to an undue extent, particularly in the case where cyanide consumptions run from 10 to 100 lb. per ton of ore or concentrates, leads to a decrease in the available alkalinity of solutions, and steps have had to be taken to eliminate it. These steps consist in the addition of any simple precipitating agent for lime, the precipitated lime being removed in the filter with the mill tailings.

Advantages of the Product

In every case, either in the laboratory or in the mill, the cyanogen content of Aëro Brand cyanide has proved itself equally as efficient in the extraction of precious metals as that of the 98 per cent sodium cyanide pound for pound of contained cyanogen, added to which are the advantages of a considerably lower cost, slight alkalinity, and the marked influence on the rate of settling of slime in the solution. The new product has found a most favorable reception in the industry and is very widely and extensively used today. In the gold

mills it offers no problem in handling and causes no difference in the practice beyond the fact that the making up of a stock solution is not considered as good practice as the dumping of the cyanide directly into the barren solution along with the ore. In the silver mills, using a considerable quantity of cyanide per ton of ore, simple precipitating methods for eliminating accumulated lime are in use, otherwise their practice is in no way affected.

In its present state of development the new cyanide is not adapted to use in the case-hardening industry or in electroplating. For the case-hardening industry it is very questionable if it has anything to offer in the future, but in the electroplating industry steps are being taken to perfect a method to simply convert it into forms such as the electroplater can conveniently use, and it will undoubtedly make some headway in that industry.

Preparation of Cyanides, Pigments and Prussic Acid

For the preparation of cyanides it is a simple matter to dissolve the new product in water, adding sufficient soda ash to eliminate the lime, and filter. It is then ready for precipitation of the various insoluble cyanides.

For the preparation of ferrocyanide it is very satisfactory. A solution of ferrous sulphate is made up of suitable strength, and into this is dumped an equivalent amount of Aëro Brand cyanide and the mass agitated for a short time. Quantitative transformation of the cyanogen to ferrocyanide readily takes place. The insoluble material left in the treatment vat is filtered off, the filtering operation not being very complicated, but the amount of cake to be handled is considerable. The resulting ferrocyanide is then concentrated, and at a certain density about 95 per cent of it will separate out as a meal and the other 5 per cent will remain behind in solution with the chlorides of calcium and of sodium. The meal is separated in a salt filter attached to the evaporator and the solution is thrown away. Recrystallization of the meal with return of mother liquor to the original treatment tank yields a sodium ferrocyanide of remarkable purity. The transformation can be accomplished with not over 5 per cent loss of cyanide.

Recently the manufacture of anhydrous prussic acid from the crude cyanide has been successfully undertaken. Into an acid-proof generator, cyanide and water is charged, the apparatus closed and sulphuric acid run in. A considerable evolution of prussic acid gas takes place, and the solution in the generator is finally cleared of all prussic acid by the admission of live steam. A brine-cooled condenser liquefies the gas evolved from the still and condenses an impure acid containing about 80 per cent prussic acid. This is charged into an iron still and re-evaporated, the resulting condensate being about 98 per cent pure, in which state it is used in fumigating in the citrus-growing districts. The resulting liquefied product is water white and practically chemically pure, at most containing only minute traces of foreign products. The construction and operation of the liquid gas plant, as it is called locally, has been a most successful operation in every way, the only regret being that the installation was not about three times as large as originally planned, because of the great demand for the high quality material it has turned out.

There is no reason to doubt that this new cyanide will find a place in many other chemical industries, as up to the present time practically no limitations in its use have been found and no chemical properties which prevent its utilization in the many cyanide derivatives.

Quite recent developments have shown the feasibility of manufacturing the higher grade product containing about 45 per cent equivalent sodium cyanide. These developments are too new to present at this time, and a discussion of the process or of the use of the resulting product, which has several new characteristics, will be reserved for the future.

Conclusions

The development of the process of transforming cyanamide into cyanide marks another triumph of the American electrochemist.. We accomplished more in a few months than the foreign chemists accomplished in fifteen years. Three months after starting the designs of a plant our American chemists were producing to the extent of four tons of equivalent sodium cyanide per day of a much higher grade than the Germans had ever hoped for. Within a year we had reduced our operation to a single small electric furnace of a continuous type and produced a product of higher cyanide content than the Germans ever thought possible and at a nitrogen efficiency of over 90 per cent.

The resulting product, of uniform quality and excellent physical characteristics, has found a very increasing market in the various industries using such a product and is today pushing the pure high-grade product steadily out of its long entrenched fields. For the present year the outlook is for a consumption of Aëro Brand cyanide equivalent to nearly 5,000 tons of 100 per cent sodium cyanide. With further development along the lines of transforming this material into its many other derivatives, particularly in view of the very low cost of the raw materials entering into its manufacture, and the simple apparatus and process used, we confidently look forward to cyanide made from cyanamide dominating the world's cyanide market.

Laboratory for New York Department of Health

The Board of Estimate and Apportionment of the City of New York has voted a $1,000,000 appropriation to construct a new building for the Department of Health. Three or four floors will be given to laboratories. We wonder whether the gentlemen attached to the Board of Health laboratories who have lately joined a labor union will celebrate the completion of the building by a strike. Or if a non-union plumber is called in will they be obliged to quit work? Or suppose, in a threatened epidemic, Dr. Simon Flexner or Dr. Jacques Loeb were invited to come and help. So far as we are aware, despite all their scholarship and achievements, neither of these gentlemen has a union card; and if the laboratories are completely unionized they will become closed shops, whereby both distinguished savants would become "scabs."

Box-Making Course at Forest Products Laboratory

The Forest Products Laboratory is offering a course in box- and crate-making of particular value to superintendents, shipping-room foremen and others of similar qualifications. The course will require one week's time for a fee of $10. Application for enrollment should be made to the director, Forest Products Laboratory, Madison, Wis. The first week opened Jan. 26, and repetition will be made as often as found desirable.

A Study of the Lime-Soda Ash Water-Softening Process

Observations on the Changes in Alkalinity and Hardness With the Addition of Lime and Soda Ash Separately and Consecutively to Hard Water—Effects of Insufficient, Correct and Excessive Amounts of Reagents

By MAX R. HERRLE and FRANCIS M. GLEESON

IN THIS article it is our desire to call particular attention to that branch of factory control relating to the filtering, softening and purifying of water. It is an accepted fact among power plant engineers and users in general that pure clear water is essential for industrial as well as domestic use, and especially that soft clear water for boilers is a great factor in expense saving by reducing fuel bills, repairs and labor incidental to keeping boilers and heaters clean and in first class working condition.

All water on this earth has descended from the clouds at one time or another. This water in its descent has absorbed carbonic acid, air and many other impurities. The carbonic acid absorbed enables the water to dissolve many salts, chief among them being those of lime and magnesium. The common impurities are:

1. Carbonates of lime, magnesium, sodium and potassium.
2. Sulphates of lime, magnesium, sodium and potassium.
3. Nitrates of lime, magnesium, sodium and potassium.
4. Chlorides of lime, magnesium, sodium and potassium.
5. Silica and the oxides of iron and aluminum.
6. Suspended matter, as sand and mud.
7. Organic matter.
8. Carbonic acid.

These impurities are common to all waters to a greater or less extent, and it is their removal that has been the subject of many discussions and writings. There are several methods that are adaptable for the removal of these soluble impurities, and a discussion of their adaptability and practicability will now follow.

Three Classes of Water Purification

In a general sense the subject of water purification may be divided into three classes: Distillation, filtration, and chemical purification by precipitation.

Distillation, although ideal, is too expensive to be considered for supplying large quantities of water.

Filtration is of value only when a soft dirty water is to be had, as the dirt will be removed in the process, but should the water be hard due to the presence of soluble impurities, as is the case with most waters, filtration will be of value only after the soluble salts have been converted into the insoluble state.

Therefore, the only method remaining to purify a water for boiler use is chemical purification by precipitation. This method is the one that is used almost universally and the one that will give the best results under the most adverse conditions.

Having discussed the natural substances whose presence in the water supply is detrimental to steam boilers and in other industrial processes, the first thought which naturally occurs in studying the question is the use of some reagent or process which will effectively precipitate the scale-forming material so that the same may be readily removed before the water is used. The complete softening of a water requires the removal both of its temporary and of its permanent hardness. The temporary hardness of a water is caused by the carbonates of lime and magnesium being held in solution by an excess of carbonic acid. These carbonates, which are practically insoluble in pure water, can be precipitated by removing the carbonic acid. This removal is accomplished by means of lime.

This lime is added as a solution and the following equations illustrate the effect of this reagent upon the raw water:

$$CaCO_3 . CO_2 + CaO = 2CaCO_3$$
$$MgCO_3 . CO_2 + CaO = MgCO_3 + CaCO_3$$
$$MgCO_3 + Ca(OH)_2 = Mg(OH)_2 + CaCO_3$$

The lime unites with the acid carbonate of calcium to form the insoluble calcium carbonate, which then precipitates out. It also combines with the acid carbonate of magnesium to produce the insoluble carbonate of magnesium, which is further converted into the more insoluble magnesium hydrate and in turn precipitates out. The lime further effects a practically complete precipitation of the remaining magnesium compounds.

Thus we see that by the addition of lime as a reagent we secure a precipitation of the calcium and a practically complete removal of all of the magnesium compounds because of the fact that the lime removes the carbonic acid which holds the hardness-forming salts in solution.

Permanent hardness of raw water is caused by the sulphates, chlorides and nitrates of calcium and magnesium. Since magnesium compounds have been removed, the remaining permanent hardness of the water is eliminated by means of sodium carbonate, which precipitates the insoluble calcium compounds in accordance with the following equations:

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$
$$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$$

The sodium carbonate unites with the calcium sulphate to give the insoluble calcium carbonate, which precipitates out. The sodium carbonate further unites with the calcium chloride to give the insoluble calcium carbonate.

Thus we see that after the addition of the sodium carbonate all the hardness and scale-forming salts have been removed and only neutral and non-corrosive substances are left in solution.

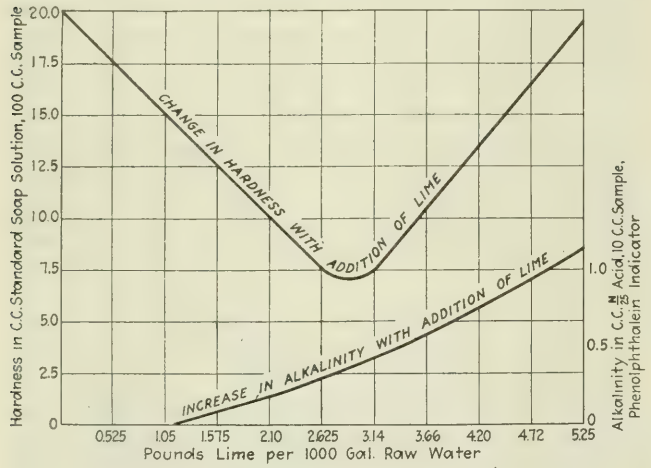
It is now evident that by means of the two reagents, lime and soda ash, an ideal water can be secured with but one problem to face us, that in order to secure this water having a relatively low hardness and alkalin-

ity great care must be taken in adding the reagents. We have carried out a series of tests which we hope will aid in effecting a correct proportioning of the reagents. They are as follows:

Test I. This test deals with the addition of lime to raw water and shows the effect of an insufficient amount of lime, the effect of the correct amount and the effect of an excess.

Test II. This test deals with the addition of soda ash to a raw water and illustrates the effect of an insufficient addition, a correct addition and the effect of an excess.

Test III. This test deals with the addition of both reagents to raw water and shows the correct adjustment of reagents which is absolutely necessary for the production of a good boiler feed water.


Hardness in C.C. Standard Soap Solution, 100 C.C. Sample
Alkalinity in C.C. N/25 Acid, 10 C.C. Sample, Phenolphthalein Indicator
CHANGE IN HARDNESS WITH ADDITION OF LIME
INCREASE IN ALKALINITY WITH ADDITION OF LIME
Pounds Lime per 1000 Gal. Raw Water

CHANGE OF HARDNESS AND ALKALINITY WITH ADDITION OF LIME

Following the tests there is a paragraph dealing with the value of water analysis which also contains the analysis of our raw and treated waters.

Test I. Effect of Lime (CaO) Upon Raw Water

A 30-gal. sample of raw water was taken for this experiment. The water had a hardness of 20.0 deg. with standard soap solution and no alkalinity with N/25 acid, using phenolphthalein as an indicator. The water was treated with successive charges of hydrated lime, which was added as a solution by mixing each charge with some of the water of the original sample. After each addition the entire sample was very thoroughly stirred so as to insure a complete and uniform precipitation. The hardness and alkalinity were then tested for as above.

Turning our attention to the graph, it will be noticed that the hardness of the water decreased uniformly after each charge until the hardness of 7.0 deg. was reached, which is the minimum that can be obtained with lime alone. Upon further charging, the hardness increases uniformly but much more rapidly.

The hardness curve may be explained as follows: The hardness decreases uniformly as long as the chemical action between the lime and raw water takes place. When this chemical action is complete the water is at its minimum hardness and any further addition of the lime tends only to introduce an excess of this reagent and increase the hardness and alkalinity of the water.

This conclusion is substantiated when an examination of the alkalinity curve is made. No alkalinity is observed until the second charge, after which the alkalinity rises uniformly until the minimum hardness is reached, then the alkalinity increases at a greater rate, owing to the excess free lime.

The results of this test were calculated to pounds of lime per 1,000 gal. of raw water to make them of more value to the engineer. Table I will show the amount and the effect of each addition.

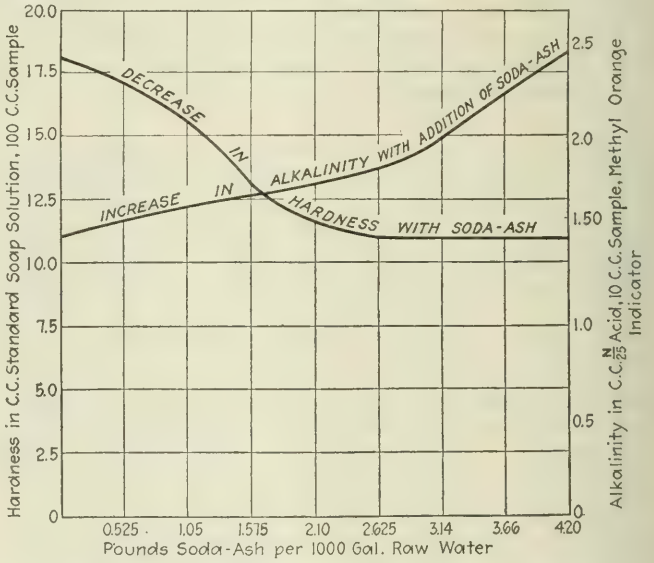
TABLE I. EFFECT OF LIME (CaO) UPON RAW WATER

Lb. Lime per 1,000 Gal. Raw Water	Hardness in c.c. Standard Soap Solution	Alkalinity in c.c. N/25 Acid Phenolphthalein as Indicator
0.0	20.0	None
0.52	17.5	None
1.05	15.0	None
1.57	12.5	0.08
2.10	10.0	0.20
2.62	7.5	0.30
2.91	7.0	0.36
3.14	7.5	0.43
3.66	10.5	0.58
4.20	13.5	0.75
4.72	16.0	0.93
5.25	19.5	1.13

The results of this experiment may be summarized as follows: Sufficient lime should be added to cause the chemical action between the lime and raw water to go to completion, but an excess of this reagent is to be avoided, as it will increase the hardness and alkalinity very noticeably.

Test II. Effect of Soda Ash (Na_2CO_3) Upon Raw Water

A second experimental run was made with 30 gal. of raw water, using successive charges of soda ash. The soda ash was added as a solution by mixing each charge with some of the water of the original sample. After each addition the sample was mixed and tested for


Hardness in C.C. Standard Soap Solution, 100 C.C. Sample
Alkalinity in C.C. N/25 Acid, 10 C.C. Sample, Methyl Orange Indicator
DECREASE IN HARDNESS WITH SODA-ASH
INCREASE IN ALKALINITY WITH ADDITION OF SODA-ASH
Pounds Soda-Ash per 1000 Gal. Raw Water

CHANGE OF HARDNESS AND ALKALINITY WITH ADDITION OF SODA ASH

hardness and alkalinity, as in the lime experiment, excepting that methyl orange was used as the indicator.

Turning our attention to the accompanying graph, it will be seen that the hardness decreases rapidly after each successive charge until the minimum of 11.0 deg. is reached. This is the minimum that can be obtained with the use of soda ash alone, and marks the point at which the chemical action between the soda ash and raw water is complete. Further addition of soda

sh produces no change, serving only to introduce an xcess of the reagent and consequently increasing the kalinity. An excess of soda ash is not to be feared, s apparently it has no effect on the hardness of the ater, although it does increase the alkalinity.

Turning our attention to the alkalinity curve, we see iat the alkalinity increases uniformly until the mini-ium hardness has been reached, after which the sud-en upward trend of the curve tells us that an excess f the reagent has been introduced and that no more oda ash need be added.

The results of this test were then calculated to pounds f lime per 1,000 gal. of raw water in order to make them iore convenient for the engineer to follow. Table II ill show the amount and the effect of each addition of ie reagent.

TABLE II EFFECT OF SODA ASH (Na_2CO_3) UPON RAW WATER

Lb. Soda Ash per 1000 Gal. Raw Water	Hardness in c.c. Standard Soap Solution	Alkalinity in c.c. N/25 Acid Methyl Orange as Indicator
0.0	18.0	1.45
0.52	16.0	1.55
1.05	15.5	1.65
1.57	13.0	1.70
2.10	11.5	1.75
2.62	11.0	1.85
3.14	11.0	2.00
3.66	11.0	2.25
4.20	11.0	2.43

The results of this experiment may be summarized s follows: Sufficient soda ash should be added so that slight excess of this reagent remains after the chem-cal action between it and the water has been completed. The excess will have no effect upon the hardness and ut little effect on the alkalinity, so that the engineer eed have no fear of its presence. This excess will rove of great value in case the raw water varies in nitial hardness, as such small fluctuations can be read-ly cared for by this reagent.

Test III. Effect of Lime and Soda Ash Upon Raw Water

We have heretofore discussed the effect produced by he addition of lime and soda ash with regard to each urve separately, and now we will discuss the effect of the addition of both soda ash and lime together pon a sample of raw water.

We have found that the addition of lime to raw water roduces a minimum hardness of 7.0 deg. by precipita-ing the soluble hardness-forming salts of magnesium nd lime, but other salts of these elements still re-nain in solution and cannot be removed by lime but will e removed by soda ash.

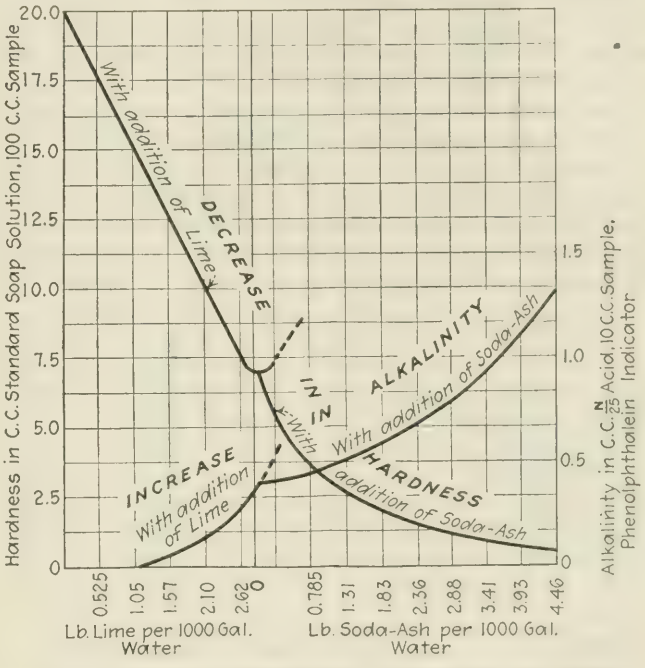
Now the addition of soda ash to raw water produces a minimum hardness of 11.0 deg. by removing to some extent the hardness-forming salts of lime and magne-sium, but other salts of these elements still remain in solution and cannot be removed by soda ash, but will be removed by the addition of lime.

Now it is obvious that by adding both reagents in their proper proportions, theoretically all the hardness-forming salts would be removed and an ideal water result. This is the experiment which will now be car-ried out to test the value of the theory.

A 30-gal. sample of raw water was obtained as in the preceding experiments and treated with sufficient lime to produce the lowest possible hardness obtainable with lime alone. This datum was obtained from the lime-water graph. Lime was added first instead of soda ash because an added excess of lime will be cared for by the addition of soda ash later on. The mixture was thoroughly stirred and allowed to set for some time. Upon testing we found that the water had dropped from a hardness of 20.0 deg. to one of 7.0 deg. Now successive charges of soda ash were added, as in the soda ash experiment, and the mixture thoroughly stirred after each addition and a sample taken to be tested as in the previous tests.

Turning our attention to the hardness curve, we find that the hardness decreases rapidly with the successive charges until the minimum of 0.5 deg. is reached, after which no further decrease is obtainable. The theoretical hardness of 0.0 deg. is not obtainable, being probably due to the small sample of water originally treated. In the water-softening system in operation at our plant it is nothing unusual to obtain a hardness of 0.0 degree.

Turning our attention to the alkalinity curve, we find that the addition of soda ash retarded the upward trend of the alkalinity, as indicated by the dotted line, and caused it to rise more slowly until at the minimum



CHANGE WITH CONSECUTIVE ADDITIONS OF LIME AND SODA ASH

hardness the alkalinity is 1.3 deg. This action of the soda ash upon the lime-treated water is very well illustrated in the combination curves which are graphically presented. For instance, an examination of the hardness shows the downward trend of the curve until the minimum hardness due to lime alone has been reached; the dotted curve shows the results of further addition of this reagent. The soda ash begins where the lime has left off and takes the hardness down to its minimum of 0.5 degree.

The same is true of the alkalinity curve. Upon the addition of lime the curve takes a rapid upward trend until the addition of soda ash, when its upward trend is decidedly retarded and a more gradual rise takes place. Table III shows the amount and effect of each addition of lime and soda ash upon raw water.

TABLE III. SHOWING QUANTITIES OF LIME AND SODA ASH IN COMBINATION CURVE

Charge in Lb. per 1,000 Gal.	Hardness in c.c. Standard Soap Solution	Alkalinity in c.c. N/25 Acid
	LIME	
0.00	20.00	0.00
0.525	17.50	0.00
1.05	15.00	0.00
1.57	12.50	0.066
2.10	10.00	0.13
2.63	7.50	0.25
2.93	7.00	0.40
	SODA ASH	
0.00	7.00	0.40
0.26	5.25	0.41
0.0785	3.00	0.43
1.31	2.50	0.50
1.83	2.00	0.58
2.36	1.50	0.66
2.88	1.00	0.76
3.41	0.75	0.92
3.93	0.65	1.09
4.46	0.50	1.30

The Analysis of Water

As before stated, all water contains soluble impurities to some extent, and, since the removal of these salts is the chief question in the production of boiler-feed water, a knowledge of which salts and the quantity of each is of the greatest importance in determining the amount of precipitating reagents to be used. This knowledge is secured from the analysis of the raw water. By this means the amount of precipitant can be regulated with accuracy.

The table below gives a complete analysis of the water with a hardness of 20.00 before treatment, and of the same water with a hardness of 0.50 obtained in the combination lime and soda ash experiment. The analysis as outlined in Stillman's Engineering Chemistry was followed. The quantities of salts are figured in grains per U. S. gallon.

	Raw Water	Treated Water
Hardness	20.00	0.50
Alkalinity with phenolphthalein	None	1.30
Silica	0.35	0.35
Oxides of iron and alumina	Trace	Trace
Calcium carbonate	10.04	1.52
Magnesium carbonate	5.71	None
Sodium carbonate	None	0.23
Calcium sulphate	2.72	None
Sodium sulphate	None	3.89
Magnesium chloride	0.42	None
Magnesium hydrate	None	0.39
Sodium chloride	1.87	1.58
Sodium hydrate	None	0.82
Volatile and organic matter	0.60	0.15
Total solids	21.41	8.93

The Philip Carey Mfg. Co.,
Lockland, Cincinnati, Ohio.

Influence of Impurities in Lead on Its Resistivity to Acid

C. E. Barrs stated in a paper presented before the December, 1919, meeting of the London Section of the Society of Chemical Industry that lead which contained 0.002 per cent of copper was attacked at 250 deg. C., whereas a sample which withstood strong acid up to 296 deg. was found to contain 0.021 per cent. He concluded that the most satisfactory percentages of copper as regards increasing the resistance of lead to the action of hot acids lay between 0.002 and 0.05 per cent, such lead being able to withstand corrosion up to 280 deg. In the discussion that followed Mr. Lancaster stated that a really pure lead, quite free from copper, will withstand the action of strong sulphuric acid up to 300 to 310 deg. C.

Legal Notes

By Wellington Gustin

Contract Prohibiting Presence of a Given Substance in Ore Does Not Imply Exclusion of Others

PLAINTIFF brought action to recover for the breach of contract by defendant for the purchase of 150 tons of antimonial lead. On affirming a judgment for the plaintiff the Appellate Court held that where defendant contracted to purchase of plaintiff certain "Newark antimonial lead, running approximately from 15 per cent to 18 per cent antimony and not above 1 per cent arsenic," and accepted a certain quantity shipped but refused to accept further shipments unless they were found to be absolutely free from copper, and defendant's witnesses testified no antimonial lead is produced "absolutely free of copper," and there was no evidence that the amount of copper supposed to be in the antimonial lead was sufficient to impair its value or render it unsuitable to defendant's purposes, then defendant's refusal to accept shipments unless found to be absolutely free from copper constituted a breach of the contract for which the plaintiff would be entitled to recover.

Ruling on the effect of a provision in a contract as to the prohibition of a given substance in ore, the court said that the expression in a contract of prohibition against the presence of a given substance in ore sold would, under ordinary canons of construction, exclude any implied exclusion of any other substance. (American Metal Co. vs. U. S. Reduction Co., 205 Ill. App., 492.)

Factory Refuse—What Is Held to Be Polluting Matter—Public Health Paramount

In a suit to enjoin violation of a statute providing that polluting matter shall not be discharged into any stream or suffered to remain upon the banks thereof above the point where a municipality obtains its water supply, the Chemical Co. of America, Inc., was not permitted to plead that the pollution is not perceptible at the municipality involved, because of mitigation in quantity and quality of the effluent; nor that the polluting matter is harmless as diluted, nor that the municipal inhabitants would suffer no inconvenience were their filtration plant of an up-to-date type and properly managed. Nor is it a defense, under the statutes, said the court, that the pollution cannot be traced to spigots in the municipality, the pollution aimed at by the law being at the point of discharge into the stream. (State ex rel. Department of Health of New Jersey vs. Chemical Co. of America, Inc., 107 Atl., 164.)

The Charge Against Defendant

In this action the defendant was charged with discharging factory refuse into the Rahway River, and of depositing such refuse on the river bank above the point from where the city of Rahway takes its water supply, in violation of the statute which provides that "no excremental matter, domestic, factory, workshop, mill or slaughterhouse refuse, creamery or cheese factory waste, garbage, dyestuffs, coal tar, sawdust, tanbark or refuse from gas houses, or other polluting matter" shall be discharged into any river, stream, etc., or placed or suffered to remain upon the banks thereof, above the point from which any municipality obtains its supply of water for domestic use.

Defendant's chemical plant is located at the confluence

of two streams called north and south branches, which empty into the Rahway River about five miles above the Rahway intake. All the liquid waste of the factory was emptied directly into the south branch until 1917, when the municipality of Rahway objected. The chemical company then took measures to clarify the refuse by eliminating the more objectionable matter, the solids, and to store and retain the effluent upon its own premises. Elevated settling basins were installed, and a lagoon was constructed, and later a second and connecting lagoon, into which the effluent from the settling basins is discharged. These remedial steps were taken after consultation with the State health officials and apparently with their approval. However, the progress made and methods pursued were unsatisfactory to these authorities and before the completion of this work the Attorney General of New Jersey asked for an injunction against this alleged pollution.

Tolerated During War Work

From the facts in the case it appears that pollution of the stream was established at a hearing in May, 1918, but as it was not appreciable at Rahway and the defendant was furnishing the Federal Government with an exclusive product for the prosecution of the war, the injunction was withheld at that time. However, the case was retained, with leave to bring the matter on for further hearing if the dike and other devices then under construction failed of their object. After the armistice the State brought up the cause for further hearing, complaining that the efforts of the chemical company to abate the pollution were futile. At that time the dike of the outer or second lagoon had been finished; a moat, of a depth lower than the lagoons and skirting the dike, was dug and connected to sumps, or catch-basins, to intercept seepage, and the sumps were fitted with automatic pumps to force the seepage back into the lagoon. More than that, it appears that before this second hearing came to an end the bed of the south branch was filled up and the stream diverted, so that its nearest point to the lagoon was 150 ft. away, and scientific experiments to neutralize the effluent were under way.

Polluting Matter Seeps Through Lagoon Walls

The court said despite this earnest endeavor the lagoons were not watertight, and some of the waste contents still leaked into the streams, polluting them, though perhaps not noticeable or even chemically discoverable at Rahway. A part of the wall of the first lagoon is made up of a pervious railway embankment through which the liquid seeps and runs into the north branch. Other evidences pointed to a time, sooner or later, when the effluent will find an outlet in the new stream bed. That the refuse, the wash of chemical compounds, is deleterious to health and objectionable because of odor, taste and discoloration is proved by the fact that all fish life in the immediate vicinity of the factory was destroyed during the first years of operation of the plant when the flow of waste into the streams was unrestrained.

Plea Not Good That Pollution Was Not Perceptible

Said the court, it was not a good plea that the pollution was not then perceptible at Rahway, nor that the more obnoxious of the polluting matter is nitrobenzol, which to taste and smell is likened unto oil of bitter almonds and sometimes used by bakers as its substitute, or that it is benzaldehyde; nor that to take a poisonous dose one would have to drink more of the water than would be required to drown in. These defenses might be of value were the case one of suppression of a common-law nuisance, but this suit was in aid of the police power of the State and such defenses were wholly beside the issue.

In the amendment of 1918 the Legislature determined that factory refuse and the other mentioned wastes and cast-offs are contaminating, and peremptorily forbade their discharge into streams and their deposit upon the banks thereof. The defendant was violating the law in both of these aspects, said the court. There was drainage of the refuse into at least one of the streams and it matters not if it cannot be traced to spigots in Rahway. The pollution aimed at by the statute law is at the point of discharge into the stream. Further, it condemns not only actual pollution but pronounces as imperatively against the threat and menace of it upon the banks of the streams.

Storing of Liquid Waste on Banks of Stream a Standing Menace

The vast body of liquid waste stored on the banks was a standing menace, the court said. The lagoons cover about five acres and the average depth of the liquid content about 2½ ft. Overflows after heavy downpours of rain, breaks in the dikes from wash or lateral pressure, wastage through fissures in the lagoons, are ever threatening dangers. Then there was seepage at various places in the dike, and other possible dangers. In the circumstances, the confidence expressed by the defendant that it could successfully retain the refuse in the lagoons, and its assurances that it will do so, to the immunity of the water, could not be considered, said the court.

The court also said that the legislative scheme to purify the waters of streams embraced two specific avenues of pollution. One was the discharging of polluting matter directly into the stream, which must include the placing of it on the bank where it must necessarily fall or flow into the stream, and the other was the depositing of it so near the banks as to remain a menace of ultimately reaching the water, contaminating it. "It would be playing with words and trifling with legislative mandate to hold that discharges of polluting matter on the bank anywhere below the brink would be violative of the statute, while a deposit on the bank an inch away from the brink would not be." In another case cited it was then said that no doubt garbage dumps on lands immediately adjacent to the Delaware River, the refuse of which in normal times by reason of the natural slope of the ground found its way into the waters of the river, violated the provisions of this statute.

Good Faith of Company Not Questioned

In granting the injunction against the chemical company preventing the discharge of its factory refuse into either of the branches of the river and the suffering of such factory waste to remain on the banks of these streams, the court said that the company had assiduously and in good faith sought to abate the pollution; and as it had prospects of neutralizing the waste, it ought to be given reasonable opportunity to develop the treatment.

This was done, but the costs of the action were put upon the company.

Recovery of Pyridine From Byproduct Coke Ovens*

By F. E. Dodge and F. H. Rhodes

Among the comparatively less important components of coal tar are the so-called "tar bases," pyridine, quinoline, isoquinoline, and their homologues. These tar bases are formed during the coking process, either as primary products from the thermal decomposition of the coal substance or as products of secondary reactions occurring in the gases. When the coal tar is distilled, most of the pyridine and its lighter homologues come over with the light oil fraction; while quinoline, isoquinoline, and the higher homologues of pyridine are concentrated in the carbolic oil. By extracting these oils with moderately dilute sulphuric acid, separating the resulting pyridine sulphate solution from the oil, and liberating the tar bases with an alkali, the crude tar bases may be obtained. From the crude bases pure pyridine or "commercial pyridine" of various grades may be prepared by further purification and rectification. It may be noted in passing that the term "pyridine," as used commercially, is applied, not only to true pyridine (C_5H_5N), but to all of the various tar bases, in somewhat the same way that the term "benzols" is used to include all of the simpler homologues of benzene.

Until fairly recently the supply of pyridine from the coal tar oils, although comparatively small, was sufficient to supply the demand. However, the growth of the American chemical industries which has taken place within the last few years has developed new uses for the pyridine bases, and has greatly increased the amounts required for the purposes for which they were formerly used. The development of the dyestuff industry has created a demand for anthracene and carbazole, and in the purification of each of these products pyridine is used. Light pyridine as a denaturant for alcohol is being introduced to some extent into this country; and some grades of tar bases are finding application as solvents for certain industrial processes. Moreover, recovery of pyridine bases from tar oils is a rather costly process and the pyridine thus obtained is so expensive as to prohibit its use for some purposes for which it would otherwise be suitable. Finally, the tar bases obtained from oils consist largely of "heavy pyridine" (quinoline, isoquinoline, etc.), for which only a comparatively slight demand exists, and contain relatively little of the more valuable light pyridines. In view of these facts it became evident that a larger and less expensive source of light pyridine bases must be developed if the increasing demand was to be met.

Coke Oven Investigation

In the development of new sources of pyridine the first problem which presented itself was the determination of the amount of pyridine in the coke oven gases which escaped condensation with the tar. In view of the fact that the lighter pyridine bases have distillation ranges somewhat corresponding to those of benzol, toluol, and solvent naphtha, it appeared probable that a considerable amount of the pyridine formed during the coking was not condensed either in the hydraulic main or in the tar separators, and it seemed logical to expect that a considerable amount of this pyridine would be absorbed and retained by the acid liquor in the ammonia saturators. Accordingly an investigation of the pyridine balance for the ammonia saturators in a byproduct coke oven plant was undertaken. This work was done by Mr. Dodge and Mr. Rhodes at the plant of the Toledo Furnace Co., at Toledo, and by Mr. Dodge and Mr. Warner at the Clairton byproduct coke plant of the Carnegie Steel Co. At each of these plants Koppers byproduct coke ovens were used. Tar and some ammonia water is condensed in the usual way by passing the gases through hydraulic mains, primary coolers, and tar extractors. Tar-free gas is then reheated slightly and passed through the ammonia saturators, in which the gas is forced to bubble through a saturated solution of ammonium sulphate containing 6 to 10 per cent of free sulphuric acid. Ammonia-free gas is then passed to benzol scrubbers and finally to distributing mains. In the ammonia saturators ammonium sulphate is formed and precipitated from the solution and the solid ammonium sulphate is continuously removed and separated from the mother liquor by centrifuging, while the sulphuric acid concentration of the bath is continuously maintained at the desired point by the addition of the fresh acid. The installations at the two plants were essentially similar, there being only slight differences in form of the individual pieces of apparatus and only minor differences in the operation.

This work showed that a very considerable amount of the pyridine bases formed during the coking of the coal is not condensed with the tar but passes through the primary coolers and tar separators and is absorbed by the acid solution in the ammonia saturator baths. The work showed also that the pyridine sulphate thus formed remained in solution in the saturator bath liquor until the concentration of pyridine sulphate in the liquor reached a certain point, and that further absorption of pyridine by the bath liquor containing more than this critical amount of pyridine sulphate resulted in the separation of a portion of the pyridine sulphate with the ammonium sulphate crystals. For example, it was found that no pyridine could be detected in the salt from a bath containing 2.5 per cent pyridine and that the pyridine contained in a salt from a bath containing 7.5 per cent pyridine was almost one-quarter per cent. The work done at the coke ovens also showed that the amount of pyridine bases not condensed with the tar amounted to approximately from one-tenth to one-eighth of a pound per ton of coal coked.

On the basis of these results it was calculated that the total production of pyridine bases available from coke ovens which are operating in the United States and which use the semi-direct sulphate process is approximately 446,000 gal. per year.

Method of Separation

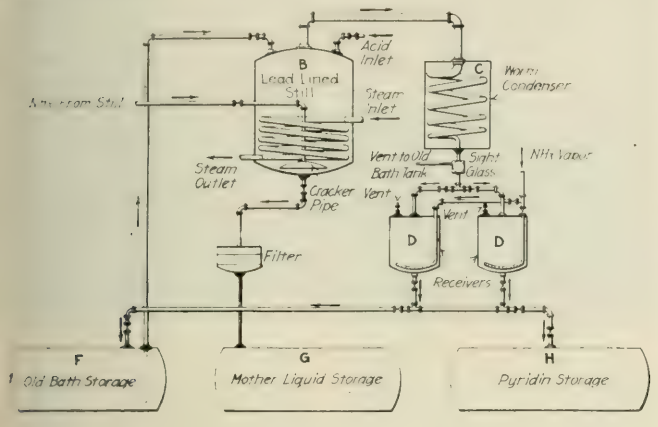
Because of the relatively small amount of bases present in the bath liquor at any one time, and because of the large loss of pyridine which occurred when the concentration of pyridine sulphate in the bath was allowed to rise above a certain very low point, it was evident that any process which would prove economically practicable must not involve the use of expensive chemicals and must not interfere with the normal operation of the plant.

Further investigation showed that if the pyridine-containing mother liquor from the saturator bath is made alkaline by passing ammonia through it, the pyridine

*Read before American Institute of Chemical Engineers, Dec. 6, 1919, Savannah, Ga.

bases originally present in combination as pyridine sulphate are liberated and separate from the saturated ammonium sulphate solution as a distinct layer. It was found, moreover, that if the neutralization of the acid solution was effected rapidly by bubbling through it a gas rich in ammonia, the heat generated by the reaction was sufficient to bring the solution to its boiling point and to steam-distill off the pyridine bases as fast as liberated. On the basis of this work a process for the recovery of pyridine from the ammonia saturator baths was developed and a plant suitable for operating this process was designed and installed in connection with the byproduct coke oven plant at Toledo. The design of this plant is shown diagrammatically by the accompanying sketch.

Tank "F" is a large storage tank for holding the saturator bath liquor before treatment to recover the pyridine bases. This is provided with an outlet to the



hot drain tank, not shown, and with a discharge line leading to the pyridine still proper. "B" is a still in which the saturation of the bath liquor with ammonia vapor is effected. This still is lead-lined and is shown provided with a steam coil for heating the liquor (not found necessary in practice) and with an inlet line for the admission of ammonia vapor. Ammonia vapor required for saturating the bath liquor is taken from the ammonia still operated to concentrate the weak liquor that separates from the gas with the tar. The pyridine still itself is provided with a vapor pipe extending to the condenser and with a discharge line leading through a filter to the mother liquor storage tank. An acid inlet is also provided so that the final pyridine-free liquor may be acidified before being discharged. The mixture of pyridine vapor, ammonia, and water vapor coming from the pyridine still is condensed in the worm condenser "C" and the condensate is collected in receivers "DD," which are provided with discharge lines leading to the pyridine storage tank.

The operation of the plant is as follows: The ammonia saturators are run normally until the pyridine content increases to such a point that pyridine begins to appear in the solid ammonium sulphate as removed from the saturator. When this point is reached the saturator bath is discharged into the old bath storage tank "F" and a new bath is put in operation in the saturator. Sufficient of the material from tank "F" is then pumped to the pyridine still "B" to make a charge. The solution is saturated with ammonia vapor until strongly alkaline. The heat of reaction raises the charge to the boiling point and a mixture of pyridine vapor and water distills over, is condensed, and the condensate collects in the receivers. This condensate, as thus obtained, carries a considerable amount of water, and before this material is shipped or further worked up for pyridine it is desirable to remove as much as possible of this water. This is effected by agitating the material in the receivers with ammonium sulphate, adding approximately 1 lb. of solid ammonium sulphate for each gallon of distillate. The ammonium sulphate absorbs and is dissolved in the water and the resulting saturated solution separates to the bottom of the receiver, leaving an approximately dry pyridine as the upper layer. The ammonium sulphate solution is allowed to settle and is drawn off to the old bath storage tank, while the dry pyridine bases are drawn off to the regular pyridine storage tank.

It has been found that when the old saturator bath is made neutral or alkaline by the passage of the ammonia vapors a blue or bluish black precipitate is formed. This precipitate consists apparently of finely divided free carbon or of a mixture of free carbon with ferro- and ferri-cyanides of iron. In order to remove this precipitate the liquor from the still is filtered through a small filter. The filtered liquor is then stored in the mother liquor storage tank "G." This filtered, pyridine-free liquor may be charged directly to the ammonia saturators as a fresh saturator bath. We have found, however, that this filtered mother liquor may be used to very good advantage as a wash liquor for washing ammonium sulphate crystals in the centrifuges as they come from the saturator baths, since by using this liquor in this way it is possible to wash the crystals free from adhering impurities without incurring any danger of solution of the crystals.

It will be observed that this process involves a minimum amount of handling of various solutions. Moreover, no material is used which is not available in large amounts at any byproduct coke oven plant, and the process as outlined does not interfere in any way with the normal operation. Finally, the only materials which are used in this process are ammonia and sulphuric acid and all of the ammonia and all of the sulphuric acid thus used are recovered as ammonium sulphate by the normal operation of the plant.

The plant erected at Toledo was on a semi-experimental scale only and the production has not thus far been very large. However, several hundred gallons of pyridine bases have been produced at this plant and the results obtained appear to be very encouraging. The pyridine which has been produced has been essentially a crude, light pyridine, distilling very largely below 200 deg. C. The water content has varied considerably, although several of the lots have shown only a trace of water. This pyridine as produced appears to be a very satisfactory crude pyridine for the preparation of refined pyridine bases for denaturing and chemical purposes. The extension of this process to other and larger coke oven installations should afford a supply of light pyridine bases adequate to the present or the immediate future needs of the country.

Since the development of this process a new and very interesting aspect of its application to the byproduct coke oven industry has appeared. As is well known, the presence of pyridine is objectionable in sulphate of ammonia. The use of this pyridine recovery process in conjunction with the semi-direct ammonium sulphate process insures the absence of pyridine sulphate in the ammonium sulphate produced, which is very desirable from several points of view.

Electrical Precipitation in Japanese Smelters

By Dr. Ritaro Hirota and Kyoshi Shiga

A NUMBER of electrical precipitators have been installed in Japanese smelters since 1918 by the Metallurgical Research Institute, which owns the Japanese rights of the Cottrell process. These plants are all quite similar, consisting of from one-half to ten repeated sections, each containing sixty-four pipes, 12 in. in diameter and 16 ft. long (30.5 cm. x 4.9 m.) of cross-section shown in Fig. 1. Ordinarily one motor-generator set serves two sections, each set comprising a 15-hp., 50-cycle, 500-volt, three-phase motor, a 10-kva., 50-cycle, 200-volt generator, and a 10- or 15-kva. transformer capable of giving 100,000 volts on the secondary. Details of the various installations given below are taken from a pamphlet issued by the Metallurgical Research Institute.

Ashio Smelter, Furukawa Mining Co.

There were two treaters installed in 1918; one, which is called the main treater, was intended to treat the mixed gases from four McDougall roasters, two copper blast furnaces and four converters; and the other, called the reverberatory treater, was intended to treat the

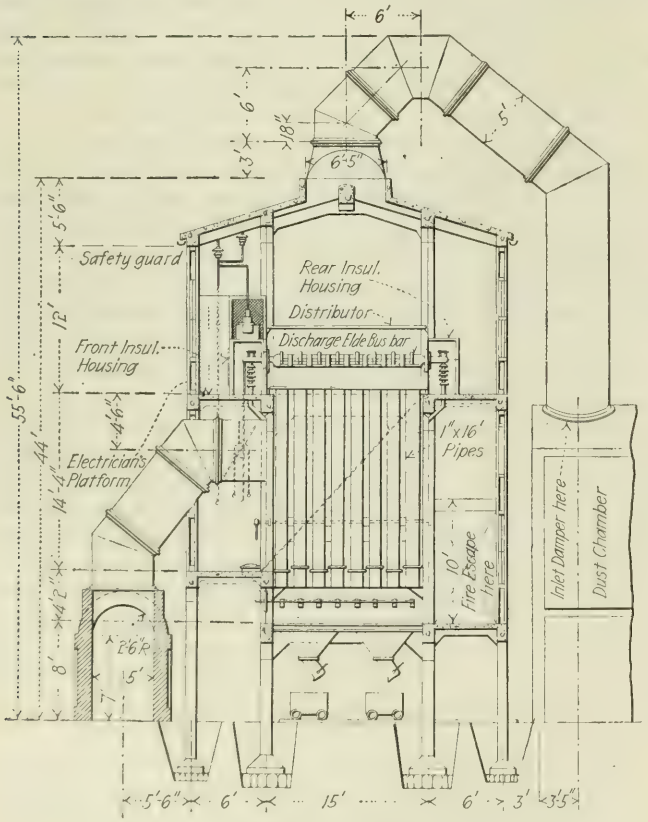


FIG. 1. ELECTRICAL PRECIPITATOR

gases from a reverberatory furnace after having passed through waste-heat boilers.

The gases are drawn through the main treater and discharged directly from the fan casings, while those of the reverberatory furnace are drawn through the reverberatory treater by the natural draft of the stack. As the reverberatory furnace is not operating continuously at present, the gases and those of eleven pot roasters, four blast furnaces and four copper converters are mixed and treated entirely by the main treater. Thus the gas volume now handled by the main treater seems somewhat in excess of 150,000 cu.ft. per min., as designed. The amount of dust collected varies from six to ten tons per 24 hr.[1] The efficiency of precipitation seems to depend upon the nature of the furnace charge and the moisture and temperature of the gases treated. When the conditions are very favorable, it runs as high as 98 per cent, passing a white smoke, but sometimes it drops to about 70 per cent, when the smoke acquires a yellow tint. When the conditions are such that the charging voltage can be raised above 80,000 volts with a comparatively small increase of the current, precipitation is very satisfactory.

Several years ago a large dust chamber was installed, using the Roesing wire system. The gases passed from this chamber to four large stacks, in which they were diluted by the forced admission of fresh air, before being discharged into the atmosphere. The main treater was installed at the side of this dust chamber, so the gases pass through the dust chamber before going through the treater. The numerous suspended wires in the dust chamber were removed, so that only the heavier dust, which is of more value because of its higher percentage of metals, would be caught in the chamber and all the lighter dust which cannot be efficiently collected by gravity settling would be caught in the Cottrell treater.

An analysis of one of the samples of the Ashio main treater precipitate is as follows:

	Per Cent		Per Cent
Cu	1.37	Al_2O_3	1.45
Fe	2.99	As	31.33
S	19.72	Pb	0.84
SiO_2	3.92	Zn	5.57
CaO	1.19	Moisture	6.40

As the analysis shows, the precipitated dust contains rather large quantities of the oxides of arsenic. These oxides are extracted by subliming the dust in a small reverberatory furnace, and the cinders resulting, which are quite rich in copper, are sent back to the pot roasters after being briquetted.

Kamioka Smelter, Mitsui Mining Co.

The gases passing through the treater come from the following furnaces: Three lead-smelting blast furnaces, two liquation furnaces, five softening furnaces, and all the lead-refining furnaces and kettles. The Kamioka Smelter is located in the heart of the sericulture district, and the residents in the vicinity made strenuous objections and demanded heavy indemnities, claiming that the smelter smoke damaged the mulberry leaves and killed the silkworms. Therefore, every effort was made to complete and start the Cottrell plant at an early date. About 1 to 1½ tons of dust are collected per day in a three-section treater.

Analysis of the precipitate is as follows:

	Per Cent		Per Cent
As	19.65	Free S	1.13
Pb	57.26	SO_4	0.63
Cu	Trace	Zn	1.68
Bi	0.16	Ag	0.0063
Fe	0.16	Au	Trace
Total S	5.91	Insol. residue	0.31
		Moisture	0.90

Naoshima Smelter, Mitsubishi Mining Co.

The erection of this smelter was permitted by the government on the condition that the smelter gases would be cleaned by the Cottrell process. The operation of the treaters (Fig. 2) was therefore begun when

[1] Long tons—approximately equivalent to metric tons—are used throughout this paper.

the smelter started up in March of 1919. It was designed for a capacity of 80,000 cu.ft. per min. (2,300 cu.m. per min.), assuming a velocity through the pipes of 5 ft. (1.5 m.) per sec. The lead-bearing fumes from the lead-smelting furnaces and the fumes from the McDougall roasters and converters of the copper smelter are mixed, and are both treated by the precipitator. Natural draft is furnished by a stack 150 ft. high and 10 ft. inside diam. (45.7 x 3.05 m.).

The smelter being only recently started, the furnaces are not yet running at their full capacity and the gas

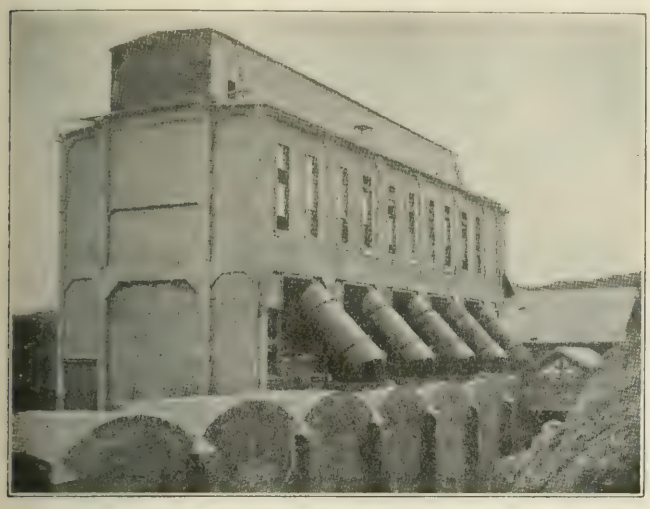


FIG. 2. TREATER AT NAOSHIMA SMELTER

volume handled runs from 40,000 to 45,000 cu.ft. per min. (1,100 to 1,300 cu.m.) Visual clearance by an S-section plant is practically perfect.

The dust collected every 24 hr. amounts to about 1.5 tons, and its analysis is as follows:

	Per Cent		Per Cent
Cu	2.30	Sb	3.14
Pb	22.54	Zn	3.29
Fe	11.20	Loss on heating	25.68
S	12.00		G/Ton
As	13.43	Ag	100
Au	Trace		

IKUNO SMELTER, MITSUBISHI MINING CO.

The treater at the Ikuno Smelter handles the gases from two blast furnaces smelting copper ores. After passing through an old dust chamber, the gases are drawn through the treater by an exhaust fan and are discharged from the old stack. At the first trial the treater showed good efficiency, but this lasted only a couple of days and then the operation became so unsatisfactory that the diminution of smoke could scarcely be recognized even when the treater was charged with a high potential. After experimenting in various ways, it was decided to humidify the gases, a practice which was found necessary for satisfactory precipitation in several American plants. A dozen orchard spray nozzles of $\frac{1}{16}$-in. diameter (1.6 mm.) arranged in the dust chamber using water at 120 lb. pressure per sq.in. (8.4 kg. per sq.cm.) injected a fine spray into the gases before they entered the treater. Thus precipitation was conspicuously improved and the efficiency raised to about 95 per cent, and at the same time the operator can raise the charging voltage to 80,000 volts while the current is only 30 amp. When, in order to examine the effect upon precipitation, the water sprays are turned off, the charging potential drops and the current increases so that the clearance becomes as low as 50 per cent.

The amount of dust precipitated per 24 hr. is about 0.6 ton, and its analysis is as follows:

	Per Cent		Per Cent
Ag	0.0007	As	32.39
Pb	7.80	Sb	Trace
Cu	0.50	Sn	10.80
Bi	2.48		
Fe	1.01	SiO_2	1.05
Al_2O_3	0.20	S	12.17
Zn	6.80	SO_4	6.78
CaO	0.30	H_2O	5.40
MgO	Trace	C, etc.	12.32

NIKKO ELECTROLYTIC COPPER REFINERY, FURUKAWA MINING CO.

Here the gases from two cupellation and two reduction furnaces are treated to recover silver-bearing lead dust. The treater consists of one section of 32 pipes, arranged in a rectangle 8 x 4.

The treater was started in May, 1919. The analysis of the precipitated dust is as follows:

	Per Cent		Per Cent
Au	Nil	Pb	54.90
Ag	0.6896	Se	14.23
Cu	0.23		

The amount of the precipitate is about 100 lb. (45 kg.) per 24 hr. The power consumption is comparatively high, being from 2.5 to 5 kw.

Scottish Oil-Shale Possibilities

H. M. CADELL read a paper before a recent meeting of the Mining Institute of Scotland in which he discussed the origin of their important oil-shale beds. He said that all really competent authorities were at one in ascribing mineral oil to an organic source in the shape of vegetable or animal remains embedded in certain strata, the decomposition of which had produced solid or liquid hydrocarbons or natural gases. The origin of the oil in the shales had been explained in two ways.

ORIGIN OF OIL SHALES

The most natural explanation is that the shales were originally beds of fine silt or clay, deposited in lakes or lagoons near the shores of a carboniferous land area, and the impalpable mud was mixed with a large quantity of vegetable or animal matter, like the black vegetable slime that was washed off a peat moss. During the carboniferous period vegetation was luxuriant, and there were both forests and peat mosses, the debris of which might easily be washed away and deposited in the adjacent lagoons round the coast, or in land-locked basins where the water was tranquil. The vegetation mud in the oil shales formed a more or less uniform impervious stratum, and each seam originally covered a wide area—more than 100 sq.mi. in extent. The uniformity in composition and the extent of the shales was remarkable, and could only be explained by a long-continued deposit of fine silt under steady conditions of climate and topography.

ANOTHER THEORY

The second of the theories supposed that the shales were not originally petroliferous at all, but were merely receptacles of oil that had been injected or "inspissated" into them in some manner from some oil-bearing reservoir in the vicinity. However, so-called oil shale does not contain oil or oil matter at all. It contains a substance called kerogen, which is not oil or bituminous in nature, but at once turns into oil when heated to a certain temperature. In some cases the shales have been invaded

by igneous rock, which had once been hot enough to raise them to the temperature that would distill the kerogen and produce oil on the spot, but except at such places the kerogen remains unaffected. It appears obvious that the igneous invader had not an excessive temperature, because in most cases the surrounding rocks, if affected at all, show only the effects of the heat for a few feet or inches from the edge of the whinstone mass. The Scottish shalefields are therefore in more likelihood a potential oilfield that had been arrested in its infancy for want of the kindly warmth in Mother Earth that was required to turn kerogen into liquid hydrocarbon, but which had produced the finished article in more favored locations.

Estimates of Oil-Shale Resources

Other interesting material on the same subject is abstracted in the *Iron and Coal Trades Review* for Oct. 24, 1919, from the 1918 "Summary of Progress of the Geological Survey," containing a series of estimates of the oil-shale resources. In preparing these, all substances except oil-shale have been excluded, though oil can be obtained, and has been produced in Scotland on a small scale from cannel coal, torbanite or bog-head, parrot coal and parrot shale, peat and ironstone coal. As regards the thickness and quality which render a shale workable, it was decided to adopt as a standard the conditions which existed in the Scottish oil-shale industry during the ten years preceding the war. Accordingly, shales less than 3 ft. in thickness have been excluded, except in a few cases where their high quality or other favorable conditions have proved them to be of practical value. Also those areas have been excluded where the oil-shale, though present, is known to be of no practical value.

A rough approximation only to the amount of oil likely to be obtained from the oil-shale reserves by distillation is possible. A shale yielding a large quantity of ammonium sulphate can be distilled at a profit, even though it produces only 19 gal. of crude oil per ton. The richest shales yield 60 or 70 gal. per ton. In the Reports of the Mining Inspectors of recent years, 25 gal. of oil per ton is given as the average figure.

As regards depth, 300 fathoms (1,824 ft., or 556 m.) has been taken as the present limit, for it happens, from the geological structure of the shale-fields, that the oil-shale resources below that depth are not large and would not greatly affect the totals obtained. Moreover, there are no bore-records which can serve as reliable indications of the occurrence, thickness and quality of these deep-seated shales. The limit has hardly been reached by the deepest shale mines.

Considerable Number of Shale Seams Worked

The number of shale seams that have been worked in Scotland is considerable. Nearly all of them lie below the Scottish carboniferous limestone. The principal shales are, in downward order, the Raeburn, Mungle, Fells, Broxburn, Champfleurie, Dunnet, Camps, and Pumpherston shales. Of these seams, the more important, such as the Broxburn, Dunnet and Pumpherston, may form a series many feet in thickness, which is separated into bands of good oil-shale with barren shale or blaes between, and each band may have a separate designation. In no district are all the shales present in workable development: often at the horizon of an oil-shale only a carbonaceous shale or shaly blaes is met with. The horizon is generally recognizable in the bores by the presence of some equivalent bed, or the oil-shale may be there but too thin to work. Oil-shales seem to be much more variable than coal seams in these respects. It is noteworthy also that they do not pass laterally into coal seams, but into dark carbonaceous shales yielding little oil.

Each of the important oil-shales is confined, as regards its maximum development in thickness or quality, to one or more areas, and in no one area is it usual to find more than three or four of the oil-shales in satisfactory condition. The numerous masses of intrusive igneous rock that have been injected into the oil-shale measures of the Lothians have destroyed a vast quantity of oil-shale by a process of subterranean distillation, and unfortunately the principal oil-shale seams—the Broxburn, Dunnet, and Pumpherston—have all been extensively subjected to this action.

Future of Scottish Shale-Oil Mining

Other factors, not geological, affect the estimates of workable reserves. A shale that was unworkable before the war may, by changed commercial conditions, prove to be of value. As an example, the Pumpherston shales, which are comparatively poor in oil but rich in ammonia, were once practically valueless, but now are of great importance. The future of shale-oil mining in Scotland would seem to depend principally on two factors—the rates of wages and the prices obtained for shale-oil products (oil, paraffine wax, and sulphate of ammonia)—and any changes in these will directly affect the magnitude of the payable reserves of oil-shale.

Since 1873 the output of the oil-shale from Scottish mines has been reported each year in the Home Office returns. From 1873 to 1917, inclusive, it amounted to 89,401,981 tons, or, say, 90,000,000 tons.[1] The rise of Scottish oil-shale mining dates approximately from 1862, when the Torbanehill mineral was exhausted, and an allowance of 10,000,000 tons is more than sufficient to cover all mining before 1872 and also the output for 1918 (not yet published). This gives 100,000,000 tons as approximately the amount of shale that has been mined. To this must be added the amount lost in working from a variety of causes, say in the neighborhood of 20 per cent, or 20,000,000 tons; giving a total of shale mined 120,000,000 tons.

Reserves and Present Output

The estimated reserves for the oil-shale fields are as follows:

	Proved and Probable, Tons	Possible, Tons
Midlothian	163,497,000	356,120,000
Linlithgowshire	416,539,000	371,211,000
Lanarkshire	16,730,000	67,000,000
Peebles-shire	5,120,000	28,020,000
Fifeshire	.....	61,440,000
	601,886,000	883,791,000
Deduct amount already worked as above	120,000,000	
Total still available	481,886,000	

Practically all areas where igneous intrusions are known to occur on or near the horizon of an oil-shale have been omitted from the estimated reserves.

At present the output is approximately 3,000,000 tons a year. Adding 20 per cent for loss in working we get 3,600,000 tons as the yearly depletion of reserves. This indicates 133 years as the duration of these proved and probable reserves at the present rate of working.

[1] A metric and long ton are practically equal.

Air Conditioning in the Industries

By E. E. Leason

AIR conditioning is becoming recognized as a subject of increasing importance by those who are interested in atmospheric conditions in factories, mills, laboratories, bakeries, tanneries, and the like, because the proper conditioning of air not only aids manufacturing processes but gives employees the proper air to breathe.

The possibilities of overcoming unhealthful air conditions are multitudinous. Among the most pronounced examples are chemical laboratories, bakeries, confectionery factories, film manufacturers' laboratories, lithography and printing plants, textile mills of all classes, and hide and leather establishments. The possibilities, however, of conditioning air are by no means confined to the industries just enumerated. Wherever there is "sick" air there is a remedy.

Specific Examples

To be more explicit about the application of air conditioning systems, a few specific examples may be considered. For instance, in dye houses where no air conditioning system is installed the amount of fog or steam may be so great that a light will not show through it more than 30 in. away. The drip from the roof in such a room is a nuisance and the drops of water collecting on the roof soon cause decay and deterioration. Furthermore, in a number of chemical industries the materials used are highly hygroscopic. This is true in the manufacture of gelatine products and explosives where it is imperative that constant comparatively low temperatures and constant low moisture content be maintained. In other processes, those which involve oxidation, it is necessary that constant atmospheric conditions be maintained in order that the oxidation may be regular and rapid. This occurs more particularly in processes which involve the use of varnishes and paints.

Air conditioning is also a prime factor in the regulation of conditions in laboratories or manufacturing plants where very delicate tests are made. Balances which weigh to the fifth or sixth decimal place are affected by variations in atmospheric conditions. It is evident, by eliminating these variations, that tests, no matter how far apart, can be accurately compared.

In Candy Factories

In candy and chocolate factories, cool, dry air is an absolute requirement. If hard candy is kept in moist air for even a short period before being wrapped or hermetically sealed, the product loses its transparent color and resolves again into the appearance of granulated sugar; also the moisture makes the candy sticky and any particles broken off in the process of manufacture become affected in the same way. Automatic machinery is gummed up and eventually the whole factory must be closed down due to the fact that the machines cannot be run. If, however, moisture is taken out of the air and it is kept at a comparatively low temperature, the candy remains indefinitely as it was originally made and the particles are as so much dust which may be collected by a vacuum cleaner, as it will be a dry sand-like powder. Chocolate candy which is made in warm moist rooms assumes the familiar gray color due to the working of the cocoa oils. In this industry, too, uniform low temperatures and low moisture content are prime necessities.

In the Baking Industry

It is found that in the baking industry, a high humidity at a proper temperature maintained throughout the year will insure the baker standardized time for the rising of the dough. This is most essential where all baking and handling is done by machinery and thousands of customers wait each day for their fresh bread. The relief of a baker whose dough is ready for baking every day at the same hour can readily be imagined. The profit that results from having the bread ready at a specified time each day as compared to losses resulting from irregularity in deliveries makes an air-conditioning installation a paying investment.

In Photography

Manufacturers and users of photographic films are being greatly helped by the proper conditioning of air. Films are made by a gelatine process and are therefore not only hygroscopic, but are soft and melt in warm humid air and must be dried at a low temperature and low humidity. Without manufactured air conditions the film manufacturer must depend upon favorable natural weather to produce films. Frequent forced shutdowns result because the weather is too hot or too damp. With artificially controlled atmospheric conditions, manufacturers of moving picture films, photographic paper and dry plates can operate 365 days in the year.

Lithographing and Color Printing

Successful lithographing and color printing where more than one color is used is dependent on air conditions. One of the most important points in work of this kind is the registering of the various colors so that they blend with one another. Every one has seen pictures where this registering was not perfect. This results almost entirely from the expansion and contraction of the paper due to variations in moisture content in the printing room.

In Other Lines of Industry

In the textile, paper, chemical and drug, and meat industries, the maintenance of constant moisture content is a great factor of profit or loss. In these industries the manufacturers must protect their materials against loss of weight by loss of moisture. If textile fabrics, for instance, are allowed to become dry and are sold in the dry state, the manufacturer will lose a startling amount of money in a year. With cotton and wool at present prices one cannot buy the raw material with 12 per cent moisture in the case of wool and sell finished cloth with 4 or 5 per cent without taking a loss that would more than pay for an air-conditioning installation.

Furthermore, in the textile industry, silk, cotton and wool, static electricity is a source of constant worry to the factory superintendent, especially in winter. As the fibers pass over the machines, friction develops which causes the fibers to repel each other so that a close-spun thread or yarn with the fibers lying parallel does not result, producing, thereby, a product of inferior strength and resulting at the same time in the formation of a great deal of "fluff" or "fly." This "fly" floats around the room and is breathed by the operators. The way to overcome this condition is to add

enough moisture to the air to make it a favorable conductor of electricity so that as soon as a static change is formed in the product, it is drawn off and dissipated. Further, if enough moisture is present, the particles of "fluff" absorb moisture, become heavy and settle to the floor, where they may be readily swept up.

Equipment for air-conditioning is manufactured by the B. F. Sturtevant Co., Boston, Mass. Supplementing the manufacture of this apparatus the engineering organization of W. L. Fleisher, Inc., of New York City investigates industrial atmospheric problems.

Rennerfelt Electric Reverberatory Furnace

By H. A. De Fries

THE Rennerfelt Electric Reverberatory is based on U. S. patent 1,313,834, of Aug. 19, 1919, covering generation of electric heat by means of arcs drawn between vertical electrodes and a conducting bed located horizontally within the furnace. The rays of the heat thus generated strike the melting chambers not only directly, but also indirectly, by reverberating downward from the roof, if it is given the proper curvature.

A wide range of temperatures can be obtained by shortening or lengthening the arcs formed between the electrodes and the conducting bed, and it is also possible to obtain a smothered arc by bringing the electrodes in direct contact with this conductor. In the latter case the same conditions will prevail as in ordinary fuel-fired reverberatories. These arrangements tend to give the furnace a wide range of applications to various processes, such as the smelting of ores, reduction of chemicals, distillation processes, bullion smelting and melting, refining of copper, etc., and also melting of all of the non-ferrous metals and alloys. The construction of this furnace is made as simple and cheap as possible.

From the illustration it will be seen that the furnace is of rectangular shape, built of common firebrick, retained within a reinforced steel box for the smaller sizes and held together with buckstays, skew-backs, etc., for large capacities. The smaller sizes can be made tiltable, whereas the large furnaces will always be stationary. The roof is also of common firebrick and can be built stationary or removable as occasion may require. The electrodes enter through this roof vertically and the number of electrodes depends principally on the characteristics of the current, but to some extent also on the size of the furnace.

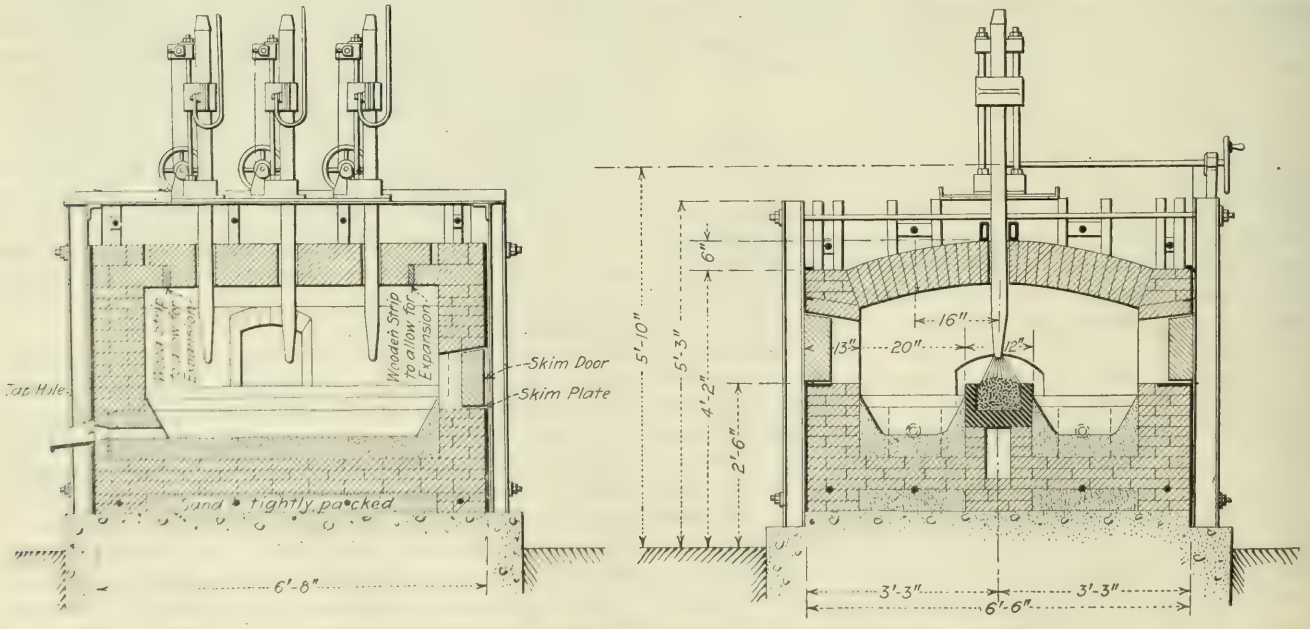
When three-phase current is available, the number of electrodes should be three or a multiple of three. In case of two-phase current, the number is two or a multiple of two. If only single-phase or direct current is available, the power is divided between two or more electrodes.

The bottom of the furnace contains the conducting bed. This bed consists of a carborundum trough in 2-ft. sections placed on a brick pier running lengthwise through the center of the furnace. The trough is filled with coarse graphite particles. This filling not only protects the carborundum trough, but also promotes smooth burning of the arcs by introducing a considerable resistance in series with the arcs and also acts as the heating element when the smothered arc is used. Doors are provided on either end of the furnace through which this trough may be removed and renewed. The filling of the trough can be renewed through these doors and also through the other working doors of the furnace.

An air duct runs the entire length of the furnace, directly beneath the carborundum trough, providing for the necessary radiation and thus insuring a longer life. The melting chambers are located on both sides and somewhat below the top of the conducting bed. These chambers are lined with either acid or basic materials, as need may require, and the bottoms slope slightly toward the tap holes, located in the front of the furnace.

It will be noted that these melting hearths are independent of each other, in other words, it is possible to charge and tap either one without disturbing the process going on in the other. This arrangement tends to cheapen the labor cost and also to increase the daily output of the furnace.

All doors are of the plug type and as many can be provided as the process would require. This type of door will permit making the furnace as airtight as possible. Ordinarily one door on either side of the furnace should be sufficient unless the furnace is of large size,



RENNERFELT ELECTRIC REVERBERATORY FURNACE

when more doors can easily be built in. In case reduction work is carried out skim plates and skimming doors should be provided for each hearth in the back of the furnace as in ordinary reverberatory furnace construction.

The electric equipment necessary for the furnace is most simple, mainly for the reason that only one voltage of 100-volt low tension will be required, as all heat regulation is obtained by fixing the distance between the conducting bed and the electrodes. No external resistance is necessary. In general, therefore, the electric equipment will consist of oil switch, transformer, instruments and the necessary cables or busbars to bring the current to the electrode contacts. The electrode regulation can be either by hand or automatic.

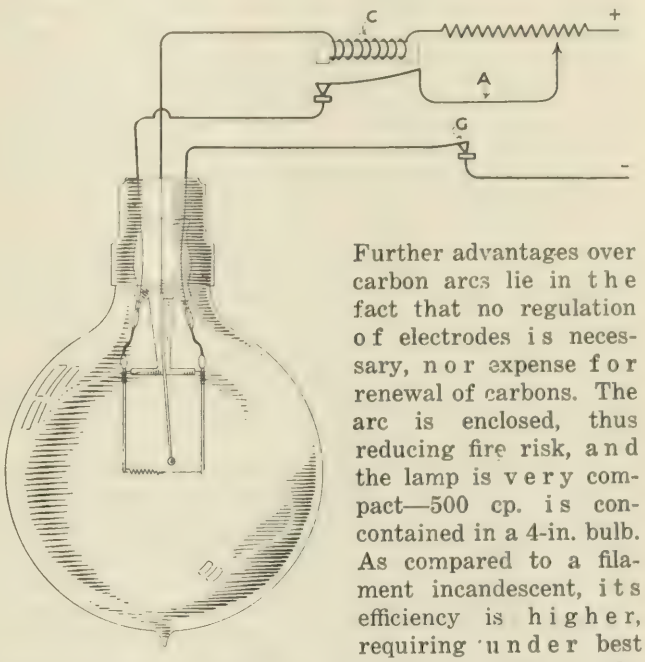
From this description it can readily be seen that the furnace is adaptable to numerous processes, and also that capacity is unlimited. As all the electrodes are in one row, any multiple can be added, thus giving additional strength to the furnace, and the width of the hearth can also be increased in proportion. When a multiple of electrodes are employed they can be connected up to the same transformer by splitting the phases, but it may be of advantage to employ a number of transformers, each controlling one set of electrodes, independent of the other. By this arrangement it is possible to regulate the heat in the various sections of the furnace.

The builder of this furnace, Hamilton & Hansell, Inc., of New York City, has also succeeded in adapting the Rennerfelt Electric Reverberatory to melting glass and enamel by making a slight change in construction and substituting tanks for the melting chamber.

Synopsis of Recent Chemical and Metallurgical Literature

A New Microscope Illuminator.—For the last three years there has been marketed in England under the name "Pointolite" a very interesting lamp, really consisting of a tungsten arc in a gas-filled globe of size of common incandescent bulbs. It was developed by E. A. GIMINGHAM and S. R. MULLARD at the laboratories of the Edison Swan Electric Co., Ltd., Ponders End, Middlesex, and described by them in the *Transactions* of the Institution of Electrical Engineers, vol. 54 (1916), p. 15. With the idea of developing a small, enclosed arc lamp with metallic electrodes, the investigators first built a globule of fused tungsten in actual contact with a brush of tungsten wires, mounting the whole in a nitrogen-filled globe of suitable size. When current was impressed, the heat so warped the supporting wires as to draw the electrodes apart, striking the arc. However, it was found that the metal soon sputtered and stuck together, so that the deformation of the metal supports could not separate the electrodes.

The successful d.c. form is illustrated herewith. To operate, switch *G* is closed, and shunt *A* leading to the filament carries practically all the current. The filament becomes incandescent, ionizing and rendering conductive the gas immediately surrounding it. At first a small current flows through the arc circuit, rapidly increasing until the cut-out is opened, breaking the ionizer circuit and striking the arc. The support is then warped by heat so that the arc moves slightly along the filament, so that the destructive action of the arc on the ionizing properties of the wire will not prevent re-starting the lamp in its cold position. Practically all the light comes from the 0.1-in. globe of fused tungsten, and does not flicker or wander in the slightest degree.



Further advantages over carbon arcs lie in the fact that no regulation of electrodes is necessary, nor expense for renewal of carbons. The arc is enclosed, thus reducing fire risk, and the lamp is very compact—500 cp. is concontained in a 4-in. bulb. As compared to a filament incandescent, its efficiency is higher, requiring under best loading only 0.3 watts per cp., its life is 500 hr., the tungsten ball has 10 times the intrinsic brilliancy of a filament—ranging up to 30,000 cp. per sq.in. The color ranges from yellow to white, depending upon the impressed current, and at heavy duty the spectrum is very continuous and strong, extending about as far into the ultra-violet as the visible range. Under these circumstances, it is readily apparent that the lamp will attract much attention from microscopists needing a continuous concentrated light from a point source.

Effect of Copper in Steel.—The Metallurgical and Testing Division, Navy Department, has made experiments on steel in which the copper content was increased to as much as 2 per cent. The gun factory has been manufacturing nickel steel with copper content between 0.4 and 0.7 per cent, and when properly handled these steels showed a marked superiority for most purposes over steel free from copper. Steel containing appreciable amounts of copper when properly made has not been found by them to be more red-short than steel of similar quality free from copper. With poorly made steel red-shortness may be found.

In successfully manufactured steel containing an appreciable amount of copper, precaution must be taken to prevent the copper from liquating or separating during solidification, as the solubility of copper is not as great in ternary alloys as is that of other alloying elements. Usual practice in the gun factory is to keep the manganese content slightly higher when the alloy carries an appreciable amount of copper, which tends to hold the copper without segregation, and prevents the tendency to red-shortness due to the presence of slightly excessive amounts of sulphur.

Steel with 2 per cent copper shows most excellent physical properties when liquation was prevented by rapid solidification of the ingot through a low pouring temperature and by use of a very heavy chill.

Recent Chemical and Metallurgical Patents

Treating Manganese Silver Ores.—LESLIE W. AUSTIN of San José, Cal., finds that it is possible to recover profitably the silver and gold from manganese silver ores by leaching with alkaline sodium cyanide solution if the ore is first treated with sulphuric acid and iron sulphide in the form of pyrite or marcasite. The treatment of the ore with sulphuric acid and pyrite reduces the manganese dioxide as indicated in the equation,

$$2FeS_2 + 15MnO_2 + H_2O = Fe_2(SO_4)_3 + 15MnO + H_2SO_4$$

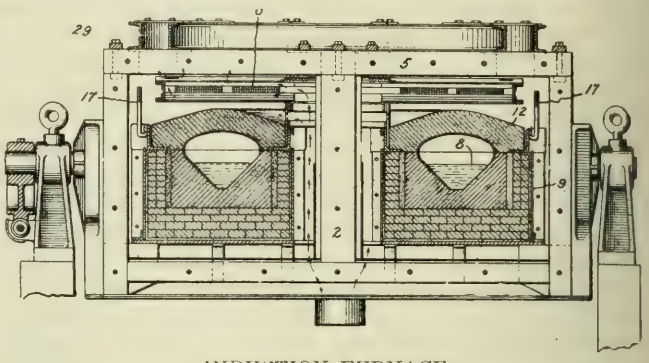
In certain cases the ferric sulphate is hydrolyzed, thus,

$$Fe_2(SO_4)_3 + 3H_2O = Fe_2O_3 + 3H_2SO_4$$

Also there may be formed manganous sulphate. The consumption of sulphuric acid is in most cases small. (1,327,974; Jan. 13, 1920.)

Precipitation of Metals From Solutions.—ARTHUR GORDON of Johannesburg, Transvaal, uses amalgamated aluminum plates for the precipitation of gold or silver from cyanide solutions. The action is more energetic than that of zinc or of a zinc-lead couple, fewer precipitation boxes are needed and it is possible to employ weaker working solutions. A considerable saving is effected thereby. The use of plates $\frac{1}{16}$ in. thick is recommended. These are amalgamated by immersion in a 1 per cent solution of mercuric chloride. The metals are precipitated by the nascent hydrogen which is liberated by the amalgamated plate from the water in the mill solution, and the mercury prevents the formation of a film of oxide on the surface of the plates. In using this method the protective alkalinity of the mill solution is increased to about 0.04 per cent, and lime is preferably used. The lime combines with the liberated hydrocyanic acid and the calcium cyanide so formed is a solvent for gold and silver. (1,328,588; Dec. 2, 1919.)

Induction Furnace.—The design of an induction furnace with the primary winding located entirely above the container for the charge or secondary winding has been suggested. The construction of a commercial furnace of this type has not been attempted, however, because it has been considered necessary to locate the legs of the core outside the essential parts of the magnetic leakage field of the primary winding and the charge. Such a design would necessitate a large core, increasing construction cost, the core loss and the amount of exciting current required. MANGUS UNGER has found that it makes no appreciable difference in the power factor of a furnace to place the legs of the core close to the primary winding and the charge container, and that this construction does not appreciably increase the stray flux loss. The magnetic core of the furnace is so proportioned that the magnetic flux density is substantially uniform when the furnace is under load. This results in a reduction of core loss and the amount of exciting current required in the primary winding. This latter is an important factor in the economy of operation. The details of the design of this furnace are shown in the illustration. The charge to be treated is contained in the annular crucible 8 located beneath the primary winding 6 and surrounding the central leg 2 of the core. The crucible has a shell 9 provided with insulated joints, is lined with firebrick and is preferably made from magnesite. The crucible cover 12 is supported from the yoke 5 by means of bolts 17, and the yoke, primary windings and crucible cover can be removed as a unit by removing bolts 29. Provision is made to cool the central leg of the core and the primary windings by forced ventilation, as shown by the arrows. The walls of the



INDUCTION FURNACE

crucible are inclined outwardly at an angle of 90 degrees to each other. This construction gives a shallow furnace chamber and permits the bringing of the charge closer to the primary winding than is possible with a deep and narrow chamber. The heating action of the induced current in the charge is greater at the surface, and with this construction the chemical action of the slag is distributed over the maximum amount of highly heated metal. (1,326,120; assigned to the General Electric Co.; Dec. 23, 1919.)

Book Reviews

LECTURE DEMONSTRATIONS IN PHYSICAL CHEMISTRY. By *Henry S. Van Klooster, Ph.D.*, of the department of chemistry, Rensselaer Polytechnic Institute. 196 pp. 83 figs. Easton, Pa.: The Chemical Publishing Co.

One opens a book of the above title with considerable curiosity, for it would seem that the field of physicochemical measurements is a most unpromising one in which to find lecture experiments. A glance at the topics listed under the twelve chapters, however, and a reading of the author's preface, give a new idea of the scope of the book, the purpose of which is to illustrate by qualitative experiments, rather than quantitative measurements, the topics usually considered in physical chemistry. The author evidently considers it a mistake to mingle physicochemical topics with descriptive chemistry, as is done in most text books of general inorganic chemistry.

In all, 253 experiments are listed, under twelve chapters bearing the following titles: General properties of matter in the liquid and solid state; diffusion; osmosis; vapor pressure and determination of molecular weights; chemical equilibrium and the law of mass action; catalysis; electrochemistry and ionic theory; solubility and its changes; colloids and adsorption; actinochemistry; flame, combustion and explosion; liquid air experiments. A bibliography, author index and subject index are included.

The author has brought together a remarkable collection of experiments, gathered from many sources. Numerous references to the original publications enhance the value of the book. It is not quite clear to what extent the author has critically studied the experiments described, and one wishes that the author had injected more of his own experience into the record. As lecture demonstrations a number of the experiments described are on altogether too small a

scale, a fault from which the art of lecture demonstration very frequently suffers. In general, however, the selection of experiments is a happy one, and it must be said that the author has made a valuable contribution in a field to which more attention might well be devoted. No teacher of physical chemistry or of inorganic chemistry can afford to be without this book. HARRY A. CURTIS.

* * *

JAMES CUTBUSH, AN AMERICAN CHEMIST, 1788-1823. By *Edgar F. Smith.* 94 pp. Philadelphia, Pa.: J. B. Lippincott Co.

This is another of Provost Smith's delightful biographies of American chemists whose names he rescues from oblivion. It is a little volume that is easily read at a sitting. If anyone should be disposed to complain of what seems almost like unanimity among Dr. Smith's heroes in regard to being born in Philadelphia, he should put an end to his repining, look up the records of his own town, and set forth his findings with similar literary charm—if he has the gift. We are eager to encourage work of this kind, and we shall not press our reservations as to Philadelphia's intellectual leadership in the nation at the time. We admit a strong prepossesion in favor of Dr. Smith and his illuminating contributions, but we deny the senatorial incapacity to see merit if it has its origin in other sources.

James Cutbush was the fourth child of a stone-cutter, Edward by given name, and his wife, Anne Marriat. This may indicate a relationship to Captain Marryat, who filled our boyhood hearts with the wish to go to sea and fight battles and see the strange world. He had two brothers, of whom one became prominent as a surgeon in the U. S. Navy, while the other graduated from West Point and attained eminence as an engineer. Where James studied and how is not recorded, but he appears in 1808—at the age of twenty, as the author of some fifteen articles in a Philadelphia newspaper called *Aurora,* in which he explains according to the light of his day many processes of a chemical nature, and urged, as he did throughout his life, the application of the science to industry.

After the death of James Woodhouse, in 1811, when the old Chemical Society of Philadelphia went out of existence, "a number of persons desirous of cultivating chemical science" founded a successor organization, and named it the Columbian Chemical Society. Each year at the fall opening "an oration on some chemical subject" was delivered, and every month "original chemical essays" were presented. We call them all "papers" nowadays, and it might improve the form of some of them if we were to place the responsibility upon the writers of a higher finish, a greater literary polish, in connection with their work. The "Hon. Thomas Jefferson, Esq., was the Patron," and its president was "James Cutbush, Esq., professor of natural philosophy, chemistry and mineralogy in St. John's College." At this time he was twenty-three years old. St. John's College was established and maintained by a Lutheran church of that name in Philadelphia.

Dr. Smith gets a line on Cutbush from a newspaper advertisement of October, 1819, which reads:

Bleaching Liquor, Artificial Musk, Phosphate of Mercury, and Other Chemical Preparations
prepared and sold by
James Cutbush
Chemist and Apothecary
No. 25 South Fourth Street, Philadelphia,
where complete collections of chemical reagents are kept as usual.

Throughout several years announcements are found by Cutbush in St. John's Lyceum and elsewhere on general chemistry, the theory and practice of pharmacy and other subjects. On Nov. 7, 1811, he delivered an oration before the Society for the Promotion of a Rational System of Education. Dr. Smith says: "His audience was large, and consisted of the very best people of the city. The printed address shows that in addition to his chemical knowledge he was versed in the humanities, in mathematics, in philosophy and ancient history." He urged the introduction of physical science into the curriculum of schools. It hardly seems out of date now, a century later.

Another note that has a modern turn to it is that "He is often referred to as Dr. Cutbush, and in at least two instances the title M.D. is placed after his name. Yet it is a fact that in no place where he is personally responsible for the printing of his name is there any title affixed to it." Apropos of doctorates of courtesy and convention as distinguished from those of academic origin, our readers may recall that in our lament for the passing of William, the dusky servitor of the Chemists' Club, it was observed that as soon as William learned the name of a newly elected member, he addressed him from that time forth as Doctor. These titles were pleasant to the unaccustomed ear, and became known in time as "William's College Degrees." Some of them have remarkable adhesive qualities.

In 1814 James Cutbush was appointed assistant apothecary general to the U. S. Army, although in 1819 he was still in Philadelphia prosecuting his duties. In 1820 he was appointed chief medical officer in the U. S. Military Academy at West Point, where later he became professor of chemistry. Here he addressed himself vigorously to problems of pyrotechnics and explosives. Several pages of questions in regard to pyrotechny are given to indicate his scholarship and methods. His posthumous work on the subject, printed in 1825, has for many years been consulted and referred to by men of science. He was the great pioneer in this field. He must have been a man of mark and attractive personality. Over his grave at West Point is carved this inscription: "Sacred to the Memory of Dr. James Cutbush, Member of the American Philosophical Society, Late Surgeon U. S. Army and Professor of Chemistry, West Point, N. Y., who departed this life Dec. 15, 1823, aged thirty-five years. An honorable tribute of respect from his grateful pupils."

ELLWOOD HENDRICK.

* * *

A HANDBOOK OF BRIQUETTING. VOL. II. By *G. Franke.* 214 pp., illustrated. Philadelphia, Pa.: J. B. Lippincott Co.

While this book is the second volume of a series published by the author, it is a complete work in itself on the briquetting of ores and metallurgical products. The author is evidently eminently qualified to prepare such a text on this subject, as demonstrated in both this and previous volumes. A reference to and description of plants employing the processes deal mainly with European practice, for the application of briquetting processes to various metallurgical products has progressed far beyond that in American plants.

In addition to briquetting proper, agglomeration or sintering of ores and metallurgical products is also dealt with. This process consists of converting suitable fine material into lumps adapted to the particular smelting operation, without calling in the aid of the processes of molding and compression.

The book opens with a section on the various metallic briquetting materials, with reasons for, and objects of, briquetting them. Briquet testing and characteristics of good briquets, and the composition of various metallurgical and smelting briquets and agglomerates are dealt with. The subject of methods involved in briquetting is thoroughly covered, commencing with the hand-molding of the simple briquet and finishing with fusion processes in electric furnaces, these methods involving the briquetting of materials both with and without binders.

Preparation of the material and subsequent treatment for smelting and fusion embraces a series of chapters which should be of interest to all engineers and operators concerned with metallurgical plants, not only those who are interested in the design of complete new plants, but also where certain additions are contemplated in the existing processes as will effect a saving in the smelting of products which are now considered wastes. The author further enters into descriptions of complete briquetting plants now in operation in European countries. These installations are liberally illustrated by photographs and drawings.

The final pages of the work embrace appendices to both Vols. I and II, which contain further results of tests on pitch and coal briquets, cost of heat, and Hemmerling's

methods for the production of compressed peat blocks; treatment of coal slimes, and briquetting of flue dust.

A careful examination of the text matter shows a large amount of detail on briquetting methods which should be of considerable value to those interested in operating or installing briquetting plants, and the work should command the interest and attention of many who do not now consider themselves concerned with briquetting. American manufacturers are now producing machinery which adequately serves the function of producing briquets under the methods described in this book. CHESTER H. JONES.

Personal

HARRY E. BISHOP has resigned from the staff of the State Board of Health Laboratories, Indianapolis, Ind., to accept a position in the research laboratory of the National Association of Manufacturers of Glass Containers, Chicago, Ill.

J. S. BROGDON and W. C. DUMAS, formerly state chemist of Georgia, have organized the Brogdon-Dumas Laboratories, Inc., for the conduct of general business as assayers and chemists at Atlanta, Ga.

HERBERT R. HANLEY has returned to San Francisco from a trip to the various Arizona smelters.

Dr. ARTHUR R. HITCH has resigned his position as chief chemist for the Ashland Iron & Mining Co., Ashland, Ky., to accept a position as research chemist with E. I. du Pont de Nemours & Co., at its Jackson Laboratories, Wilmington, Del.

G. W. LAMBOURNE, general manager of the Judge Mining & Smelting Co., has returned to Salt Lake City from a business trip to the Coast.

WILLIAM L. LONG, formerly with Swan-Myers, Indianapolis, Ind., is now chemist with the H. K. Mulford Co., Philadelphia, Pa.

GEORGE D. MCLAUGHLIN has resigned his position as chief chemist of Kullman, Salz & Co., to do research work in colloid chemistry under Dr. Martin H. Fischer, at the University of Cincinnati, Cincinnati, Ohio.

JOHN G. MCLEOD, JR., is now research chemist in the technical service department of the Brompton Pulp & Paper Co., Ltd., East Angus, Que., Canada.

Dr. CHARLES S. PALMER, formerly of the Mellon Institute, Pittsburgh, Pa., has joined the United Fuel Gas Co., Charleston, W. Va., as chief chemist.

B. B. THAYER, vice-president of the Anaconda Copper Mining Co., sailed for Chile on Jan. 31, to inspect the company's properties.

Dr. MAXIMILIAN TOCH of Toch Bros., New York, has been appointed professor of industrial chemistry at Cooper Institute, New York, to lecture on paints, drying oils, resins and rubber.

J. E. TOOMER, formerly research chemist with the Chino Copper Co., Hurley, N. M., has accepted the position of chief chemist with the Morris Fertilizer Co., Atlanta, Ga.

Obituary

PAOLO FISCHER, at one time an assistant to Stassano, the Italian builder of electric furnaces, died recently in Chicago. Mr. Fischer was widely known in Europe in connection with the early development of the electric furnace. He designed the plant which was operated for some time at Buchanan, Mich., and more recently had designed a proposed plant for installation near the Keokuk dam.

C. H. INGRAM, of the Ruhm Phosphate Mining Co., died Jan. 8 at Mt. Pleasant, Tenn., after a short illness from pneumonia. Mr. Ingram had been actively connected with the phosphate business since its discovery in Tennessee and was widely known and very popular in the trade.

Current Market Reports

The Non-Ferrous Metal Market

New York, Feb. 9, 1920.—Little movement in the market. Nickel remained stationary; copper, zinc, tin and silver declined slightly; lead advanced from 8.62½c. to 8.80c., New York.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent	31½@32½
Antimony, wholesale lots	11.50
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	57.50
Lead, New York, spot	8.80
Lead, E. St. Louis, spot	8.45
Zinc, spot, New York	9.05
Zinc, spot, E. St. Louis	8.70
Silver (Dollars per oz.)	1.32¾

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Cadmium	lb.	$1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	80.00

SCRAP METALS

	Cents per Lb
Aluminum, cast scrap	23¼@24¼
Aluminum, sheet scrap	22½@23½
Aluminum clippings	25½@27
Copper, heavy machinery comp	14½@14¾
Copper, heavy and wire	13¾@14
Copper, light and bottoms	12½@12¾
Copper, heavy cut and crucible	15¾@16
Brass, heavy	7 @8¼
Brass, casting	10½@10¾
Brass, light	5¾@6⅝
No. 1 clean brass turnings	8⅛@8⅜
No. 1 comp. turnings	12 @12¼
Lead, tea	5½@5¾
Lead, heavy	6⅜@7
Zinc, scrap	4¼@4½

The Iron and Steel Market

Pittsburgh, February 6, 1920.

The runaway steel market, referred to in last report as having in all probability developed, is clearly defined as such. The market is nothing if not a runaway. There are no regular market prices. The Steel Corporation subsidiaries have a very well defined schedule of prices, the March 21, 1919, or "Industrial Board" schedule, but only its regular customers can buy at those prices, and then in many cases not as large tonnages as they desire. Among the independents there is probably not one that is willing to sell anyone at the March 21 schedule, while furthermore the prices quoted by independents, when they quote at all, very seldom agree. Competition does not force the market of the independents to a definite level, for the reason that the individual producers do not offer as much steel as buyers desire to purchase.

While technically there is a clearly defined condition of a runaway market, it cannot be observed that the market is running away very fast. Whether this feature is due to reserve on the part of sellers or reserve on the part of buyers cannot be determined at this time. No canvass of buyers can be made which would show the distance ahead to which they are willing to commit themselves at one price or another if given the opportunity.

One large independent steel interest is engaged in its own effort to stabilize the market, but apparently has no company. Its prices for a variety of steel products, with perhaps an occasional exception, are what are known as "Jan. 1" prices, the prices from which the Industrial Board reductions were made March 21, and to which prices were

reduced shortly after the armistice. The Jan. 1 prices are, for illustration, 2.70c., 2.80c. and 3c. for bars, shapes and plates respectively.

Operations

Steel production in January was not far from 85 per cent of capacity, and while the tonnage proved larger than had been predicted, the producers profess themselves much disappointed at conditions today, there having been little if any further increase in the production rate since the middle of January. With scarcely an exception producers ascribe the restriction to a shortage in transportation, which touches the industry in various ways—in preventing an increase in production and shipment of Connellsville coke, in limiting the shipment of coal for steel mill and byproduct oven use and in preventing all steel made from being shipped. At some mills there are large accumulations of finished product threatening to back up against the rolls and force stoppages. The railroads are not disorganized, but they have not the reserve force to cope with existing conditions, particularly the winter weather. Given a continued summer they might do fairly well.

The automobile industry is having an influence upon the steel market that is greatly regretted by many other classes of consumers, as the automobile factories are so situated that it is a matter of indifference to them what prices they pay for such small lots of steel, relative to their regular supplies, as they need in order to maintain operations. Some steel buyers feel strongly that the automobile industry is making an impress upon the steel market out of proportion to the tonnage importance of the additional steel it now requires, for all or nearly all the established factories have large tonnages of steel reaching them from week to week on old contracts, at prices much below those now bid for small prompt lots.

Lake Superior Iron Ore Market Opens

The Lake Superior iron ore market for the 1920 season was opened in Cleveland Monday, Feb. 2, by representative sales, and in accordance with a habit formed long ago the producers will adhere during the season to the prices thus developed. There is a uniform advance on the four groups of ores of $1 per ton over the 1919 schedule, making prices as follows at Lake Erie docks: old range bessemer, $7.45; old range non-bessemer, $6.70; Mesabi bessemer, $7.20; Mesabi non-bessemer, $6.55. These prices are the highest in a statistical record which begins with 1894 in the case of Mesabi ores and with 1885 in the case of old range ores. The advance, however, is moderate relative to the prevailing prices of pig iron. Mesabi non-bessemer, for instance, is at the new rate 95 per cent above its 10-yr. pre-war average in the seasons of 1904 to 1913 inclusive, while pig iron is fully 150 per cent above its corresponding pre-war average.

Pig Iron

The pig iron market is in stronger position, although no additional advances are to be recorded for the past week. Foundry iron is $40, Birmingham, and foundry and basic $40, valley, with bessemer at $41. These quotations are based on last important sales, but it is doubtful whether much additional tonnage can be had at the prices, while buyers are taking hold somewhat more freely than formerly.

Unfinished Steel

No definite prices can be quoted for unfinished steel, each of the few transactions made being a law to itself. In the past week a sale of sheet bars has been made at $65 and another at $56, the circumstances not being greatly different as to tonnage and delivery. Small billets have sold at $60.

The Ferro-Alloy Market

New York, February 7, 1920.

The car shortage is hitting the manufacturers not only in the scarcity of incoming raw material but also in the outgoing product. Deliveries on contracts are being delayed and producers are taxing their resources to keep the mills supplied.

Ferromanganese continues the most important item of the alloys; difficulty is experienced in obtaining it at $160 per ton. Spiegeleisen is strong under the impetus of the manganese demand, and the average price quoted is around $55 per ton. There has been some small business in ferrochrome at 25c. per lb., but buyers are few and far between.

The coke situation remains unchanged, indifference on the part of labor to the necessity of increasing production, extreme car shortage (totaling 30 to 35 per cent of normal number of cars), and the cold weather have successfully combined to practically cripple this industry.

The Chemical Market

New York, February 7, 1920.

The chemical market during the past week continued evenly balanced, with a slight drop in activity probably due to a scarcity of spot material. Prices have not been affected by this scarcity and remain at practically the same level as the previous report.

Aqua ammonia remains firm at 8¾@10¾c. due principally to the lack of supplies caused by the recent coal shortage. This item has not recovered, and with the present demand prices will continue at the present level. Manufacturers are offering *white sal ammoniac*, granular, at 12¾@14c. per lb. and the gray at 12@12½c. Spot materials are scarce, but contracts for forward delivery are being taken. *Bleaching powder* is practically off the spot market at present. Manufacturers who are fairly well sold up on this item are quoting $2.50@$3 per cwt. *Glauber's salts* has been quiet. Buyers have been taking a routine supply, but with the present stocks no immediate rise is looked for.

Potassium carbonate is difficult to locate on spot, but there has been some trading at 24@27c. per lb., mostly on contract, as the entire supply is in the hands of a few. *Potassium hydroxide* remains firm at 23@32c. per lb. There has been some business in spot goods in a small way at 30c. per lb. *Oxalic* has had another jump and is now quoted at 35@40c. per lb. Import grades from England are to be had at 38c. but domestic producers with their rather scanty stock are holding firm at 40c.

Coal-Tar Products

This branch of the market has been quiet during the past week, due principally to uncertainty as to the tariff, which is at present under discussion in Washington. Opinion is divided regarding what action Congress should take, the producer of coal-tar intermediates and dyestuffs holding that a restrictive tariff should be placed on all imported goods sufficient to protect the domestic manufacturer, while the textile and mill people, who desire to obtain these items at the lowest possible figure, claim this would do away with competition. Definite action will certainly ease the market. *Cresylic acid*, 97-99 per cent, has advanced from 75@80c. per gal. of last week to 90c.@$1.10, while 95-97 per cent also came up to 80c@$1, with supply falling off, and further advances are looked for soon. *Phthalic anhydride* remains at 60c. per lb. There are plentiful stocks of this material in the hands of large producers. Through a typographical error the prices on *salicylic acid* were reversed. The present quotation is 43@45c. per lb. for tech. and 55@60c. for U. S. P. grade. *Benzol* has been easier due to a replenished stock. This item can be obtained by actual users in reasonable quantities for prompt shipment at 27c. per gal. *Phenol* remains unchanged and the large stocks on this item have kept the price at 12c. per lb.

Naval Stores

Turpentine continues upward, the present quotation in the local market being $2.04 per gal., while Savannah is quoted at $1.97 per gal. *Rosins* remain firm with a slight falling off in inquiry.

Crude Rubber

The crude rubber market continues easy, buyers holding out for more favorable prices. Manufacturers are fairly well supplied and are not in the market except for concessions, and the present indication is that a still further drop will take place.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0.16 –$0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.50 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.00 – 5.50	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 –12.50	13.50 – 15.50
Boric, crystals	lb.	.14½– .15½	.15½– .16½
Boric, powder	lb.	.14½– .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 –	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½– .07
Molybdic, C. P	lb.	.....	4 25 – 5.00
Nitric, 40 deg	lb.	.06 – .06½	.07 – .08½
Nitric, 42 deg	lb.	.06½– .07	.08 – .09½
Oxalic, crystals	lb.	.35 – .40	.40 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.20 – 2.40	2.30 – 2.60
Sulphuric, 60 deg., tank cars	ton	17.50 –22.00	.....
Sulphuric, 60 deg., drums	ton	.....	.....
Sulphuric, 66 deg., tank cars	ton	22.00 –25.00	.....
Sulphuric, 66 deg., drums	ton	.....	.....
Sulphuric, 66 deg., carboys	ton	.....	.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	30.00 –	32 00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P	lb.	.....	1.35 – 1.45
Tannic (tech.)	lb.	.....	.42 – .55
Tartaric, crystals	lb.	.....	.69 – .74
Tungstic, per lb. of WO	lb.	.....	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	.....	.76 – .78
*Alcohol, denatured, 190 proof	gal.	.....	.71 – .73
Alum, ammonia lump	lb.	.04½– .05	.04½– .04¾
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½– .02	.02½– .02½
Aluminum sulphate, iron free	lb.	.02½– .03	.03½– .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½– .10½	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.....	.30 – .33
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white sal ammoniac)	lb.	.12½– .14	.13½– .17½
Ammonium chloride, granular (gray sal ammoniac)	lb.	.12 – .12½	.13 – .13½
Ammonium nitrate	lb.	.22 –	.....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	.....	.10½– .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	.....
Barium chloride	ton	80.00 –85.00	100.00 –110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.11 .13	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½– .04
Bleaching powder (see calcium hypochlorite)		.....	.....
Blue vitriol (see copper sulphate)		.....	.....
Borax (see sodium borate)		.....	.....
Brimstone (see sulphur, roll)		.....	.....
Bromine	lb.	.90 – .95	.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	.....	.04¾ .05
Calcium chloride, fused, lump	ton	20.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½– .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	.....	2.50 – 3.00
Calcium peroxide	lb.	.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	.....	.75 – .80
Calcium sulphate, pure	lb.	.....	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	..... – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	.....	.75 – .....
Caustic potash (see potassium hydroxide)		.....	.....
Caustic soda (see sodium hydroxide)		.....	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	.....	1.50 – 1.55
Copperas (see iron sulphate)		.....	.....
Copper carbonate, green precipitate	lb.	.....	.28 – .31
Copper cyanide	lb.	.....	.65 – .70
Copper sulphate, crystals	lb.	.07½– .08¾	.09 – .09½
Cream of tartar (see potassium bitartrate)		.....	.....
Epsom salt (see magnesium sulphate)		.....	3.00 – 3.25
Formaldehyde, 40 per cent	lb.	.....	.51 – .52
Glauber's salt (see sodium sulphate)		.....	.....
Glycerine	lb.	.....	.24½– .26
Iodine, resublimed	lb.	.....	4.10 – 4.30
Iron oxide, red	lb.	.....	.03 – .20
Iron sulphate (copperas)	cwt.	1 20 –	1 25 – 1.75
Lead acetate, normal	lb.	.....	.14 – .23
Lead arsenate (paste)	lb.	.....	.13 – .17
Lead nitrate, crystals	lb.	.....	.70 – .80
Litharge	lb.	.....	.09½– .10½
Lithium carbonate	lb.	.....	1.50 – .....
Magnesium carbonate, technical	lb.	.....	.13 – .14½
Magnesium sulphate, U. S. P	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.16 –	.17 – .....
Phosgene (see carbonyl chloride)		.....	.....
Phosphorus, red	lb.	.....	.60 – .90
Phosphorus, yellow	lb.	.....	.35 – .37
Potassium bichromate	lb.	.28 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	.....	.56 – .60
Potassium bromide, granular	lb.	.....	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	16 – .20	.21 – .....
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.23 – .32	.35 – .42
Potassium iodide	lb.	.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	.....	.65 – .95
Potassium prussiate, red	lb.	.....	1.10 – 1.20
Potassium prussiate, yellow	lb.	.....	$0.40 – $0.70
Potassium sulphate	ton	$225.00 –	.....
Rochelle salt (see sodium potas. tartrate)		.....	.....
Sal ammoniac (see ammonium chloride)		.....	.....
Sal soda (see sodium carbonate)		.....	.....
Salt cake (sodium sulphate)	ton	18.00 –21.00	.....
Silver cyanide	oz.	.....	1.25 – .....
Silver nitrate	oz.	.....	.81½– .82½
Soda ash, light	100 lb.	2.05 –	2.25 – .....
Soda ash, dense	100 lb.	2.25 – 2.35	2.50 – 2.75
Sodium acetate	lb.	.06½– .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.20 – .21	.22 – .25
Sodium bisulphate (nitre cake)	cwt.	5.00 – 6 00	8.00 – 10.00
Sodium bisulphite	ton	7.00 – 8 00	8.50 – 9.00
Sodium borate (borax)	lb.	.08½– .08½	..... – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	.....	4.35 – 4.50
Sodium hyposulphite	lb.	.....	.03¼– .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	.....	.30 – .32
Sodium phosphate, dibasic	lb.	.03½– .04½	.04½– .05
Sodium potassium tartrate (Rochelle salt)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .39	.24 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¼– .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½– .03	.05 – .06
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.30 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60-62 per cent. (conc.)	lb.	.....	.05 – .06
Sodium sulphite, crystals	lb.	.03½–	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½–	.06 – .....
Sulphur, crude	ton	22.00 –	.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½–	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – .....
Zinc carbonate, precipitate	lb.	.....	.20 – .....
Zinc chloride, gran	lb.	.13 –	.13½– .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.11½– .12½	.13 – .15
Zinc oxide, dry American	lb.	.....	.09½– .12
Zinc sulphate	lb.	.03½– .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.36
Aniline oil, drums extra	lb.	.34 —	.36
Aniline salts	lb.	.42 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.30
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.52
Beta naphthol, sublimed	lb.	.65 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U.S.P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.90 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.80 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.70 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.90 —	1.00
Dinitrobenzol	lb.	.26 —	.37
Dinitrochlorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.58 —	.75
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.00 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.90 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.15 —	.18
Paranitraniline	lb.	1.00 —	1.20
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.50 —	4.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.60 —	1.00
Phenol, U.S.P., drums (dest.), (240 lb.)	lb.	.12½ —	.19
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.43 —	.45
Salicylic acid, U.S.P.	lb.	.55 —	.60
Salol	lb.	.90 —	.95
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.22 —	.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30

Toluidine	lb.	$1.70 —	$2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white, pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18½ —	.20
Paraffine waxes, crude match wax(white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp.gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp.gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp.gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp.gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl	280 lb.	$19.00 —	$19.50
Rosin E-I	280 lb.	19.50 —	19.70
Rosin K-N	280 lb.	19.75 —	22.50
Rosin W. G.-W. W	280 lb.	22.50 —	24.25
Wood rosin, bbl	280 lb.	17.00 —	17.50
Spirits of turpentine	gal.	.... —	2.04
Wood turpentine, steam dist	gal.	.... —	1.70
Wood turpentine, dest. dist	gal.	1.64 —	....
Pine tar pitch, bbl	200 lb.	8.25 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	14.75
Retort tar, bbl (500 lb.)	bbl.	15.00 —	15.25
Rosin oil, first run	gal.	.... —	.91
Rosin oil, second run	gal.	.93 —	.94
Rosin oil, third run	gal.	1.10 —	1.12
Rosin oil, fourth run	gal.	.... —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naptha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.44 —	$0.46
Upriver coarse	lb.	.33 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.50 —	.54½
Ribbed smoked sheets	lb.	.49 —	.51
Brown crepe, thin, clean	lb.	.48	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23½ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.21 —	.21½
Cocoanut oil, Cochin grade, in bbls	lb.	.20½ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N Y	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1 20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	$ .04½ —	$ .06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	40.00 —	45.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	50.00 —	52.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% Carbon content	lb.	.... —	.07½
Graphite, crucible, 86% Carbon content	lb.	.... —	.07½
Graphite, crucible, 87% Carbon content	lb.	.... —	.07½
Graphite, crucible, 88% Carbon content	lb.	.... —	.08
Graphite, crucible, 89% Carbon content	lb.	.... —	.08½
Graphite, crucible, 90% Carbon content	lb.	.... —	.08½
Graphite, crucible, 91% Carbon content	lb.	.... —	.08½
Graphite, crucible, 92% Carbon content	lb.	.... —	.09
Graphite, crucible, Plus 92%		.... —	.12
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, TN	lb.	1.10 —	1.15
Shellac, D. C	lb.	.... —	....
Shellac, V. S. O	lb.	.... —	....
Shellac, Diamond I	lb.	.... —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Shellac, bleached, bone dry	lb.	1.35 —	....
Shellac, bleached, fresh ground	lb.	1.10 —	1.15
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	150.00 —	160.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluorspar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

* Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

NEW HAVEN—The State Bd. of Health, 308 Church St., Hartford, and Bilderbeck & Langdin, archts., Manwaring Bldg., New London, will receive bids about March 1 for the construction of a 3-story, 51 x 111 ft. laboratory and experimental station on Highland St. Testing and experimental apparatus will be installed in same. Total estimated cost, $125,000.

Illinois

CHICAGO—The Illinois Glass Co. is having plans prepared for the construction of an addition to the plant which will be built at Crawford and Whitewood Aves. Estimated cost, $250,000. The company also plans to build addition to the plants of the United States Bottlers' Machinery Co., and the Kimble Glass Co., subsidiary corporations, at a cost of $250,000. Herbert H. Green, archt.

CHICAGO—Lindstrom, Smith & Co., 1104 South Wabash Ave., has awarded the contract for the construction of a 1-story, 130 x 250-ft. factory for the manufacture of electrical specialties, on Lake St. and Kedzie Ave., to Jacob Rodatz, 209 South LaSalle St. Estimated cost, $125,000.

Iowa

SIOUX CITY—The Sioux City Soap Co., 302 Grain Exch. Bldg., plans to build a soap factory.

Kansas

BAXTER SPRINGS—The Empire Development Co. plans to move its old Kentex Mill from Quapaw to a site which it has leased, southwest of here. The company is in the market for 1 compressor, 2 gas engines, 9 tables, rolls and screens. E. Mallocsay, supt.

TOPEKA—The city plans to construct a 10,000,000-gal. filtration plant. Estimated cost, $190,000.

Kentucky

RIVERSIDE—The Standard Oil Co., 424-30 West Bloom St., Louisville, is having plans prepared for the construction of additions to its refinery at Riverside Station. The new plant will more than double the present capacity. Estimated cost, $2,000,000.

Louisiana

MONROE—N. C. McGowan, Shreveport, plans to build a carbon black plant about 17 mi from here. Estimated cost, $250,000.

SHREVEPORT—R. S. Seamans, pres. of the Foursome Oil Co., plans to build a 5,000-bbl. refinery. Estimated cost, $600,000.

Maine

PORTLAND—The Amer. Can Co., B'way, New York City, has awarded the contract for the construction of a cannery, to the Turner Constr. Co., Tremont St., Boston, Mass. Chemical equipment, etc., will be installed in same.

PORTLAND—A. S. Hinds, 20 West St., has awarded the contract for the construction of a 90 x 150-ft. laboratory, to Lorello & Piofano, 217 Stevens Ave. Chemical equipment will be installed in same. Estimated cost, $150,000.

Maryland

BALTIMORE.—A. H. Kuhlemann Co., 2961 Frederick Ave., has awarded the contract for the construction of a 3-story, 75 x 200-ft. factory for the manufacture of oleomargerine, on Frederick Ave., to W. L. and G. H. O'Shea, 29 B'way, New York City. Estimated cost, $100,000.

Massachusetts

BOSTON—The Simbroco Co., 161 Devonshire St., has awarded the contract for the construction of a 1-story, 60 x 200-ft. factory at 270 Baker St., for the manufacture of concrete products, to Simpson Bros. Co., 166 Devonshire St. Estimated cost, $70,000.

New Jersey

NEWARK—The General Lead Batteries Co., 123 West 56th St., New York City, is having plans prepared for the construction of a 5-story factory on Lester Ave. and Chapel St. Estimated cost, $150,000. Timmis & Chapman, 315 5th Ave., New York City, archts. and engrs.

NEW BRUNSWICK—George E. Maguire, pres. Trenton Porcelain Co., 803 East State St., will soon award the contract for the construction of a 2-story, 32 x 100-ft. porcelain plant. Estimated cost, $20,000. W. A. Kleman, 1st Natl. Bank Bldg., archt.

New York

BUFFALO—The Buffalo Porcelain & Enameling Co. plans to construct a 2-story factory at 1927 Elmwood Ave. Estimated cost between $20,000 and $25,000.

ITHACA—C. D. Bostwick, comptroller, Cornell University, will receive bids until Feb. 24 for the construction, heating, sanitary and electric work at the Laboratory for Economic Investigation of Insects, New York State College of Agriculture, here.

UTICA—The Bowen Mfg. Co., manufacturer of paper and twine, 401 Columbia St., has awarded the contract for the construction of a 1-story, 102 x 225-ft. factory, to the Kimberly Constr. Co., Mayno Bldg. Estimated cost, $29,000.

Ohio

CINCINNATI—The Jarecki Chemical Co., Broerman Ave., has awarded the contract for the construction of a 1-story, 120 x 350-ft. factory, to the Austin Co., 16112 Euclid Ave., Cleveland. Estimated cost, $300,000.

CLEVELAND—The Crucible Steel Forge Co., 6600 Grant Ave., has awarded the contract for the construction of a 1-story, 60 x 900-ft. rolling mill, annealing plant and machine shop on Grant Ave., to the Masters & Mullen Constr. Co., Electric Bldg. Estimated cost, $500,000. Noted Jan. 7.

CLEVELAND—The Hydraulic Pressed Steel Co., Hydraulic Ave., has awarded the contract for remodelling the 1-story heat treating plant on Hydraulic Ave., to E. R. Russell, Sincere Bldg. Estimated cost, $10,000.

LIMA—The Union Tank Line Co. has purchased a 130-acre site adjoining the property of the Solar Refinery and plans to build a large tank factory on same. Estimated cost, $20,000,000.

Oklahoma

BEGGS—The Kre-Ko Refining Co., Bristow, is having plans prepared for the construction of a 1-story, 3,000-bbl. refinery, 1 mi. north of here. Estimated cost, $400,000. John D'Arcey, genl. mgr. Foster & Gilmore, Tulsa, archts. and engrs.

South Carolina

CHARLESTON—The Commissioners of Pub. Wks., Water Dept., 14 George St., have awarded the contract for the construction of a filter plant, consisting of fourteen 1,000,000-gal. units, to the New York Continental Jewell Filtration Co., Flatiron Bldg., New York City. Estimated cost, $125,000.

Texas

CLINTON—The Keen & Wolf Refining Co., 317 Beatty Bldg., Houston, is having plans prepared for the construction of a 1,000-bbl. oil refinery, including several buildings and 5 stills, near here. Estimated cost, $300,000. A. Peterson, care of company, chief engr.

QUANNAH—The Four States Oil & Refining Co. plans to build a 1-story refinery, south of here. Estimated cost, $400,000.

RANGER—The International Oil & Refining Co. plans to build a refinery. Estimated cost, $300,000.

RANGER—The Olda-Clark Refining Co. plans to build a refinery. Estimated cost, $250,000.

Wisconsin

CLEAR LAKE—W. L. Albans, archt., Endicott Bldg., St. Paul, Minn., will soon award the contract for the construction of a 2-story, 53 x 94-ft. high school, for the Bd. Educ. A septic tank will be installed in same. Estimated cost, $60,000.

CUDAHY—The Federal Rubber Co., Packard Ave., is having plans prepared for the construction of three 6-story, 160 x 220-ft. factory buildings. G. B. Allen, 424 Jefferson Ave., Milwaukee, archt. and engr.

MILWAUKEE—The Westinghouse Lamp Co., 32nd and Center Sts., plans to construct two 3-story, 75 x 300-ft. additions to its factory on 32nd St.

Ontario

BELLEVILLE—The Bd. Educ. plans to build a 3-story Collegiate Institute. Chemical and physical laboratory equipment will be installed in same. Estimated cost, $350,000. A. McGie, chn.

LONDON—The city plans to build a sewage disposal plant to include an Imhoff tank or activated sludge system. Estimated cost, $250,000.

TORONTO—The Bd. Educ. plans to construct 2- and 3-story additions to various schools in the city. Chemical and physical laboratory equipment will be installed in the high schools, collegiate and technical schools. Estimated cost, $1,500,000. W. W. Pearse, 155 College St., Mgr.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a meeting on Feb. 27, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16 to 19.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION will hold its convention at the Waldorf-Astoria Hotel, New York City, Feb. 26 and 27.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, February 18, 1920 — *Number* 7

Proposed Amalgamation Of Heat-Treating Societies

A WELL-DEFINED movement has been instituted looking toward the amalgamation of the American Steel Treaters' Society and the Steel Treating Research Society. It will be recollected that about two years ago the Chicago section of the Steel Treating Research Society, whose general offices were in Detroit, became dissatisfied with the conduct of the parent society and seceded, forming the American Steel Treaters' Society, with headquarters in Chicago. Some time later, under the energetic leadership of W. H. EISENMAN, business manager of the younger organization, a campaign for members was instituted which resulted in the formation of a number of new chapters, in some instances invading the territory already occupied by a local section of the Detroit body. This could not help but cause intense rivalry between the competing bodies, both local and national, and as a natural result more or less recrimination and unpleasantries passed between the partisans.

Such duplication of effort was evidently quite wasteful, and under the initiative of Professor A. E. WHITE, of the University of Michigan, both bodies appointed a committee to consider whether consolidation could be effected. This joint conference, after finding the societies financially solvent, formulated a plan of amalgamation which has now been submitted to the membership and its adoption recommended by the national officers.

Briefly, the plan contemplates a society to be named "The American Society for Steel Treating," with headquarters in Cleveland, to assume the assets and liabilities of the two founder organizations. Membership qualifications and classification are practically unchanged, while the annual dues for members are to be fixed at $10, members of the founders' societies having their membership extended a time covered by the balance of their paid-in dues. Such members will vote on the proposed consolidation, and participate in the election of new general officers.

There seems to be very little to be said against such a move for the unification of effort among heat treaters, except perhaps the individual pride which enthusiasts feel in a pet project. Even this can be well expended in making a joint association better, bigger, and more worthwhile than either one of a sharply competing pair could be.

There certainly is a world of opportunity waiting the effort of any earnest body of men who start out to correlate the scientific principles of metallurgy to the everyday technique of heat treating. In such an aim the new society should and will enjoy the undivided support of all manufacturers, metallurgists and artisans who believe in making good steel better.

The Mission Of Sir Oliver Lodge

SIR OLIVER LODGE is lecturing to capacity audiences with standing room only and applicants turned away. He has been made the subject of no little criticism from sources distinguished for scientific learning and research on the ground that he reveals nothing in physics or chemistry, hitherto unknown. Why, it is asked, does a man of his standing and achievement address himself to the elements of physics and then meander off into the imaginary field of ghosts and spooks? As a man of science, why does he not appeal to scientific men and either prove his case or quit?

We are not in sympathy with these strictures, although a diligent reading of his books and earnest attention at a number of his lectures have failed to persuade us of his conclusions. But as men of science it behooves us above all things to maintain catholic minds. We may have some curious ideas of our own perchance that would not find general acclaim if they were told to the world. Sir OLIVER is one who in the ripeness of his years has suffered a great sorrow. His investigations into psychical research had already persuaded him that communication may be held with the spirits of the dead. It seems to us a strange and unprofitable notion, but it does not seem so to him, and he is a man of great intelligence as well as a keen observer. He is entitled to his own conclusions. And he has found such comfort and solace in them that he believes others may do likewise. This is the basis of his plea.

"Our faculties," he says, "have not been developed for purposes of philosophy," and since our principal occupation is the business of living, we do not consider the ether of space. He makes a strong plea, however, for the postulate of the ether of space, and holds that without it the conductivity of light is impossible. The observation that light is affected by gravity, and is accordingly a ponderable thing, leads to the conclusion that if the ether can maintain one ponderable thing it can also maintain many others. That we have no organs to apprehend such phenomena except light and Hertzian waves does not prevent the existence of a great variety of things that may be present with us in the ether, despite all our denials. His plea is that within this medium which is to us both dark and impalpable there may exist the mystic state we know as consciousness. How consciousness can exist without all the nitrogenous paraphernalia of nerve-stuff is beyond the understanding of the writer of these lines, but Sir OLIVER'S argument is that it cannot be definitely and conclusively denied; and that is true. We know very little of consciousness anyway. Starting with this, he builds up his structure of persuasion.

Well, why shouldn't he? Science is not a close cor-

poration and its literature is not included in an *index expurgatorius*. Men of science are individuals, and they are entitled to any opinions they please to hold. Life would be dull indeed had they to march like a company of Prussian infantrymen. We have our friend Dr. JACQUES LOEB of the Rockefeller Institute, who is the protagonist of the mechanistic theory of life, and now along comes Sir OLIVER with a theory of vitalism that beats the biologists in opposition. That is as it should be. It is said of Sir OLIVER that he is a delightful companion, and we know few men indeed who are more engaging in conversation than Dr. LOEB. Both are worthy of praise for their courage to speak. Let us keep our minds open, avoid censure, and hold our hearts ever young in the hope for more light.

Reversing the In and Out Ratio of the Chemical Engineers

ABOUT twelve years ago a small group of chemical engineers held a meeting in Philadelphia and organized a society which they called the American Institute of Chemical Engineers.

In the constitution of the society they stated the objects of the organization should be:

> To advance the cause of applied chemical science.
>
> To give the profession of chemical engineering such standing before the community as will justify its recognition by municipal, state and national authorities in public works.
>
> To raise the professional standard among chemical engineers, discouraging and prohibiting unprofessional conduct.
>
> To co-operate with educational institutions for the improvement of the education of the men who are to enter this profession.
>
> To encourage original work in chemical technology.
>
> To promote pleasant acquaintance and social and professional intercourse among its members.
>
> To publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall increase industrial activity.

How well the society has succeeded in accomplishing these several purposes in their fullest measure is largely open to conjecture. In the first place the membership has been so limited by rules for qualification that there are six times as many eligible men out of the society as there are in it. The non-member engineer has felt content to stay among the "six outs," while hitherto the "one in," overcome with the honor of being "all qualified," has lost sight of the real broad purposes of the society in strengthening by uniting the chemical engineering profession and done nothing toward reversing the ratio of membership. However, it may confidently be stated that a new spirit has come into the Institute and that during the present year it is planned to start a campaign to make it as alive and representative as any of the other great American engineering societies.

To do this will not mean that high standards will of necessity be disregarded, but only that they will have to be adjusted to a practical degree. This matter will be left to the council of the society to decide on in the case of each individual application for membership nomination. As the society grows in numbers, the scope of its influence will increase. It will form a nucleus around which can be rallied the very old, widely scattered, most neglected and but recently appreciated profession of chemical engineering. The society will then take on more weight and be of a wider national importance.

What To Do With Five Million

IT IS a pleasure, indeed, to learn that the Carnegie Corporation of New York has announced its purpose to give $5,000,000 for the use of the National Academy of Sciences and the National Research Council. We take pleasure in adding our congratulations to these agencies on this deserved recognition.

The suggested plan to erect in Washington a suitable home for these organizations appeals to us as a scheme worthy of support, and we trust that this program can be carried through in the very near future. Washington is more and more coming to be recognized as a world center as well as a national center for things scientific and technical. It is the logical place for certain co-ordinating and directing agencies in this field. Our Federal Government activities there, the presence of many technical organizations and societies, and the less strenuous atmosphere of a community not so intimately associated wth industrial life, all favor clear thinking, research, and sound scientific development work.

This new recognition of Washington should augment greatly the scientific life of our national capital. Particularly we hope that this new building may be so arranged as to become the real scientific center of the city. In our opinion we should find gathered in this structure the headquarters of scientific and technical organizations which maintain Washington offices. We should find there the offices of our most prominent scientific workers of various sorts who are outside the Government, and we should hope that club facilities might also be associated with this structure, possibly even to the extent of a well-appointed structure housing one of the existing clubs such as the Cosmos Club. Anyone familiar with the great advantages in New York City of the United Engineering Societies Building and the adjoining Engineers' Club knows how splendid an opportunity it affords to technical men when this combination is properly worked out. We trust that these possibilities will be very carefully considered by the management of these agencies in Washington which have been so fortunately recognized, before the exact plans and program for their new home are formulated.

Creative Engineering And Theoretical Science

ECONOMICAL attainment, next to actual accomplishment, is the most essential requisite of engineering. Therefore the ability wisely to govern expenditures of money and materials must be possessed to a high degree by all responsible engineers. This does not mean that they should be penurious individuals, spectacled ledger column totalers or the like. They should, however, have a keen perception of the effect on their work of variations in costs with changes in design and be able to adjust their plans to approach as closely as possible the most satisfactory economic solution. In cases where many of the technical details have been established by actual performance, a mass of data compiled from practice is usually available as a guide, the proper use of which will enable any designer to locate what has previously been found faulty and make suitable amendments accordingly. Most engineering practice consists of adapting well established designs to new settings with a certain amount of fault eradication thrown in for novelty. Creative engineering, on the

other hand, must start with the formulation of an economic, scientific and technical program in combination, if the enterprise is to be assured any certainty of success.

In this issue there is offered to the reader the first of a serial of four numbers entitled "The Theoretical Study of Nitrogen Fixation by the Electric Arc." It affords an excellent example of the relation of theoretical science to creative engineering. It is to be hoped that Dr. STEINMETZ by publishing these articles is giving ideas that will shortly be converted to use not alone among those interested in nitrogen fixation by the arc, but by all investigators of problems having similar factors. At the same time, it is our thought that by reviewing such a study, any readers who are by nature not followers but leaders and developers of engineering will find pleasure in this opportunity to freshen as well as to maintain their acquaintance with the astute art involved in it.

It is to be regretted that the vast majority of our technical school and college graduates regard integral and differential calculus as a sort of mental gymnastics, which upon graduation is to be abandoned along with football, baseball and other forms of vigorous effort. Many an intending reader will find himself to be a member of this majority, and if he believes he would like to become better acquainted with the ways of our eminent contributor, he would do well to provide himself with the mathematical text books the same author has written specially for engineers and get busy! The tonic effect on his mental life would be prodigious.

New York Public Library Combines Science With Technology

THE great New York Public Library on Fifth Avenue extending from Fortieth to Forty-second Street is pretty well in the heart of things. It is not set back in an academic retreat, under shady trees, inviting only scholars to enter and browse. It is visited every day by thousands of people—from 8,000 to 10,000 in fact—and most of these visitors come with a purpose. They want to know something—and usually they want to know it right away. It is a vast storehouse of books, millions of books, periodicals, pamphlets, prints and the like, and substantially everything it contains is available on demand.

Now, leaving out medicine and biology, zoölogy and botany, which are housed in other departments, the works relating to science were divided into two sections: pure and applied, or rather, as they called it, Science and Technology. Practice shows what in all modesty we have been trying for years to preach: that science and technology may not be separated. And because they constantly overlap, the sections have been consolidated. The library authorities have long felt the need of this arrangement, and now it is practically an accomplished fact. In chemistry, for example, all material relating to the subject has been brought into one large room, whether it be in regard to pressing oil from copra or to determining atomic weights.

Of course difficulties will always present themselves, and one such had to do with the problem of treating works on electricity and on electric processes—excepting electrochemistry. These have been consolidated, under the general heading of Technology. Of course all study of electricity is not technological, but the point is they shift so fast from pure science to technology that these must be kept together. For instance, the measurement of electricity was formerly a problem of pure science, whereas now it is distinctly a technological matter.

Still another difficulty was the separation of books and periodicals relating to mining and metallurgy, on the one hand, from those on geology, on the other. They were found to interlock so closely that they were brought together in the Science room. According to the general definitions, mining and metallurgy are both technological subjects, while geology, although it is as practical and as often applied as psychology, still ranks as "pure" science. The relationships, however, of the three professions are such as to make it necessary to keep them together. In short, the titles of the three divisions of Science, Technology and Chemistry are merely names. Chemistry, with approximately 10,000 volumes, is so big that it has to be housed by itself, while Science and Technology are but traditional designations that indicate the necessary separation of a department of science into fractions of the whole that would otherwise become cumbersome on account of its size. All these divisions are completely catalogued.

The relation between physics and engineering (with the exception of the field of chemical engineering, which is included in chemistry) is not close enough for the two to be consolidated, so that mathematics and pure physics still remain in the general category of Science, while all general engineering works are included in Technology. Such subjects as Military Science and Art, Agriculture, etc., are so placed as to be in stacks convenient to the section of Technology. Indeed all of these Science sections are contiguous to one another.

Scientific periodicals to the extent of about 600 titles are shelved, and index cards are made of contents, both as to subject and author. This indexing is carried out by a system whereby the current number of each periodical is not kept away from its place for over 24 hours, and check cards provide for the prompt return of numbers in use. Generally current periodicals are checked up and indexed within one week after receipt. Check cards are also kept of all books ordered.

We cannot urge too strongly upon manufacturers whose works are under scientific control the need of a proper administration of their scientific libraries. Books are useless things unless their contents are available, and neither titles nor names of authors are adequate to point to the information that is sought and frequently furnished with all the authority and accuracy of careful compilation and printing. A library is not a rest room or a sleeping apartment, neither is it properly a conference room, although we have seen a number of technological libraries that seem to be so regarded. The management of the New York Public Library is famous for its efficiency, and Mr. GAMBLE, who has charge of the general departments of Science, Chemistry and Technology, and his assistants are always both willing and disposed to give aid to those seeking information as to good library administration.

There are people not interested in libraries; their mental horizon is bounded by what man can remember. And yet it was Professor FRIEDEL of Paris who took one of his assistants by the arm and, pointing to his books, said, "Voila, mon ami! There is all I know. Books are useful instruments, and we should use them. Why should I clog my brains with a multiplicity of detail which is all set forth and easily obtained from their printed pages? But the *general principles*, my friend, these I must ever keep alive in my mind!"

Western Chemical and Metallurgical Field

Victorville Cement Mill

THE application of electric drive in the operation of a cement mill and the advantages to be derived therefrom are unusually well exemplified in the plant of the Southwestern Portland Cement Co. at Victorville, California. The town is in the southwestern part of California, about 100 miles from Los Angeles, on the Santa Fe Railroad, the tracks of which pass by the plant, affording a convenient outlet for the finished product.

The mill has an output of 300,000 bbl. a year of portland cement, and employs approximately 80 people. All of the buildings are of substantial concrete construction, built to withstand the severe conditions imposed by the heavy cement mill machinery installed.

The system of manufacture used is known as the wet process, and water for use throughout the mill is raised to a reservoir on a hill back of the plant by a 15-hp. motor-driven triplex pump.

Rock and shale are brought to the mill from the quarry, which is located seven miles distant, by steam locomotive hauling trains of cars which have two compartments or hoppers, one of which is dumped at a time to the crusher.

Electric current is purchased from the Southern Sierras Power Co., thus relieving the company of the expense and trouble incident to the operation of a power plant. Current is received at 33,000 volts and stepped down to 440 volts, for application to the various motors installed throughout the mill.

The transformers and switching apparatus are of the outdoor type, located immediately adjacent to the mill. The current is taken from here to a seven-panel marble switchboard, from which it is distributed to the various power and lighting circuits in the mill.

The lime rock is delivered from the hopper cars direct to the crusher, but a reserve pile of crushed stone, amounting to between 3000 and 5000 tons, is maintained, sufficient to keep the mill operating for a period of approximately 30 days. This reserve is maintained in the event of an accident, such as a washout, crippling the railroad service from the quarry to the mill.

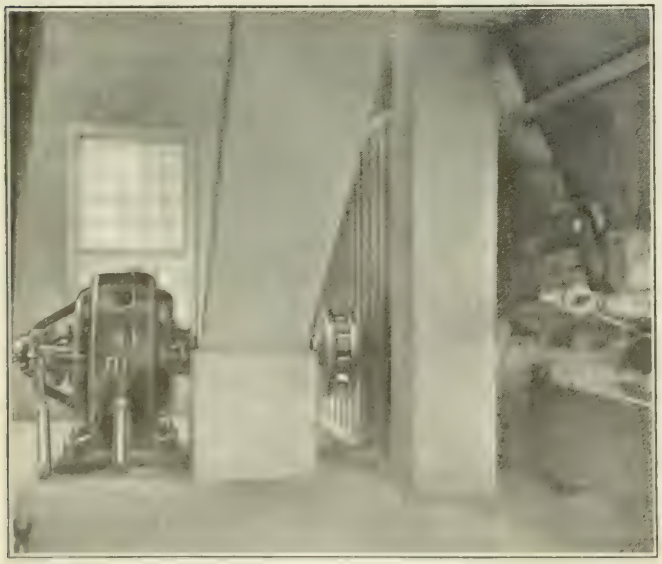


FIG. 1. 250-HP., 60-CYCLE, 700-R.P.M., 440-VOLT WESTINGHOUSE TYPE CW MOTOR DRIVING CRUSHER AND WILLIAMS MILL.

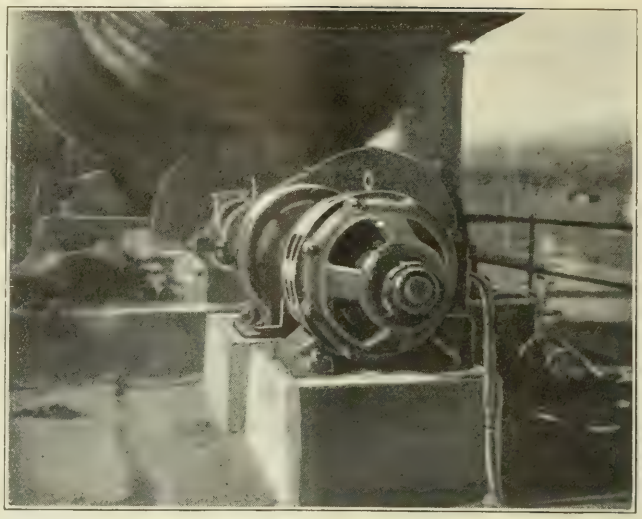


FIG. 2. 50-HP., 440-VOLT, 60-CYCLE, 3-PHASE, 700-R.P.M., MOTOR DRIVING ROTARY KILN

The crusher and Williams mill are driven by a 250-hp. Westinghouse type "CW" wound motor as is shown in Fig. 1, which breaks the rock into pieces about the side of a walnut or a little larger. From here the rock is elevated to a storage bin by a bucket elevator, driven by a 30-hp. motor, and thence by belt conveyor to the pulverizing house. Up to this time no water has been put with the rock except what is thrown on at the time it goes into the crusher, which is done with a hose to eliminate whatever dust rises at that time.

During the process of pulverization, water is added, eliminating the dust. After being thoroughly pulverized the mixture is taken to the slurry tanks, where it is kept in motion by air agitation until ready for admission to the kiln.

There are six slurry tanks, served in pairs by elevators operating at a speed of approximately 88 ft. per min., for elevating the mixture from the pulverizing house tanks. These elevators are driven by a 7½-hp. constant speed motor.

After the mixture has been thoroughly agitated it is transferred to the slurry tanks nearest the kiln. From here it flows into a sump and is delivered to the kiln by a motor-operated measuring device. The dipper is made in the shape of an "S," the outlet being in the center. By raising and lowering the dipper in the sump the amount of slurry entering the kiln can be controlled. The dipper is driven by an extended shaft, provided with two universal joints, from one of the elevators and is raised and lowered by a ¼-hp. 1725-r.p.m. motor by means of remote control from the clinker end of the kiln. A large indicator is visible to the operator at the clinker end, and he can feed the proper amount of mixture to the kiln, and control the temperature of his fire at the same time.

Fig. 3, taken from CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, p. 440, shows the general layout of the kiln building, slurry tanks and burner equipment. The rotary kiln is approximately 200 ft. long and 20 ft. in diameter, lined with firebrick and heated by an oil burner to a temperature of about 2500 deg., which is measured by a radiation pyrometer. It is driven at a speed of one revolution per minute by a 50-hp. type "CW" 700-r.p.m. motor through Foote reduction gears

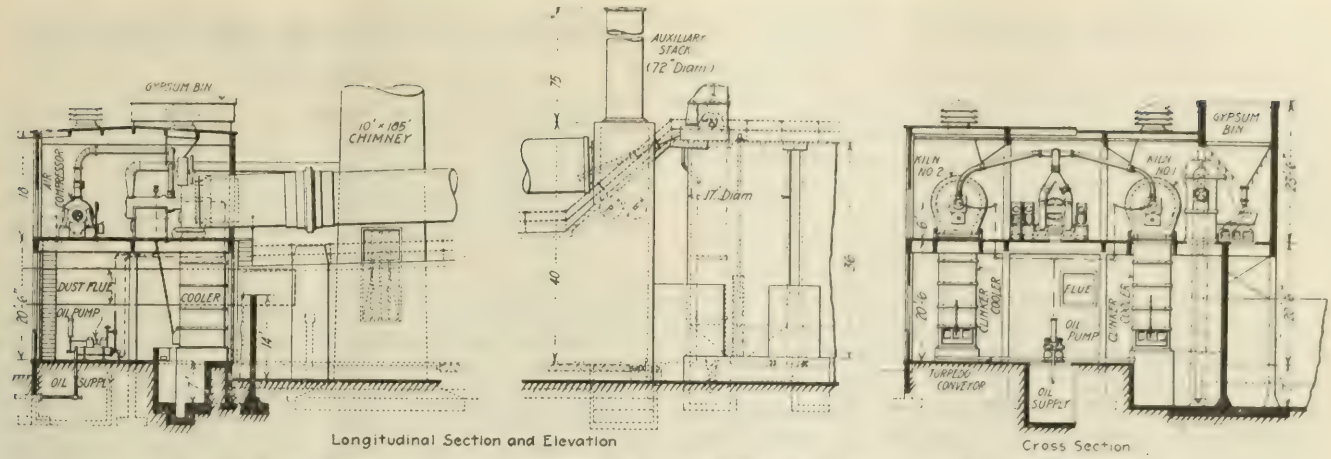


FIG. 3. LAYOUT OF KILN BUILDING, SLURRY TANKS AND BURNER EQUIPMENT

(Fig. 2). Upon coming from the kiln the clinker falls about 20 ft. into a pit to allow it to cool somewhat; it is then elevated by the clinker elevator, which is driven by the 7½-hp. 680-r.p.m. motor shown in Fig. 4 to an automatic scale and dumped into the storage bin. From the clinker storage it is transferred by means of locomotive crane with a clamshell bucket to a bin from which it is fed into a finish mill. The locomotive crane is also used for mixing the clinker, as it will vary somewhat in quality. After being ground and analyzed by the chemical laboratory, it is ready for the packing house, to which it is carried on a belt conveyor over a weighing machine, which automatically records the number of barrels that pass.

From the storage bins, the cement is taken to the sacking machines, driven by a 15-hp. motor. A sack cleaner is driven by a 7½-hp. 680-r.p.m. motor through a Foote reduction gear. A 15-hp. motor-driven blower for collecting dust from the sacking and sack cleaning machines is also used.

All motors are of Westinghouse design, alternating current, 440-volt, 60-cycle, three-phase. This plant was designed and built by Mr. L. D. Gilbert, and has been in operation over three years, during which time no shutdowns have been experienced due to any trouble with the electrical equipment. It is a model plant from every standpoint, extremely well built and practically dustless.

It is not only an excellent plant from a mechanical standpoint and an efficient producer of high grade cement, but is notable to chemists as being the location of extensive experiments on the wet-cleaning of kiln gases for the recovery of potash. This phase of their work has already been exhaustively described by their chemical engineer, J. A. Dean, in CHEMICAL & METALLURGICAL ENGINEERING for Sept. 26, 1918, vol. 19, p. 439.

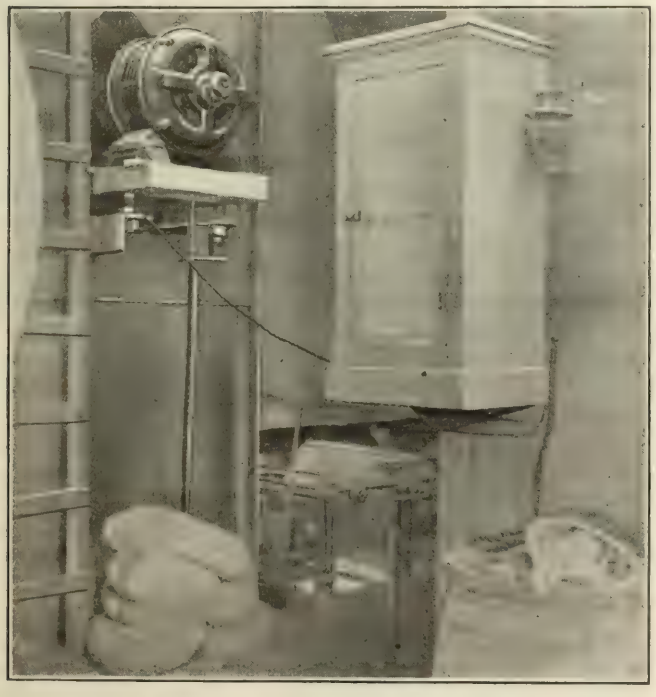


FIG. 4. 7½-HP., 680-R.P.M., 440-VOLT, 60-CYCLE, MOTOR DRIVING CLINKER ELEVATOR

Radium Minerals

Radium minerals are generally found in connection with granitic masses—that is, in places where granite forms at least part of the rock of the country. Most of the original radium minerals, such as uraninite, samarskite and brannerite, are black and have a shiny fracture and a high specific gravity. These minerals are rarely found in commercially valuable quantities. Pitchblende, which has the same composition as uraninite and the same general appearance except that it shows no crystal form, occurs in veins. It has been found in only a few places—in Bohemia, southern Saxony, Cornwall, and Gilpin County, Col. When these original minerals break down through weathering, other radium minerals are formed from them, such as autunite, torbernite, carnotite, and tyuyamunite.

Carnotite and tyuyamunite are the most abundant of these minerals and now furnish the bulk of the world's radium. They cannot be told apart by the eye, for both are of bright canary-yellow color and are powery, finely crystalline, or, rarely, claylike in texture. Carnotite is a hydrous potassium-uranium vanadate. Tyuyamunite is similar in composition but contains lime instead of potash. The greatest known deposits of these two minerals are in southwestern Colorado and southeastern Utah, where both are associated with fossil wood and other vegetation in friable, porous, fine-grained sandstone. Small quantities of carnotite have been produced near Olary, South Australia. The only other deposits that yield tyuyamunite in notable quantity are those of Tyua-Muyun, in the Andiyan district, Ferghana Government, central Asiatic Russia (Russian Turkestan), where tyuyamunite occurs with rich copper ores in a pipe in limestone.

Dye Bill Ready for Senate

THE Senate Committee on Finance has finished its consideration of the coal-tar products bill. The form in which the bill will be reported to the Senate differs materially from the third sub-committee draft, which was discussed in CHEMICAL & METALLURGICAL ENGINEERING, Feb. 11, 1920, p. 248.

REDUCTION IN TARIFF RATES

The most striking change is the reduction in the traiff rates, the rate for commodities in Group II (intermediates) having been changed from 40 to 15 per cent *ad valorem*. Finished products, Group III, were reduced from 45 to 30 per cent *ad valorem*. The special duties of 6c. per lb. for articles in Group II and 7c. per lb. for Group III have been changed to 2½c. and 5c., respectively. The latter figure also serves as a basis for computing the duties on dyestuffs which exceed the standards of strength which shall be established by the Secretary of the Treasury.

On and after the date of passage of the act, no package containing dyestuffs shall be admitted if it or the invoice bears any false or misleading statement as to the nature of the contents.

CHANGES IN DUTIABLE LIST

With the exception of natural methyl salicylate or oil of wintergreen or oil of sweet birch, and natural coumarin, the natural products mentioned in our last issue as having been removed from Group III have been retained in that group.

SUPERVISION OF IMPORTS LIMITED TO THREE YEARS

Section 504 now provides that the Tariff Commission shall regulate the importation of coal-tar products for three years.

PRACTICE AND PROCEDURE

Section 508 has been modified in accordance with Mr. Choate's suggestions and now reads as follows:

> Sec. 508. That the United States Tariff Commission, in executing the duties imposed upon it by this act, may regulate its own practice and procedure and make all rules and regulations necessary and proper for the accomplishment of the purposes of this act: Provided, That no article enumerated in Group II or Group III of section 500 of this act shall be admitted to entry or delivered from customs custody in the United States or in any of its possessions in any case where the United States Tariff Commission shall determine that the actual consumer for whose use such article is intended has received or may obtain on reasonable terms as to quality, price, and delivery, a six months' supply of such article: And provided further, That no article enumerated in Group II or Group III of section 500 of this act which may be useful both as a substitute for a domestic article and for some other purpose for which the domestic article is not adapted shall be admitted to entry or delivered from customs custody in the United States or in any of its possessions, except when the United States Tariff Commission shall determine that such article is imported for such other purpose.

PURPOSE OF THE ACT

The concluding section of the bill states: "That it is hereby expressly declared to be the intent of the Congress in enacting this act to build up, develop and protect the dyestuffs manufacturing industry in the United States and its possessions, and that each and every of the foregoing sections shall be so construed as to effectuate such intent."

American Engineering Standards Committee

AFTER almost three years of painstaking investigation and discussion by the engineering fraternity, and under the able guidance of Prof. Comfort A. Adams as chairman, the revised constitution of the American Engineering Standards Committee, along with the by-laws and rules of procedure, has been adopted, and has been ratified by the American Society of Civil Engineers, the American Institute of Mining & Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Society for Testing Materials, and the three Government Departments, Commerce, Navy and War. Each of these interests have three representatives, and although the Committee as it exists today consists of twenty-four members, the new Committee is of very wide scope and allows the direct or indirect participation of anyone interested in standardization.

A. A. Stevenson is the newly elected chairman and Dr. P. G. Agnew is now permanent secretary, with headquarters at the Engineering Societies Building, 29 West 39th St., New York City.

OBJECTS

The American Engineering Standards Committee makes it possible to give an international status to approved American engineering standards and to co-operate with similar organizations in other countries. Similar organizations are now functioning in Great Britain, France, Switzerland, Holland and Canada.

Through the new Committee the methods of arriving at engineering standards will be unified and simplified and, by co-operation, the duplication of standardization work will be prevented. Standards will not be created without giving all interested an opportunity to participate.

The American Engineering Standards Committee is not only ready for business but it has made considerable practical headway, and now that the organization of the Committee has assumed such definite and precise form, no doubt its activities will be greatly extended and accelerated.

HOW THE COMMITTEE OPERATES

Any organization may request the Committee to approve standards which it has formulated, or to approve committees that it has appointed, and by so doing becomes a sponsor society.

A standard must be referred to as that of the sponsor, using whatever title the sponsor has given it, followed by the statement: "Approved by the American Engineering Standards Committee." The approval may be given in one of three ways: "Recommended Practice," "Tentative Standard" or "American Standard."

Any standard or group of standards adopted by any organization or in process of preparation, prior to Jan. 1, 1920, may be approved by the Committee, if in the opinion of the Committee it has either been developed by a properly constituted committee, or has, by actual practice, proved its right to become a standard.

The Committee will also act as a bureau of information regarding standardization. It will collect information regarding existing standards and as to the bodies that have formulated or adopted them. This will enable it to properly give the data to those who

select a committee to formulate a new standard or revise an old one.

Provision is made for direct representation on the American Engineering Standards Committee, of additional organizations (or groups of organizations) interested in engineering standardization. Already several important additional organizations of national standing have applied for membership on the Committee.

Bureau of Mines Will Investigate Tunnel Ventilation Problems

A NUMBER of inquiries have come to the Bureau of Mines in regard to the ventilation problems arising in the construction of tunnels to be used principally by motor vehicles. It is a well-known fact that the exhaust gases from such vehicles contain varying proportions of poisonous gases, especially carbon monoxide, which has caused many cases of asphyxiation in closed garages where automobile motors have been permitted to run. It is evident, therefore, that the construction of a long tunnel such as is now being designed for automobiles under the Hudson River between New York and New Jersey presents an unprecedented problem in providing adequate ventilation to render these gases harmless.

This particular tunnel will be 8,000 ft. long, and it is estimated that 2,113 motor vehicles may pass through it in one hour. The amount of gases that will be generated by these machines will be extremely large, and there are no data available on which the exact amount can be computed, because the percentage of carbon monoxide in the exhaust from gasoline engines varies with the condition of use, the load carried, the adjustment of the carburetor and other factors. The proportion of carbon monoxide can, therefore, not be determined theoretically, and the only way to arrive at figures which may be used for a basis for ventilation designs is to make a large number of tests with various types of automobiles under the different conditions to which their use in the tunnel will be subjected.

Physiological Investigations Necessary

Another important phase of this ventilation problem is the proper amount of dilution to render these exhaust gases harmless. Physiological authorities differ on the percentage of carbon monoxide that a human being may breathe without suffering any injury. Most of the information now available has to do with the effect of small percentages of carbon monoxide on miners and other workmen. Little if any consideration has been given to the effect of this gas and other constituents of exhaust gases on persons in delicate health, or to their effect on women and children. Physiological investigations should, therefore, be made from this point of view to provide information from which a figure can be determined for the proper dilution of these poisonous gases.

It is evident that the engineering design of the tunnel and arrangements for removing the deleterious or toxic gases, and the kind of ventilating apparatus, must be correlated to the quantity of production of such gases and the physiological test results.

Other Hazards in Tunnel Construction

From past experiences in driving tunnels under the Great Lakes and elsewhere, as at Milwaukee and Cleveland, it has been found that inflammable gases have been encountered and caused in one instance a disastrous explosion, killing twenty men and injuring thirteen. Other similar tunnels for water supply are now being planned. There is need of investigating the conditions in which such gases are encountered, safe methods of elimination, and protection from ignition by electric power or other causes, and the best methods of ventilation as affected by the design of the tunnel and the appliances used.

The Bureau has been called upon by certain state commissions to determine the safety and construction of certain tunnels in quicksand or water-bearing ground, the methods of bulkheading and the need of putting in air locks to prevent inrushes, and, where such bulkheads and airlocks were used, of methods of ventilation to provide for the carrying away of inflammable and deleterious gases.

There is also a need for investigating diseases of workmen caused by the presence of other deleterious gases than carbon monoxide, or by high air pressure in tunnels and shafts under water pressure, or in sinking caissons for bridge piers and buildings, especially the caisson disease, which is attributed to high air pressure. It is expected that with a better knowledge of these diseases and their causes, means of lessening or preventing them can be developed by adoption of proper methods and appliances.

Tunnels Under Consideration

The Hudson River vehicular tunnel has been mentioned because the construction work on this tunnel is to be started soon, and there is an urgent need for information on which the ventilation design may be based. There are, however, a number of other tunnel projects in various parts of the United States, among them being a vehicular tunnel through the South Hills at Pittsburgh, Pa., which will be 6,000 ft. long. Tunnel designs are also under consideration in Boston, Mass., San Francisco, Cal., and New Orleans, La. Furthermore, the time is rapidly approaching when heavy motor truck traffic will pass under the streets of large cities; such a project is now being considered for Chicago. A system for avoiding pollution of the atmosphere in such subways is urgently needed.

From the foregoing, it will appear that the problem is one of national importance, and investigative work should be commenced immediately in order that definite information may be provided on which recommendations can be made to Federal, state and municipal officials regarding methods of ventilation, physiological effects of various tunnel gases, absorbents and protective appliances for such gases, and engineering designs, in order that the atmosphere in such tunnels, shafts and other places may be made safe and healthful, not only during the construction period, but for all time, and danger from fire and explosions may be reduced to a minimum. Accordingly, it is recommended that Congress be requested to make an appropriation of $100,000 for the purpose of undertaking the work.

The immediate need for such data is further emphasized by the fact that the report of the New York commission which is studying the Hudson River vehicular tunnel has been submitted to the Governor and the Legislature. The preliminary work will probably be started about Sept. 1. The report of Chief Engineer C. M. Holland refers to the progress of the investigations being carried out under contract by the Bureau of Mines.

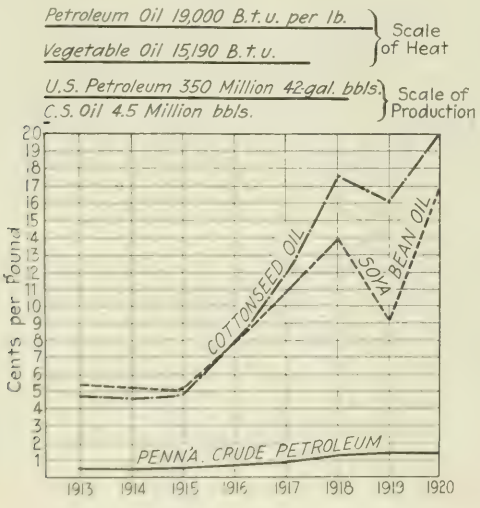
Chemical Societies Discuss Liquid Fuels

ON FRIDAY evening, Feb. 6, the New York Sections of the A. E. S., A. C. S. and S. C. I. held a joint meeting at Rumford Hall. The subject of liquid fuel was discussed. Sumner R. Church of The Barrett Co. opened the program by reviewing the various aspects of the use of coal tar for fuel. He said that some tar was being burned in open-hearth steel furnaces, especially in plants having byproduct coke oven tar available. This practice was started during the war-time fuel shortage. The sulphur content in these tars has been found to average about 0.38 per cent and they are therefore highly satisfactory for use where low-sulphur steel is required. Metallurgical coke containing less than 0.3 per cent ash, 1.0 per cent volatile and 0.11 per cent sulphur is now being made by retorting hard pitch. This coke can be used in the manufacture of high-grade electrodes. Of the tar oils, 90 per cent benzol is an important fuel, being used in making high-grade blended gasolines. As benzol freezes at 32 deg. F., it does not lend itself well for motor fuel use in the pure state. However, more than can be produced is in demand for increasing the vapor pressure of the lower cut gasolenes. Dead oil was used by the British Navy for fuel during the war. In this country it has been burned extensively for the manufacture of lampblack, but the great demand for creosotes for railroad tie, paving block and other wood preservation has made the supply of oils derived from the tar acid fractions limited.

Vegetable Oils

Dr. David Wesson next spoke on the fuel possibilities of vegetable oils. He gave comparisons between petroleum and seed oils, as follows:

The thermal values of petroleum oil and vegetable oil, the relative production of the two oils, and also the prices of cottonseed and soya bean oils for the last seven years, in comparison with the price of crude


Petroleum Oil 19,000 B.t.u. per lb.
Vegetable Oil 15,190 B.t.u.
Scale of Heat
U.S. Petroleum 350 Million 42-gal. bbls.
C.S. Oil 4.5 Million bbls.
Scale of Production
Cents per Pound
COTTONSEED OIL
SOYA BEAN OIL
PENN'A. CRUDE PETROLEUM
1913 1914 1915 1916 1917 1918 1919 1920

Pennsylvania petroleum, all in cents per pound, are clearly illustrated in the accompanying chart. As you all know, Pennsylvania petroleum is the most expensive crude petroleum in the country. One doesn't have to study the figures very long to see that the quantity of cottonseed oil produced is infinitely small as compared with the amount of petroleum oil, that it is not so good a fuel as petroleum oil, and, lastly, that it costs altogether too much money. In making up this chart, no effort has been made to show the price range of soap stocks and candle pitches, as these products, taken together, do not amount to 10 per cent of the cotton oil crop. Cotton oil pitch, as a byproduct of distillation, was at one time such a drug on the market that a large company almost made up its mind to burn it under its stills, but about that time the war started up, and it was found much better to sell it and buy fuel oil, which was then selling around 75c. per bbl. of 42 gal. This material is used mostly in making roofing and paints.

It is evident from the facts already presented that there is little chance commercially of using vegetable oils for fuel so long as there is a hungry world calling for food in the form of fat.

The best equipment to use in the combustion of cottonseed, peanut, soya bean, and cocoanut and other vegetable oils is somewhat cylindrical in shape and supported on two legs. A full description can be obtained from any book on human anatomy, and the process of operation will be found in various works on physiology, or in Lusk's classic work on the Science of Nutrition.

To show how economical this apparatus is, I have made a few calculations. If you will excuse me for mentioning such a thing as a Ford, which is generally considered a very economical car, making about eighteen miles on a gallon of gasoline, we will compare its performance with the apparatus I have just mentioned. A Ford with a man in it weighs about 1,550 lb. An average man weighs about 155 lb. To move a Ford one mile there is required $\frac{1}{3}$ lb. of gasoline, which is equivalent to 6,333 B.t.u., or 1,580 calories. A man, in walking one mile, uses up fifty-eight calories. Now, a Ford with a man in it weighs ten times as much as a man; therefore, to do the same amount of work in a Ford requires 158 calories, as against fifty-eight calories for the man. If we use cottonseed oil at the present price of 25c. a lb., it will cost 0.36c. for fifty-eight calories used in this form when fed to a man. One hundred and fifty-eight calories of gasoline fed to the Ford is equivalent to about $\frac{1}{30}$ lb. of gasoline, which, at 30c. a gal., would cost $\frac{1}{4}$c. So we see that petroleum fuel, when burned in a Ford, will do twice as much work for the same amount of money as vegetable oil when burned in a man. Chemists, during the last ten or fifteen years, have done wonderful things with vegetable oils by means of hydrogenation. Let us hope that the future may see synthetic edible fats made from petroleum oil, to help cut down the high cost of living.

Alcohol as a Motor Fuel

B. R. Tunison gave an excellent review of the motor fuel situation as a whole and then spoke on alcohol as follows:

That alcohol has real value as a motor fuel no one can deny. This has been demonstrated repeatedly in this country and abroad. That it has not been a factor in this country up to the present time has been due to an economic condition rather than to inherent difficulties in its use. Petroleum products have been so plentiful and cheap that alcohol could not compete with them. But the time is not very far distant when alcohol must become a factor as a motor fuel. That alcohol cannot meet the situation immediately is readily seen from a consideration of our present alcohol production. If all the alcohol produced last year for industrial

purposes were used for fuel, it would make available for motor purposes less than 100,000,000 gal., which represents about 2.5 per cent of our fuel requirements for 1920. However, the so-called blended alcohol fuels are of importance to us at the present time. That these fuels can compete with gasoline even now is being demonstrated by the United States Post Office Department in its airplane mail service. Its tests show a great increase in the number of miles per gal., an increase in power and a very marked saving in the quantity of lubricating oil used.

The following is an analysis of the consumption of alcohol fuel at the various speeds, the tests covering thirty-one non-stop flights between New York and Washington:

R.p.m.	Gal. per Hr.
1440 1460	15 9
1475–1480	20.1
1500	21 5
1520 1525	22.44

A comparative analysis of the fuel consumption with gasoline and alcohol fuel at different engine speeds follows:

R.p.m	1440 1460	1,475	1,500
Gasoline		24	24 17
Alcohol fuel	15 9	20 1	21.5

The following is a comparative analysis of lubricating oil consumption at different engine speeds:

R p.m	1440–1460	1,475	1,500
Gasoline		4.65	4.95
Alcohol fuel	4.5	4.2	4.2

These tests also show much less carbon formation than when using gasoline and the number of forced landings due to fouled spark plugs has been reduced to a minimum.

The U. S. Bureau of Standards has been making exhaustive tests on blended alcohol fuels, and the results of these tests are indeed indicative of the superiority of these alcohol fuels over those ordinarily obtainable. The results of these tests are available at the Bureau of Standards.

It is to be hoped that the United States Government may recognize the significance of this question and endeavor to stimulate a great increase in the production of alcohol and make possible its sale at a lower price by removing to a large extent the costly regulation of its manufacture and distribution. Alcohol should be manufactured in very large quantities and suitably denatured. Alcohol when used in blended fuels such as in admixture with petroleum distillates, benzol, etc., would naturally make a rather unsatisfactory beverage and the interests of the Government would be protected.

It is the writer's belief that this country should make a definite effort to make possible the manufacture, sale and distribution of cheap alcohol by increasing the growth of the industry so that we may benefit by the low unit cost of quantity production, by making the Internal Revenue Bureau supervisions of such a nature that the product may be handled as a cheap commodity, which it really is, instead of a $5 a gal. product as it is now being handled. The Internal Revenue Bureau is at present co-operating to a greater extent than ever before and we hope that these improvements may be made. These steps should be taken, however, before the situation becomes acute and we are forced to solve our fuel problem in the way Germany did.

It is believed that if cheap alcohol is not available the prices of the other suitable fuels will gradually rise until such times as alcohol can compete with them. Undreamed of quantities of alcohol must be produced in the future in order to protect our industries and meet the increasing demand for fuel.

Oils From Shale

Prof. Charles Baskerville closed the program with a splendid review of the possibilities of oil production from shale. He pointed out that very large-scale production would be necessary for financial success, but that a great amount of preliminary development work is now required on a small plant scale to properly test out proposed ideas of retort design and processes. He stated that shale was not a proposition for stock selling promotion schemes, will not yield quick financial returns, but if properly developed, on a conservative basis, it cannot be thought of as a gamble.

Investigation of Sulphur and Phosphorus in Steel

IT WILL be recalled that the American Society for Testing Materials, at its 1918 meeting, recognized that it would be impossible to supply the war needs of steel and yet maintain the specified sulphur and phosphorus limits because high-sulphur coal and high-phosphorus pig and scrap would necessarily have to be consumed. Consequently the limit for sulphur was horizontally raised 0.01 per cent for the period of the emergency in forty-three of its specifications, with an increase in phosphorus of a like amount for acid steels.

About a year ago the limits were again reduced in twenty-nine of these specifications, covering what might be called the special steels, such as spring steels, forging steels, and tire and wheel steels, but action on the remaining, covering tonnage materials such as rails, structural steel and plates, was deferred until 1920. It appeared essential to many parties concerned, however, systematically to procure actual data as to the effect of these elements, in addition to what was already known and published, so recommendations could be based on reliable information. Accordingly a representative committee has been appointed at the initiative of the American Society for Testing Materials, the United States Railroad Administration and the Bureau of Standards for the investigation of this important problem. Associated in the enterprise are also the Society of Automotive Engineers, Association of American Steel Manufacturers, Steel Founders Society of America, United States War and Navy Departments and Shipping Board and the National Research Council. G. K. Burgess of the Bureau of Standards is chairman and C. L. Warwick, secretary of the A.S.T.M., is secretary of the joint committee.

Organization was effected about three months ago, as noted in CHEMICAL & METALLURGICAL ENGINEERING, Nov. 5, 1919, p. 566. During this time three sub-committees have been named and have started to work. The sub-committee on statistics is headed by H. L. Whittemore, of the Bureau of Standards, and is engaged in visiting large manufacturers and users of steel, obtaining information about material high in sulphur and phosphorus which has either proved satisfactory or failed in service, and collecting samples of such material worthy of study. An investigation of the published literature is also under way.

A second sub-committee on manufacture, headed by G. K. Burgess, of the Bureau of Standards, has sub-

mitted a program of tests, and will supervise the manufacture of all metal made for this investigation. Two classes of steels will be studied—one containing moderate amounts of residual impurities, while the other will contain excessive amounts of sulphur or phosphorus added to the metal during a late stage of the manufacture. Below are the analyses to be studied in Series A.

SERIES A. RESIDUAL IMPURITIES

Group	Material	Carbon	Manganese	Phosphorus	Sulphur
1	Rivets, tubes...	0.06 to 0.12	0.35 to 0.40	0.02 to 0.03 0.04 to 0.05 0.06 to 0.07	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
2	Plates and shapes.....	0.16 to 0.22	0.35 to 0.40	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
3	Forgings.....	0.45 to 0.55	0.50 to 0.60	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
4	Rails, wheels, tires.....	0.65 to 0.75	0.60 to 0.70	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
5	Springs.....	0.95 to 1.05	0.35 to 0.45	0.02 to 0.03 0.04 to 0.05 0.06 to 0.07	0.03 to 0.04 0.05 to 0.06 0.07 to 0.08
6	Castings.....	Compositions not yet determined.			

It will be understood that when studying the effect of sulphur, the phosphorus is to be held as nearly constant as possible and equal to the usual value for that group of materials, and vice versa. Particular emphasis is placed on the requirement that sulphur (or phosphorus) in Series A shall be "residual," that is, sulphur present in the steels by virtue of its being contained in the pig, scrap, ore or fuel used. The opinion is held by many that high sulphur, for instance, is not harmful as such, but is indicative of other undesirable conditions in the steel, inherent in the various stages of manufacture, and that these undesirable conditions do not necessarily accompany high sulphur when the latter is obtained by addition in the ladle or mold. Thus, Unger* made a series of high-sulphur steels from three normal open-hearth heats by adding sulphide during ingot pouring, yet metal containing as high as 0.23 per cent sulphur did not exhibit any expected trouble in rolling due to hot-shortness, while the static properties suffered but slightly. Another similar series of tests on phosphorus was reported by him to the American Iron and Steel Institute in 1918. Both acid and basic open-hearth metal containing up to 0.115 per cent phosphorus gave practically the same tension tests as low-phosphorus material tested transversely to the direction of rolling, while vibratory and impact tests did not fall off as might be expected. In steels of Series B it is realized that very high sulphur probably could not be obtained without additions of extraneous sulphur-bearing material, but these will be added before reaching the mold in order not to duplicate Unger's work.

It has been decided to concentrate upon the sulphur problem first, since it presents the most urgent economic problem. The committee on manufacture has therefore supervised the manufacture of a considerable quantity of rivet steel, and will select such material as is approximately uniform in carbon, manganese and phosphorus, with sulphur varying from 0.03 to 0.08 per cent. About a ton of material of each analysis will be obtained, of which one-half will be used in testing, and the other reserved for future use.

A beginning has also been made in Series B by arranging with a large steel company for the manufacture of three heats of steel, covering groups 2, 3 and 4, from each of which eight ingots will be poured to obtain sulphur content from 0.04 up to 0.15 per cent by the addition of sulphur or pyrite in the pouring box. The upper limits are never likely to be approached in ordinary practice, but should be prosecuted to a point where the material will unquestionably fail from the effect of high impurities.

The committee on tests, headed by F. C. Langenberg, of the Watertown Arsenal, will supervise the mechanical testing. In addition to the usual standard tests of the A.S.T.M. special proof- and service-tests will be made, including, where possible, those for impact and endurance. An endeavor will also be made to determine the amount and types of gases present. The metals under investigation will be also put through fabrication processes and observed under normal service, which should give information essential to the proper interpretation of laboratory work. Under fabrication tests for the soft steel, first to be experimented upon are included such operations as flanging, punching, drifting, cold pressing and riveting. Service tests will also comprise a detailed study of such metal of abnormal analysis whose history can be definitely determined, and which has been discarded through failure or wear.

Much interest has been manifested in this investigation, which is probably unique in being the first concerted effort on the part of interested organizations to make a thorough study of a research problem of considerable magnitude. Manufacturers in particular are volunteering to furnish at their own expense the materials desired. Testing will be done by governmental laboratories, and those of large consumers, such as railroads, so there is no reason to believe that a special fund will have to be raised to defray the expenses.

Iron Age, vol. 97, p. 146.

Aluminum as an Engineering Material

At a joint meeting of the New York Section of the American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and the Society of Automotive Engineers, held Feb. 10, 1920, the subject of aluminum as an engineering material was presented by a number of speakers.

The subject was not treated as a symposium on aluminum, but by independent outlines, mainly on the characteristics of the aluminum metal, its alloys and their applications, and on aluminum die castings. Graphs and micrographs were presented to show the characteristics of the different alloys, especially Al-Cu, Al-Zn, Al-Fe.

It was developed in the meeting that in the United States practically all the light alloys are aluminum-copper, whereas in Great Britain and other European countries the alloys Al-Zn predominate. This is due in part to the scant information available in America on the Al-Zn alloys. The New Jersey Zinc Co. is now doing quite extensive research work on the properties of Al-Zn alloys, and it might be expected that the results will determine whether the use of aluminum-zinc alloys will be pushed in American markets.

Aluminum die casting offers a series of difficulties, but judging from the increased number and varieties of castings produced recently it can be seen that many troubles have been overcome; it is possible now to make about 150,000 castings with a single die.

Production of aluminum is increasing rapidly and enthusiasts are prophesying that by 1930 aluminum production will equal, if not surpass, that of copper.

Theoretical Study of Nitrogen Fixation by the Electric Arc—I

Chemical Dynamics of the Nitrogen-Oxygen Reactions at the Temperatures of the Arc and During Cooling—Equations of Reaction Velocity and Temperature Equilibrium—Tables of Thermal Nitrification Constants, Reaction Periods and Velocities in Air

By CHARLES P. STEINMETZ

THE national importance of the nitrogen fixation problem consists in the rapidly increasing demand for nitrogen fertilizers to maintain our agricultural productiveness, as the result of the enormous and increasing losses of nitrogen compounds by wastage and dissociation, which is not sufficiently compensated for by the action of the nitrifying bacteria, and the enormous amount of nitric acid required for our national defense in war emergencies, in the manufacture of high explosives.

The arc process of nitrification directly produces nitric acid, while all other processes, chemical and by-product, produce ammonia, and in a sudden emergency the former could therefore be immediately deflected to war purposes, while with the latter processes a new industry will have to be created under the war emergency, the oxidation of the ammonia produced by the fertilizer industry of peace to the nitric acid required by the manufacture of high explosives.

The arc process requires practically nothing but air, water, and electric power as raw materials; but thus far its power consumption is much higher than that of the other processes, and its industrial economy therefore still questionable. On the other hand, apparently so very little broad and general study of the arc process and its underlying phenomena, such as the characteristics of the electric arc, has been done, and there are still so many possibilities in this field that an extensive theoretical and experimental study of the problem of electric arc nitrification appears desirable.

Commercial Developments

The first industrial work[1] was done by Bradley and Lovejoy on nitrogen fixation by the electric arc. After a thorough study of the conditions of nitrification by the electric arc, a plant for the production of nitric acid from the air was established at Niagara Falls. In this plant a very large number of low-current high-voltage transient arcs was used; the efficiency was good, but the cost of installation was high. Probably for this reason, and also due to the low price of Chilean nitrate at that time, the plant was not a commercial success, and had to be abandoned.

The method using a single high-power alternating current arc was developed by Birkland-Eyde. The installation made in Norway was commercially successful, has been greatly enlarged since, and a number of other arc nitrification plants have been built, using the Birkland-Eyde process or modifications thereof. Little further study seems to have been done on the arc nitrification problem in its broadest aspect, but the work chiefly consisted in developing different forms of arc furnaces, such as the Schoenherr furnace, etc., all of which, however, comprise the same principle as the Birkland-Eyde furnace, that is, a high-power, high-voltage alternating current arc moving rapidly with regard to the air acted upon by the arc. The differences between the various arc nitrifying furnaces consist chiefly in the means of producing the relative motion between arc and air: by a magnetic field, by a spiral air blast, by the heat of the arc, by a three-phase arrangement, etc.

Various other solutions of the nitrification problem have since been found and by-product coke, cyanamide and Haber processes have come into extensive industrial use, while others appear promising.

The nitrogen fixed by prehistoric plant life is recovered in the form of ammonia as by-product from coke ovens and gas works. This is now the foremost source of the ammonia supply. It is capable of enormous extension, but, due to the nature of a by-product, is not entirely unlimited.

The cyanamide process is based on the reactions:

$$CaO + 3C = CaC_2 + 3CO$$

$$CaC_2 + N_2 = CaN_2C + C$$

$$CaN_2C + 3H_2O = CaO + CO_2 + 2NH_3$$

The process is partly electrical, as the first step, the formation of calcium carbide, is carried out in the electric furnace. The electric power required for this part of the process is, however, relatively small, only about one-third to one-quarter that required by the Birkland-Eyde process of arc nitrification. It is extensively used industrially.

The Haber process of synthetic ammonia is based on the reaction:

$$N_2 + 3H_2 = 2NH_3$$

As the reaction occurs under condensation, high pressure and low temperature are favorable, but as the reaction velocity decreases with decrease of temperature, a moderate, compromise temperature, the use of a catalyzer and the highest mechanically permissible pressures are employed. This process is reported to be industrially and commercially successful in Germany.

Various other fixation precesses, as cyanide, nitride, etc., have been more or less developed.

It is interesting to note that in all fixation or recovery processes, except the arc process, ammonia is the resulting product, and to convert this into nitric acid the additional process of oxidation is required

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

and the further conversion of the NO into NO_3H in the same manner as in the arc process.

The oxidation of ammonia occurs under the influence of a catalyst, but unless the ammonia is very pure, as

[1] "Nitrogen Fixation Furnaces," Chem. & Met. Eng., vol. 19, pp. 710-715 and 757-761.

that of the Haber process, electric heating of the catalyzer seems to be necessary to retard its poisoning by the impurities of the ammonia.

Nitrogen Fixation by the Arc

The method of nitrogen fixation by the electric arc differs from all other methods in that it requires as raw materials nothing but electric power and air and water (and some alkaline material, as soda ash, limestone, dolomite, or magnesite, if alkaline absorption is used). It is the only method which produces nitric acid directly and not through intermediary products as ammonia, calcium cyanamide, carbide, etc. It has, however, the disadvantage or requiring more electric energy per ton of fixed nitrogen, and thus far a higher plant investment than the purely chemical processes.

The reactions involved in the nitrogen fixation by the arc are:

In the arc:

$$N_2 + O_2 = 2NO \qquad (1)$$

In the cooling gas stream:

$$2NO + O_2 = 2NO_2 \qquad (2)$$

In absorption:

$$2NO_2 + H_2O = NO_3H + NO_2H \qquad (3)$$

Then, as secondary reaction:

$$2NO_2H = NO + NO_2 + H_2O \qquad (4)$$

and NO and NO_2 are again converted by equations (1) and (2), so that the final result is:

$$2N_2 + 5O_2 + 2H_2O = 4NO_3H \qquad (5)$$

Energy Required and Efficiency Obtained

The equation (1) requires per gram molecule of NO:

$Q = 21{,}600$ cal. $= 91.8$ kj. (kilo-joule) of energy.

All the other reactions set energy free. Thus the total resultant reaction, (5), *sets free*, per gram molecule of NO_3H

$$Q = 7330 \text{ cal.} = 31.2 \text{ kj.}$$

According hereto, 1 kw.-hr. should produce $3600 \div 91.8 = 39.2$ g. mol. NO, giving $39.2 \times 63 = 2470$ g. NO_3H, and thereby give back 1.34 kj. as heat energy.

An industrial output of 660 kg. of NO_3H per kw.-yr., or 75 g. per kw.-hr., which seems to be a good average efficiency of the big arc process nitrate plants, thus would represent, referred to equation (1), an efficiency of about 3 per cent, while, referred to the reaction (5), the efficiency obviously is negative.

If, however, we include, in the energy required for arc nitrification, the heat energy necessary to raise the gases to the arc temperature, and assume an average specific heat of air of 0.25, and an arc temperature of 3300 deg. abs., at an NO concentration of 4.35 per cent in the arc, an additional expenditure of energy, per g.-mol., would be required, of

$$500{,}000 \text{ cal.} = 2120 \text{ kj.}$$

One kw.-hr. thus would theoretically give only 103 g. NO_3H, and the commercial output of 75 g. per kw.-hr. thus would represent an efficiency of 73 per cent.

If the heating of the air occurs at constant volume, about 25 per cent less energy would be required, giving 136 g. per kw.-hr. With arcs very quickly started and moving, probably the heating occurs between constant pressure and constant volume conditions.

Furthermore, more or less of the temperature rise of the gases could, at least theoretically, be given by regeneration.

However, the heat energy required to raise the gases to the arc temperature depends on the arc temperature, which, at least theoretically, is not a fixed invariable quantity, and on the concentration in the arc stream, so that such efficiency calculations appear of little practical value and meaning.

Scientific Study Required

It may be of interest, therefore, to study further the theoretical side of the arc nitrification problem.

As I have been interested in the problem for many years, theoretically and experimentally, such a study was undertaken. Two considerations contributed.

During the late war practically unlimited means was available to create a nitrification industry in our country, producing nitric acid for the manufacture of high explosives. Nevertheless, when the armistice was signed after a year and a half of war, I believe not a single ton of nitric acid had been produced synthetically, showing the enormous difficulty of creating a new industry rapidly on the gigantic scale required for high explosives in modern war. If it thus had been a war of defense against invasion, and the supply of Chilean nitrate had been cut off by an enemy controlling the ocean, we would have been practically defenseless. The existence of a powerful nitrification industry in peace times, which may be deflected to war uses in emergency, thus is essential for our national safety. The only demand large enough to support such an industry in peace time is that for fertilizer. However, ammonia can be used directly as fertilizer. Thus the oxidation of ammonia to nitric acid would not be required by the peace requirements, and this essential step in the war industry would remain undeveloped. Therefore the arc method of nitrification would be safer for this purpose, as its product, nitric acid, is directly applicable to the high explosive manufacture

Furthermore, when looking into the problem of arc nitrification, it appeared that since the days of Koenig and Bradley very little general investigating has been done, and the development has all been in one direction, the use of high-power alternating arcs. Even the most fundamental data on arcs, and particularly the transient arcs used in nitrification, are very little known and uncertain, and it appears that the possibilities of development are much greater with the arc process than with any other nitrification process.

Reaction Velocity and Temperature Equilibrium

Starting with the meager available data, the reaction velocities, reaction time and thermal equilibrium conditions among oxygen, nitrogen and nitric oxide will be taken up; that is, the nitrifying action of the electric arc in air is considered and investigated as a thermal phenomenon.

The nitric oxide equilibrium concentration in air is extremely small, except at very high temperatures, and at the latter, the reaction velocity, and more particularly the dissociation velocity, is so enormous that it appears impossible to save any appreciable part of the nitric oxide from dissociation during the period of cooling, unless an extremely rapid cooling can be resorted to. The problem of thermal nitrogen fixation thus is essentially that of rapid cooling of the reacting gases.

With a given rate of cooling, or given cooling law, the maximum possible residual nitric oxide concentration, that is, the highest nitric oxide concentration in the air passing through the arc which can be saved, is limited to definite and not very high values, irrespective

of the reacting temperature in the arc, and irrespective thus of the initial nitric oxide concentration, provided the reaction temperature is higher than the equilibrium temperature of the residual concentration. Any material increase of the reaction temperature beyond the equilibrium temperature of the residual concentration possible by the cooling law thus offers no advantage, but is a waste of energy and thus of efficiency.

In the following some theoretical considerations on the arc process of nitrification are given. To a considerable extent obviously they must be of the nature of a review and very general.

In 1 g.-mol. of air, let the mol. fractions of nitrogen be n; oxygen, o; nitrogen oxides, a; and inert gas such as argon, b. Thus

$$n + o + a + b = 1 \qquad (6)$$

The normal composition of atmospheric air is $n = 0.777$; $o = 0.210$; $a = 0.000$; $b = 0.013$; so that the weight of a g.-mol. can be readily calculated from the molecular weights as follows:

Nitrogen	$= nN_2 = 0.777 \times 28 =$	21.76 g. per g. - mol. air
Oxygen	$= oO_2 = 0.210 \times 32 =$	6.72 g. per g. - mol. air
Argon	$= bAr = 0.013 \times 40 =$	0.52 g. per g. - mol. air
Air	$=$	29.00 g. per g. = mol. air

The volume of the g.-mol. then is, assumed as ideal gas, by $pV = RT$, in which atmospheric pressures, centimeters volume and Centigrade absolute temperatures are used.

$$V = \frac{RT}{p} = \frac{82 \times 273}{1} = 22{,}400 \text{ cc. (29 g. air)}$$

In the case of exhaust gases from an arc nitrogen fixation furnace having about 2 per cent nitric oxide content, the weight of a g.-mol. is as follows:

Nitrogen	$= 0.767 \times 28 =$	21.48 g.
Oxygen	$= 0.200 \times 32 =$	6.40 g.
Nitric oxide	$= 0.020 \times 30 =$	0.60 g.
Argon	$= 0.013 \times 40 =$	0.52 g.
Arced air	$=$	29.00 g.

Reaction Velocities

The velocity of combination of nitrogen and oxygen to NO may be expressed:

$$v_1 = c_1 no \qquad (7)$$

where the formation velocity constant c_1 is a function of the absolute temperature T of the reaction.

The velocity of dissociation of NO is similarly expressed:

$$v_2 = c_2 a^2 \qquad (8)$$

where the dissociation velocity constant c_2 is likewise a function of the absolute temperature T.

The rate of increase of NO is the resultant between v_1 and v_2 and is expressed

$$v = \frac{da}{dt} = v_1 - v_2 = c_1 no - c_2 a^2 \qquad (9)$$

In these equations there are three variables, n, o and a. It is frequently more convenient to denote

n_o = initial nitrogen concentration = 0.777

o_o = initial oxygen concentration = 0.210

and as

$$n = n_o - \frac{a}{2}$$

$$o = o_o - \frac{a}{2} \qquad (10)$$

the equations can be reduced to the single variable a,

$$v_1 = c_1 \left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right) \qquad (11)$$

$$v = c_1 \left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right) - c_2 a^2 \qquad (12)$$

Equilibrium Constants

When the rates of dissociation and combination are equal, equilibrium is reached.

$$v = c_1 no - c_2 a^2 = 0$$

$$C = \frac{c_1}{c_2} = \frac{a^2}{no} = \frac{a^2}{\left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right)} \qquad (13)$$

or, more conveniently,

$$\frac{\sqrt{C}}{\sqrt{no}} = \frac{a}{\sqrt{\left(n_o - \frac{a}{2}\right)\left(o_o - \frac{a}{2}\right)}} \qquad (14)$$

The equilibrium constant C is a function of the absolute temperature T.

C, c_1 and c_2 are the equilibrium and reaction velocity constants denoted by K and k_1 and k_2 by Nernst and others, but reduced to the second as unit of time, as the second has since become the absolute time unit, while k, etc. is usually given with the minute as time unit. Thus, $C = K$, but $c = \frac{1}{60} k$. Compared with c_2, c_1 is a small quantity, the more so the lower the temperature.

The equilibrium constant C is given by van't Hoff's equation:

$$\frac{d \log_e C}{dT} = \frac{Q}{RT^2} \qquad (15)$$

where the heat of formation of NO, Q, = — 21,600 cal. Q is claimed to be independent of the temperature and the integration of equation (15) is

$$\log_e C_2 - \log_e C_1 = \frac{Q}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) = \frac{Q}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right) \qquad (16)$$

$$C_1 = C_2 e^{\frac{Q}{R}\left(\frac{T_1 - T_2}{T_1 T_2}\right)} \qquad (17)$$

From (16) substituting 21,600 for $\frac{Q}{R}$

$$\log_e C_1 = \log_e C_2 + \frac{21{,}600}{T_2} - \frac{21{,}600}{T_1} \qquad (18)$$

$$\log_{10} C_1 = \log_{10} C_2 + \frac{9380}{T_2} - \frac{9380}{T_1} \qquad (19)$$

As the average of the three determinations of Nernst gives

$$\log_{10} C = 1.048 - \frac{9380}{T} \qquad (20)$$

$$\log_e C = 2.413 - \frac{21{,}600}{T}$$

$$C = 11.17 e^{-\frac{21{,}600}{T}} \qquad (21)$$

From equation (14) then follows the equilibrium concentration

$$\sqrt{C} = \frac{a_o}{\left(n_o - \frac{a_o}{2}\right)\left(o_o - \frac{a_o}{2}\right)} = 3.34 e^{-\frac{10{,}800}{T}} \qquad (22)$$

Dr. Noyes gives $\log_{10} C = 1.091 - \frac{9426}{T}$. At 2000 deg. abs. this gives a difference of 8 deg. The values of a differ slightly from those given elsewhere, as in the latter the composition of air is approximated by $n_2 : o_2 = 80 : 20$ and equation (22) approximated by $\sqrt{C} = \frac{a_o}{n_o o_o}$

From Jellinek's data is calculated, by the $\Sigma\ \Delta$ method[2], the empirical equation of the dissociation velocity constant[3]:

$$\log_{10} C_2 = \bar{9}.113 + 5.731\ T\ 10^{-3} \qquad (23)$$

$$c_2 = 12.97e^{.0132\ T} \times 10^{-12} \qquad (24)$$

From (13) follows:

$$\log_{10} c_1 = \log_{10} C + \log_{10} c_2$$

thus substituting (20) and (23)

$$\log_{10} c_1 = 0.161 + 5.731\ T \times 10^{-3} - \frac{9380}{T} \qquad (25)$$

The equation $\log_{10} C = 0.814 - \frac{9460}{T}$, suggested by A. Wolokitin from hydrogen combustion, is hardly acceptable.

In Table I are given, for temperatures from 800 to 4200 deg. abs., the values of $\log_{10} C$, $\log_{10} c_1$, $\log_{10} c_2$, $\sqrt{C}$ c_2, c_1 and a_o calculated by the equations (20), (23), (25) and (22) for air with the composition, N : O : A = 0.777 : 0.210 : 0.013. In Fig. 1, the first four of these values are plotted.

If n, o, a, are the initial concentrations per g.-mol. at time t = zero, at constant temperature T, of N_2, O_2 and NO, differing from their equilibrium values, and n_o, o_o, a_o are these equilibrium values, and if at time t the NO concentration has increased by x (where x is negative, if $a > a_o$), the N_2 and O_2 concentrations have decreased to $\left(n - \frac{x}{2}\right)$ and $\left(o - \frac{x}{2}\right)$ respectively, when

$$\frac{dx}{dt} = c_1 \left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2\ (a + x)^2 \qquad (26)$$

[2]See "Engineering Mathematics," by author.

[3]From the same data Dr. Noyes calculates the equation (reduced to seconds):

$$\log_{10} c_2 = 9.253 + 5.635T$$

This gives a difference at 2000 deg. abs. of 9 deg.

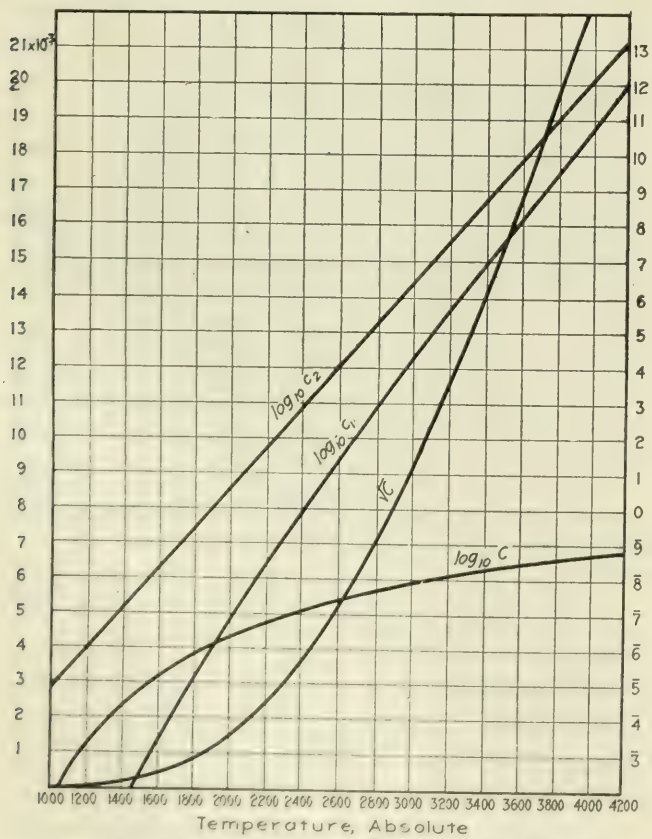


FIG. 1. THERMAL NITRIFICATION CONSTANTS

TABLE I. THERMAL NITRIFICATION CONSTANTS

Air: $N_2 = 0.777$; $O_2 = 0.210$; Neutrals = 0.013

T Deg. Abs.	$\log_{10} C$	$\log_{10} c_2$	$\log_{10} c_1$	$\sqrt{C}$ $10^{-3}\times$	c_2	c_1	a_o|% Ai
800	$\bar{9}.323$	$\bar{3}.698$	$\bar{3}.021$	0.00458	4.99×10^{-7}	1.05×10^{-17}	0.0002
900	$\bar{0}.626$	$\bar{4}.271$	$\bar{4}.897$	0.0206	1.87×10^{-6}	7.89×10^{-16}	0.0008
1000	$\bar{1}.668$	$\bar{4}.844$	$\bar{6}.512$	0.0682	6.98×10^{-6}	3.25×10^{-14}	0.003
1100	$\bar{2}.521$	$\bar{5}.417$	$\bar{7}.938$	0.182	2.61×10^{-5}	8.67×10^{-13}	0.007
1200	$\bar{3}.231$	$\bar{5}.990$	$\bar{9}.221$	0.412	9.77×10^{-5}	1.66×10^{-11}	0.017
1300	$\bar{3}.833$	$\bar{6}.563$	$\bar{0}.396$	0.824	3.66×10^{-4}	2.49×10^{-10}	0.033
1400	$\bar{4}.348$	$\bar{7}.136$	$\bar{1}.484$	1.49	1.37×10^{-3}	3.05×10^{-9}	0.06
1500	$\bar{4}.795$	$\bar{7}.709$	$\bar{2}.504$	2.50	5.12×10^{-3}	3.19×10^{-8}	0.10
1600	$\bar{5}.186$	$\bar{8}.282$	$\bar{3}.468$	3.92	1.91×10^{-2}	2.94×10^{-7}	0.16
1700	$\bar{5}.530$	$\bar{8}.855$	$\bar{4}.385$	5.82	7.17×10^{-2}	2.43×10^{-6}	0.23
1800	$\bar{5}.837$	$\bar{9}.428$	$\bar{5}.265$	8.28	2.68×10^{-1}	1.84×10^{-5}	0.33
1900	$\bar{6}.111$	0.001	$\bar{6}.112$	11.35	1.002	1.29×10^{-4}	0.46
2000	$\bar{6}.358$	0.575	$\bar{6}.933$	15.1	3.76	8.57×10^{-4}	0.61
2100	$\bar{6}.581$	1.148	$\bar{7}.729$	19.5	1.41×10^{1}	5.36×10^{-3}	0.78
2200	$\bar{6}.785$	1.721	$\bar{8}.506$	24.7	5.26×10^{1}	3.21×10^{-2}	0.98
2300	$\bar{6}.970$	2.294	$\bar{9}.264$	30.5	1.97×10^{2}	1.84×10^{-1}	1.21
2400	$\bar{7}.140$	2.867	0.007	37.2	7.36×10^{2}	1.016	1.47
2500	$\bar{7}.296$	3.440	0.736	44.5	2.75×10^{3}	5.44	1.75
2600	$\bar{7}.441$	4.013	1.454	52.5	1.03×10^{4}	2.84×10^{1}	2.05
2700	$\bar{7}.574$	4.586	2.160	61.2	3.85×10^{4}	1.44×10^{2}	2.43
2800	$\bar{7}.698$	5.159	2.857	70.6	1.44×10^{5}	7.20×10^{2}	2.8
2900	$\bar{7}.814$	5.732	3.546	80.7	5.40×10^{5}	3.52×10^{3}	3.15
3000	$\bar{7}.922$	6.306	4.228	91.4	2.03×10^{6}	1.69×10^{4}	3.54
3100	$\bar{8}.022$	6.879	4.901	102.6	7.57×10^{6}	7.96×10^{4}	3.93
3200	$\bar{8}.117$	7.452	5.569	114.4	2.83×10^{7}	3.71×10^{5}	4.35
3300	$\bar{8}.206$	8.025	6.231	126.8	1.06×10^{8}	1.70×10^{6}	4.8
3400	$\bar{8}.291$	8.598	6.889	139.8	3.96×10^{8}	7.75×10^{6}	5.25
3500	$\bar{8}.368$	9.171	7.539	152.8	1.48×10^{9}	3.46×10^{7}	5.7
3600	$\bar{8}.443$	9.744	8.187	166.5	5.55×10^{9}	1.54×10^{8}	6.15
3700	$\bar{8}.513$	10.317	8.830	180.5	2.07×10^{10}	6.76×10^{8}	6.6
3800	$\bar{8}.580$	10.890	9.470	195	7.76×10^{10}	2.95×10^{9}	7.05
3900	$\bar{8}.643$	11.463	10.106	210	2.90×10^{11}	1.28×10^{10}	7.5
4000	$\bar{8}.703$	12.037	10.740	225	1.09×10^{12}	5.50×10^{10}	7.95
4100	$\bar{8}.760$	12.610	11.370	240	4.07×10^{12}	2.34×10^{11}	8.4
4200	$\bar{8}.815$	13.183	11.998	255	1.52×10^{13}	9.95×10^{11}	8.9
∞	1.048	∞	∞	3340	∞	∞	37.6

Rearranged this equation gives:

$$\frac{dx}{dt} = (c_1 no - c_2 a^2) - 2x\left[c_2 a + \frac{c_1}{4}(n + o)\right] - \left(c_2 - \frac{c_1}{4}\right)x^2$$

or:

$$dt = \frac{-dx}{\left(c_2 - \frac{c_1}{4}\right)\left[x^2 + 2x\,\frac{c_2 a + \frac{c_1}{4}(n - o)}{c_2 - \frac{c_1}{4}} - \frac{c_1 no - c_2 a^2}{c_2 - \frac{c_1}{4}}\right]}$$

$$= \frac{-dx}{\left(c_2 - \frac{c_1}{4}\right)(x - x_1)(x - x_2)}$$

where x_1 and x_2 are the roots of the equation:

$$x^2 + 2x\,\frac{c_2 a + \frac{c_1}{4}(n + o)}{c_2 - \frac{c_1}{4}} - \frac{c_1 no - c_2 a^2}{c_2 - \frac{c_1}{4}} = o \qquad (27)$$

and are:

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \frac{-1}{c_2 - \frac{c_1}{4}}\left[c_2 a + \frac{c_1}{4}(n + o) \pm S\right] \qquad (28)$$

where:

$$S = \sqrt{\frac{c_1}{4} c_2\, 4no + 2a(n + o) + a^2 + \frac{c_1}{4}(n - o)^2} \qquad (29)$$

thus:

$$dt = \frac{-dx}{\left(c_2 - \frac{c_1}{4}\right)(x_1 - x_2)}\left[\frac{1}{x - x_1} - \frac{1}{x - x_2}\right] \qquad (30)$$

and:

$$t = \frac{1}{\left(c_2 - \frac{c_1}{4}\right)(x_1 - x_2)} \log_e \frac{x_1\,(x - x_2)}{x_2\,(x - x_1)} \qquad (31)$$

and, by (29):

$$t = \frac{1}{2S} \log_e \frac{x_1\,(x - x_2)}{x_2\,(x - x_1)} \qquad (32)$$

is the *reaction time*, that is, the time required to change the NO concentration by x, or from a to $a + x$.

Special Cases

Dissociation of pure NO to half of its value:

$$n = 0;\ o = 0;\ a = 1;\ x = -0.5 \qquad (33)$$

For convenience, reversing the sign of x in equations (26) to (32).

In substituting (33) in (26) to (32), and neglecting c_1 compared with c_2, as a small quantity:

$$S = 0.5\sqrt{c_1 c_2}$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = +\left(1 \pm 0.5\sqrt{\frac{c_1}{c_2}}\right)$$

$$t = \frac{1}{\sqrt{c_1 c_2}} \log_e \frac{1 - x + 0.5\,x\sqrt{\frac{c_1}{c_2}}}{1 - x - 0.5\,x\sqrt{\frac{c_1}{c_2}}}$$

$$= \frac{1}{\sqrt{c_1 c_2}} \log_e \frac{1 + \frac{0.5\,x}{1-x}\sqrt{\frac{c_1}{c_2}}}{1 - \frac{0.5\,x}{1-x}\sqrt{\frac{c_1}{c_2}}}$$

and, since $\frac{c_1}{c_2}$ is a small quantity (Engineering Mathematics), the $\log_e$ becomes:

$$\frac{x}{1-x}\sqrt{\frac{c_2}{c_1}}$$

thus:

$$t = \frac{x}{(1-x)c_2} \qquad (34)$$

and for: $x = 0.5$

$$t_2 = \frac{1}{c_2} \qquad (35)$$

or:

$$c_2 = \frac{1}{t_2} \qquad (36)$$

TABLE II. THERMAL REACTION TIMES

T_1 Deg. Abs.	t_2 Dissociation Time of NO to half value		t_1 Formation Time of Air to half equilibr.		t_3 Dissociation Time Air, 200 Deg. Drop	
	Seconds	Hours	Years	Hours	Years	Hours
800	.....	557	18,800	....	1,670	....
1,000	.....	39.7	114	....	18.7	164,000
1,200	10,200	2.83	1.06	9,360	0.30	2,630
1,400	730	0.203	0.0511	185	Seconds	58
1,600	52.4	....	Seconds	5.06	5,500	1.53
1,800	3.73	....	622	0.173	182	0.0505
2,000	0.266	....	24.9	....	6.3	....
2,200	0.019	....	1.05	....	0.258	....
2,400	1,360 micro sec.		0.0497	....	0.0110	....
2,600	97.1		2,510 micro sec.	...	537 micro sec.	
2,800	6.94		134		23.0	
3,000	0.493		7.35		1.17	
3,200	0.0353	....	0.420	....	0.0632	....
3,400	2,520 micro sec.	....	0.0245	....	3,230 micro sec.	
3,600	180	....	1,470 micro sec.	...	175	
3,800	12.9	....	89.7	....	9.75	....
4,000	0.917	....	5.56	....	0.58	....
4,200	0.0658	....	0.349	....	....	....

This permits to determine c_2 from the reaction time t_2.

Nitrification of Air to half the equilibrium value:

$$n = 0.777;\ o = 0.21;\ a = 0;\ x = \frac{a_o}{2} \qquad (37)$$

Substituting (37) into (26) to (32), neglecting c_1 compared with c_2, and also neglecting $\frac{x}{2}$ compared with n and o, it is:

$$S = \sqrt{c_1 c_2 n o}$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \pm\frac{1}{c_2} S = \pm\sqrt{\frac{c_1}{c_2}}\, no = \pm\sqrt{Cno}$$

and since:

$$C = \frac{a_o}{no}$$

it is:

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \pm a_o$$

thus:

$$t = \frac{1}{2\sqrt{c_1 c_2 n o}} \log_e \frac{a_o + x}{a_o - x} \qquad (38)$$

and for half equilibrium value, $x = \frac{a_o}{2}$:

$$t_1 = \frac{1}{2\sqrt{c_1 c_2 n o}} \log_e 3 \qquad (39)$$

TABLE III. THERMAL NITRIFICATION VELOCITIES IN AIR

A

$$v = \frac{dx}{dt} = c_1\left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2 x^2;\ n = 0.777;\ o = 0.210$$

T =	1800° $\times 10^{-6}$	2000° $\times 10^{-4}$	2200° $\times 10^{-3}$	2400° $\times 10^{-1}$	2600° $\times 1$	2800° $\times 10^{+1}$	3000° $\times 10^{2}$	3200° $\times 10^{3}$	3400° $\times 10^{5}$	3600° $\times 10^{7}$	3800° $\times 10^{8}$	4000° $\times 10^{9}$
$x = 0$	+ 0.30	+ 1.40	+ 5.23	+ 1.66	+ 4.63	+ 11.7	+ 2.75	+ 6.04	+12.65	+2.51	+4.81	+8.96
0.5	— 0.31	+ 0.44	+ 3.86	+ 1.46	+ 4.32	+ 11.2	+ 2.66	+ 5.91	+12.38	+2.47	+4.73	+8.84
1.0	— 2.39	— 2.40	— 0.19	+ 0.87	+ 3.47	+ 9.9	+ 2.47	+ 5.59	+11.95	+2.37	+4.58	+8.57
1.5	— 5.75	— 7.11	— 6.8	— 0.07	+ 2.11	+ 8.0	+ 2.17	+ 5.14	+11.21	+2.27	+4.43	+8.32
2.0	—10.44	— 13.7	— 16.1	— 1.38	+ 0.25	+ 5.3	+ 1.78	+ 4.57	+10.32	+2.14	+4.22	+8.01
2.5	— 16.5	— 22.2	— 28.0	— 3.06	— 2.14	+ 1.9	+ 1.28	+ 3.84	+ 9.23	+1.98	+3.97	+7.62
3.0	— 23.9	— 32.5	— 42.5	— 5.12	— 5.0	— 2.2	+ 0.68	+ 2.98	+ 7.98	+1.79	+3.69	+7.22
4.0	— 42.6	— 58.9	— 79.4	—10.3	— 12.4	— 12.7	— 0.83	+ 0.82	+ 4.80	+1.33	+3.01	+6.18
5.0	— 66.8	— 93.0	—127.0	—17.0	— 21.8	— 26.0	— 2.74	— 1.91	+ 0.87	+0.75	+2.16	+4.90
6.0	— 96.4	—134.0	—185.0	—25.1	— 33.3	— 42.2	— 5.07	— 5.25	— 3.90	+0.06	+1.14	+3.41
8.0	—172.0	—240.0	—333.0	—46.9	— 62.0	— 83.2	—10.95	—13.5	—15.70	—1.63	—1.30	—0.14
10.0	—268.0	—375.0	—522.0	—72.5	—100.0	—136.0	—18.4	—24.0	—30.7	—3.78	—4.37	—4.57

B

$$-v = C_2 x^2$$

T =	1400° $\times 10^{-6}$	1600° $\times 10^{-4}$	1800° $\times 10^{-3}$	2000° $\times 10^{-2}$	2200° $\times 10^{-1}$	2400° $\times 1$	2600° $\times 10$	2800° $\times 10^{2}$	3000° $\times 10^{3}$	3200° $\times 10^{4}$	3400° $\times 10^{5}$	3600° $\times 10^{6}$
$x = 12$	1.97	2.75	3.86	5.40	7.53	10.5	14.5	19.9	27.4	36.8	48.5	63.4
16	3.51	4.89	6.85	9.63	13.4	18.7	26.0	36.1	50.5	69.0	93.9	128.0
20	5.48	7.63	10.7	15.0	21.0	29.3	41.0	57.1	80.0	110.5	152.0	210.0
24	7.88	11.0	15.4	21.7	30.3	42.2	59.2	82.4	116.0	161.0	223.0	310.0
28	10.7	15.0	21.1	29.5	41.2	57.7	80.7	113.0	159.0	221.0	308.0	430.0
32	14.0	19.6	27.4	38.5	53.8	75.3	106.0	148.0	207.0	290.0	404.0	563.0
36	17.8	24.8	34.7	48.8	68.2	95.3	134.0	187.0	263.0	367.0	512.0	717.0
40	21.9	30.6	41.8	60.2	84.0	117.5	165.0	231.0	325.0	456.0	634.0	887.0

Thus:

$$t_1 = \frac{1.36}{\sqrt{c_1 c_2}} \qquad (40)$$

is the reaction time producing half the equilibrium value of NO in the air.

Dissociation of NO in air from a_1 corresponding to previous temperature T_1, at lower temperature T_2, giving a_2, to half the approach to a_2, that is, to $\frac{a_1 + a_2}{2}$.

$$n = 0.777 - \frac{a_1}{2};\ o = 0.21 - \frac{a_1}{2};\ a = a_1;\ x = \frac{a_1 - a_2}{2}; \qquad (41)$$

sign of x reversed, c_1 and c_2 correspond to temperature T_2.

Substituting in equation (26) to (32), and neglecting small quantities:

$$S = 1.1 c_1 c_2 no$$

$$\left.\begin{matrix} x_1 \\ x_2 \end{matrix}\right\} = \frac{-1}{c_2}\left[c_2 a_1 \pm S\right]$$

$$t = \frac{1}{2S}\log_e \frac{(c_2 a_1 - S)(c_2 a_1 + S - c_2 x)}{(c_2 a_1 + S)(c_2 a_1 - S - c_2 x)}$$

$$= \frac{1}{2S}\left[\frac{2S}{c_2 a_1 - c_2 x} - \frac{2S}{c_2 a_1}\right]$$

thus:

$$t = \frac{x}{c_2 a_1 (a_1 - x)} \qquad (42)$$

and for:

$$x = \frac{2}{a_1 - a_2}$$

$$t = \frac{a_1 - a_2}{c_2 a_1 (a_1 + a_2)} \qquad (43)$$

Thus for: $T_1 = 3840$; $a_1 = .072$

$T_2 = 2580$; $a_2 = .020$; $c_2 = 7400$

$t_2 = 1.06 \times 10^{-5}$

$= 1.06$ milliseconds.

Table II gives

t_2, the dissociation time of pure NO to half value, from (35)

t_1, the formation time of air to half equilibrium, from (40)

t_2, the dissociation time of air at 200 deg. drop, for T_2, from (43).

Table III gives the reaction velocities in air:

$$v = \frac{dx}{dt} = c_1\left(n - \frac{x}{2}\right)\left(o - \frac{x}{2}\right) - c_2 x^2 \qquad (26)$$

where: $n = .777$; $o = .210$ are the initial N_2 and O_2 concentrations respectively, and x is the NO concentration, for temperatures from 1400 to 4000 deg. abs., and NO concentrations from $x = 0$ to $x = 40$ per cent.

The second part of the table, for high concentration of NO, is calculated by the approximation permissible in this case:

$$v = -c_2 x^2$$

(*Part II will be published in our next issue*)

Forest Products Laboratory in Australia

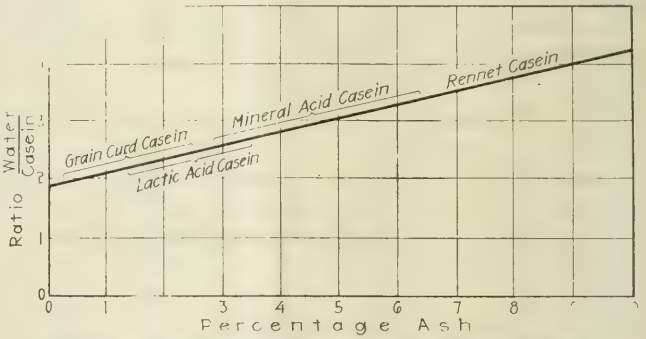
A forest products laboratory is about to be established in Australia in connection with the Perth Technical School at Perth, for the purpose of experimenting in the utilization of the byproducts of Australian timber mills and forests. I. H. Boas of the faculty of chemistry of Perth has been sent to the U. S. to conduct inquiries. He will visit the laboratories at Madison, Wis., at Montreal, and elsewhere.

Notes on Casein Glue*

It has been determined that formaldehyde used in some manufacturing processes to coagulate casein is not successful for rendering casein glue less soluble.

Discoloration of casein on heating to 212 deg. F. (100 deg. C.) is due to the presence of lactose and indicates that the curd was not very thoroughly washed. Absence of such color change indicates well-washed curd, except in the case of natural sour casein precipitated from very sour milk. In this case no discoloration is noticed, because all the lactose has been converted into lactic acid.

Proof of the value of animal, vegetable, casein and blood albumin glues as binding agents has been shown by soaking for 20 weeks in gasoline, engine oil and



ASH-WATER ABSORPTION CURVE FOR MEDIUM VISCOSITY CASEIN GLUES

castor oil, the results showing no separation of the plies. Shear tests, however, gave evidence that a gradual weakening of the glue proceeds under this treatment. The loss in strength, however, was in no case as much as would be caused by the standard test of soaking for 10 days in water.

Experiments have shown that all caseins of a reasonable degree of purity can be made into satisfactory glues by the same formula simply by varying the amount of water used.

Caseins may be divided into definite groups according to the amount of water which they require to make glue of a given consistency. This grouping is roughly the same as that according to methods of casein manufacture. Grain-curd casein requires the least water; lactic-acid casein, ordinary mineral-acid casein, and rennet casein increasingly larger amounts.

The ash content of these caseins also increases in the same order. In fact, the relation between the ash content and amount of water required is so close that if the former is known the latter may be predicted. The relation between the ash content and the water requirement may be expressed by such an equation as

$$y = mx + b$$

wherein x is the ash content of the casein, y the water-casein ratio required to give a glue of medium viscosity, and m and b constants depending upon the formula used. This gives a straight line, as shown in the diagram.

The most essential constituent used in casein to produce the casein water-resistant glue is lime. The purity of the commercial lime is not a determining factor in glue-making. When a lime of unknown analysis is to be used, it is desirable to begin with an amount which would give a glue of short- or medium-working life and a satisfactory flow. It is essential in the use of new lime that tests of the water-resistant glue products should be made as soon as possible.

*Extract from *Technical Notes*, Forest Products Laboratory.

Stack Losses at Arizona Copper Co.

By J. Owen Ambler*

THE following data taken from a report submitted by the Western Precipitation Co., of Los Angeles, Cal., to Norman Carmichael, general manager of the Arizona Copper Co., Ltd., of Clifton, Ariz., show the methods and apparatus used and the results attained in testing for fume loss at the smelter of the company, and are of general interest as showing the application of the Cottrell system to this class of work. The experiments were made in 1916 and 1917.

General Method of Test

A plan of the flue system (Fig. 1) indicates the points at which samples were taken for the various departments, and during the course of the tests operating conditions were varied so that as wide a range as possible was covered. The points chosen for the tests were located so that a fairly long passage of about the same cross-section preceded the sampling, in order that the velocity figures might be as accurate as possible.

Gas samples and velocity measurements were taken at fixed points in the cross-section of the flues, explorations of this section having been made previously to determine the ratio of the velocity at the fixed point to the average over the entire flue. The entire volume passing the section was calculated from this ratio and the Pitot tube measurements of the velocity.

The volume of the gas sample was measured by a Pitot tube located in the inlet pipe between the flue and the treater, while the dust caught was collected after

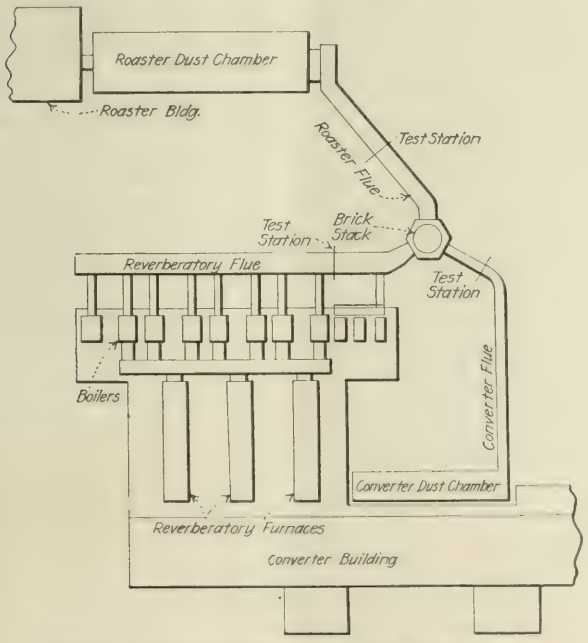


FIG. 1. PLAN OF THE FLUE SYSTEM

each run, weighed and analyzed. The weight of dust per cu.ft. of gas and the measured flue velocity were used to determine the total fume loss for the particular test.

Separation of the dust of fume from the flue gas was effected by electric precipitation in a Cottrell treater consisting of a vertical 12-in. iron pipe (the collecting electrode) in which was suspended an iron wire (the discharge electrode). A high voltage unidirectional potential was maintained between these electrodes by means of a step-up transformer and a disk type rectifier. As is well known, when the gases with their suspended particles were passed through this treater the particles became charged, and, due to the electric field, moved to the collecting electrode, where they were deposited, the gases passing through unaffected. At the completion of a test the pipe was jarred by a blow, which caused the dust to drop to the bottom of the treater, where it was collected and weighed.

Pitot tubes used in this investigation consisted essentially of two parts, one to receive the static pressure

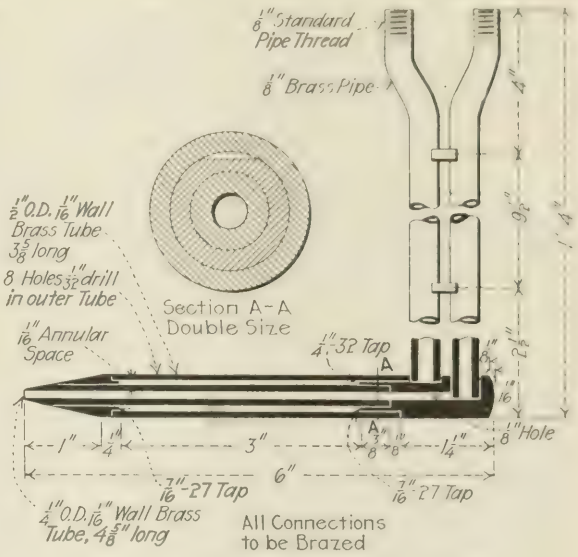


FIG. 2. DETAILS OF PITOT TUBE

and the other to receive the sum of the static and velocity pressures, the outlets from these two parts leading to the opposite ends of the gage which registered the differential pressure indicating the velocity head. The tube used was that known as the American Blower Co. type, and is shown in detail in Fig. 2. Static openings consist of small drill holes in the side of the outer sheath, and the impact opening is the end of the tube, beveled to a sharp edge. It is possible, with this type of tube and an accurate gage, to obtain an accuracy of 1 per cent, though this degree is seldom attained in general work, due to certain uncontrollable gas conditions.

Working Formula

Since in its operation the Pitot tube follows the law of falling bodies, $V^2 = 2gh$, where h is the head of fluid producing the velocity V, a working formula was developed as follows:

Let
T = absolute temperature of flowing gas, deg. F.
K = absolute temperature of flowing gas, deg. C.
P = absolute pressure of flowing gas, lb. per sq.in.
B = absolute pressure of flowing gas, in. of mercury.
d = weight per cu.ft. flowing gas at the given temperature and pressure.
G = specific gravity of flowing gas. (air = 1.)
V = actual velocity of flowing gas, ft. per sec.
h_f = height in feet of homogeneous column of gas, at given temperature and pressure, which produces V.
h = corresponding height of water column in in.
d_w = weight per cu.ft. of water = 62.37 lb. at 60 deg. F.
d_a = weight per cu.ft. of air at 32 deg. F. and 14.7 lb. = 0.08073 lb.
g = acceleration due to gravity = 32.16.

*Smelter Superintendent.

$$\text{Then, } V = \sqrt{2gh_f} = \sqrt{\frac{2ghd_w}{12d}}, \text{ since } dh_f = \frac{hd_w}{12}.$$

$$\text{But } d = d_a \times G \times \frac{P}{14.7} \times \frac{491.2}{T}$$

$$\text{Therefore, } V = \sqrt{\frac{2g\,hd_w\,14.7T}{12d_a\,491.2PG}} =$$

$$\sqrt{\frac{2 \times 32.16 \times 62.37 \times 14.7 \times hT}{12 \times .08073 \times 491.2 \times P \times G}} =$$

$$\sqrt{\frac{123.9hT}{PG}} = 15.88\sqrt{\frac{hT}{BG}} = 21.30\sqrt{\frac{hK}{BG}}$$

The pressure gages were of the standard Ellison type, and both ordinary and recording mercury type thermometers were used, care being taken to insulate the treater intake pipe carefully with magnesia covering, so that the temperature taken in the intake pipe could be used both for the flue and intake temperatures.

Typical Data on Roasting Flue

A typical set of determinations in a test of the roaster flue, showing data taken and methods of calculation of results, follows:

Average velocity intake pipe	=	0.905 velocity at point of measurement
Average velocity flue	=	0.934 velocity at point of measurement
Flue velocity head	=	0.0223 in. water
Temperature	=	359.0 deg. C. abs.
Intake velocity head	=	0.1207 in. water
Barometer	=	26.47 in.
Amount dust collected	=	3607 g.
Time of test	=	920 min.
Density of gas	=	1.02
Percentage copper in dust	=	5.71

For this case with the barometer 26.47 in. of mercury the flue velocity will be:

$$21.30\sqrt{\frac{.0223 \times 359}{26.47 \times 1.02}} = 11.59 \text{ ft. per sec.}$$

Similarly the intake velocity will be:

$$21.30\sqrt{\frac{.1207 \times 359}{26.47 \times 1.02}} = 26.95 \text{ ft. per sec.}$$

Let t be the time in minutes and let v_t be the velocity in feet per second at the point of measurement in the 6-in. dia. intake pipe. The volume passing this point will be, since the average velocity is 0.905 of the velocity at point of measurement:

$$0.905 \times v_t \times \pi \times \tfrac{1}{16} \times 60 \times t = 10.68tv_t$$

$$\text{Volume of sample} = 10.68 \times 26.95 \times 920 = 265{,}000 \text{ cu.ft.}$$

$$\text{Weight of dust per cu. ft.} = \frac{3607}{265{,}000} = 0.01360 \text{ g. per cu. ft.}$$

By Pitot tube explorations of the flue the average velocity was found to be 0.934 times the velocity at the point of measurement. The dust level in the flue was determined at the beginning and completion of the test and the mean area at the section for sampling was found to be 142.5 sq.ft. If v_f is the recorded flue velocity in feet per second, the volume of gas in cubic feet per minute will be

$$142.5 \times 0.934 \times v_f \times 60 = 8{,}000v_f,$$

and total weight of dust in pounds per 24 hr. will be

$$8{,}000 \times 1{,}440 \times \text{g. dust per cu.ft.} \times v_f \times 0.002205 = 25{,}400v_f \text{ g. dust per cu.ft.}$$

By substitution, the total dust loss in roaster flue then equals

$$25{,}400 \times 11.59 \times 0.01360 = 4{,}020 \text{ lb. in 24 hr.,}$$

and the total copper loss equals

$$4{,}020 \times 5.71 \text{ per cent} = 229 \text{ lb. in 24 hr.}$$

SUMMARY OF ALL TESTS

Roasters:	Normal Draft	High Draft
Average flue velocity in ft. per sec.	11.4	20.41
Average volume of gas at flue temperature, cu.ft.	91,200	163,300
Average temperature at sampling pipe, deg. F.	186	212
Average copper content of dust, per cent	5.65	5.41
Average dust loss per 24 hr., lb.	4,375	10,572
Average copper loss in 24 hr., lb.	247	571

	Operating Two Converters		Operating Three Converters
Converters:	High Draft	Normal Low Draft	High Draft
Average flue velocity, ft. per sec.	50.2	35.2	50.3
Average volume gas at flue temperature, cu.ft.	136,200	95,800	136,900
Average temperature at sampling pipe, deg. F.	349	375	400
Average copper content of dust, per cent	12.9	5.62	10.7
Average tons copper cast per 24 hr.	79.6	72.25	92.0
Average dust loss per 24 hr., lb.	1,738	1,252	2,935
Average copper loss per 24 hr., lb.	225	70.5	314

Reverberatories:	Normal Draft
Average flue velocity, ft. per sec.	19.01
Average volume gas at flue temperature, cu.ft.	259,500
Average temperature at sampling pipe, deg. F.	310
Average copper content of dust, per cent	3.58
Average tons dry solid charge treated per 24 hr.	810
Average dust loss per 24 hr., lb.	9,363
Average copper loss per 24 hr., lb.	336

RECAPITULATION

Total Copper Loss per Day—Normal Conditions

	Lb.
Roasters	247.0
Reverberatories	336.0
Converters	70.5
Total	653.5

Corporation Patriotism

Speaking at the American Electric Railway Association dinner in Cleveland on Jan. 8, Senator Harding gave the following intimate account of the way in which the du Pont organization served the War Department in the construction of powder plants.

"When America entered the war we were making in this country approximately two-thirds of all the powder used by the Allied Governments. We declared war in April, 1917, and it was nine months after the declaration before we contracted for the production of American powder to participate in the war.

"The reason was that the authorities did not want to tie up with what they termed big business, and nine months were wasted before a stroke was made, until finally the du Ponts were authorized to build a Federal powder plant at Nashville, Tenn. They were commissioned to build a plant that would produce 500,000 lb. of powder per day, and if they finished the plant and had it in running order by July 1, 1918, they were to receive a commission of $3,500,000 for the service rendered. They worked so effectively that the plant was in partial operation in June.

"The Secretary of War then called in their agents and said: 'We want to duplicate the plant. We will duplicate that contract and will extend the time to October. We want a million-pound capacity plant. Your commission will be $7,000,000 all told. Can you do it?' The spokesman for the company said: 'Yes, on one condition—that you will take out your pestiferous, uninformed, annoying inspectors, and let us do the job. We will promise you we will join in prosecuting every crook that appears on the scene, and if you will just let us do it, we will tear up our contract, and charge you not one cent bonus.'

"The Secretary of War said: 'You don't mean it?' And the spokesman said: 'We do mean it; is it a go?' The Secretary of War answered: 'Yes,' and the spokesman of the company said: 'I will tear up the contract, and $7,000,000 is our contribution toward helping the war along.'"

Some Developed Mineral Resources and Chemical Industries of the Southern States*

Review of the Southern Fertilizer Resources—Phosphate Rock, Mining, Grinding, Acidifying and Mixing Into Commercial Fertilizer—Mining of Sulphur, Pyrites and Pyrrhotite—Manufacture of Sulphuric Acid—Smelting of Copper

By ANDREW M. FAIRLIE

PHOSPHATE rock has been grouped here with three apparently unrelated minerals obviously because of the interdependence of the respective manufactured products—acid phosphate and sulphuric acid.

The object in preparing this paper is to present, in compact form, before the Institute at this meeting, held in a city of the South, some of the salient facts, already well known probably to those familiar with the subjects, pertaining to these rather prominent industries of the Southern states. A realization of what has been done in these fields of endeavor may serve as some indication of what may yet be accomplished in other fields, still undeveloped.

The term "phosphate rock" includes the calcium phosphates, of which apatite has probably the most definite and constant composition. Two varieties of apatite are recognized, namely, fluorapatite, $Ca_5(PO_4)_3F$, and chlorapatite, $Ca_5(PO_4)_3Cl$. Other phosphatic minerals are manganapatite, hydroapatite, "phosphorite," staffelite, and pseudoapatite.

A concise statement of the origin of phosphate rock, together with a description of the methods of mining (both underground and open pit), and an outline of washing and drying methods for the elimination of impurities and the preparation of the rock for the market, will be found in an article entitled "Phosphate," by E. H. Sellards,[1] obtainable from the State Geologist, Tallahassee, Fla.[2]

The United States, with a production in 1913 (the latest wholly pre-war year) of 3,111,221 long tons of phosphate rock, or practically one-half of the production of the entire world, leads all other countries as a producer of that mineral. All of this country's production, with the exception of 5,053 tons, was produced in the Southern states[3]; and Florida, with an output of 2,545,276 long tons, and Tennessee, with 451,559 long tons, together produced over 96 per cent of the entire output of the country. The only other phosphate-producing states worthy of mention are South Carolina and Kentucky, and the production in the latter state, as late as 1917, amounted to only a few thousand tons. The deposits of South Carolina were the first to be mined in America.[4] Phosphate rock has been mined in past years in Arkansas, but the production in this state has apparently stopped. Phosphatic minerals or marls are known to exist in four other Southern states—Virginia, North Carolina, Alabama and Georgia—and brief descriptions of these various deposits will be found in the paper by Sellards,[5] referred to previously.

On account of the preponderating influence on the market of the production from the states of Florida and Tennessee, the following extracts from Sellards' paper, with reference to the deposits of these two states, may be of interest.

Phosphate Deposits of Florida

"The phosphate produced in Florida includes two kinds, namely, hard rock and land pebble phosphates.

"The matrix in which the hard rock phosphate is imbedded is extremely variable. The formation includes a mixture of materials from various sources and of the most diverse character, further complicated by pronounced chemical activity within the formation itself. The prevailing phase of the formation is feebly coherent, more or less phosphatic, light gray sand. Aside from these sands the principal materials of the formation are clays, phosphate rock, flint boulders, limestone inclusions, pebble conglomerate, erratic and occasional waterworn flint pebbles, vertebrate and invertebrate fossils, and occasional pieces of silicified tree trunks.

"Phosphate rock, although the constituent of special economic interest, nevertheless makes up a relatively small part of the formation. The phosphate in these deposits occurs as fragmentary rock, boulder rock, plate rock, or pebble. The boulders are often of large size, in some instances weighing several tons, and must be broken up by blasting before being removed from the pit. It is also necessary to operate a rock crusher in connection with all hard rock phosphate mines to reduce the larger pieces of rock to a size suitable for shipping. The relative amount of material that it is necessary to handle to obtain a definite amount of phosphate is always variable with each pit and with the different parts of any one pit. The workable deposits of phosphate lying within this formation occur very irregularly. While at one locality the phosphate may lie at the surface, elsewhere it may be so deeply buried as not to be economically worked; while a deposit once located may cover more or less continuously a tract of land some acres in extent, elsewhere a deposit, appearing equally promising on the surface, may in reality be found to be of very limited extent. As to location, depth from surface, extent into the ground, lateral extent, quantity and quality, the hard rock phosphate deposits conform to no rule. The desired information

*Read before the American Institute of Chemical Engineers, Savannah, Ga., Dec. 6, 1919.

[1]E. H. Sellards, "Mineral Industries and Resources of Florida." Reprinted from the Sixth Annual Report of the Florida State Geological Survey, p. 71.

[2]Acknowledgment of indebtedness to Dr. Sellards' paper is here made for much of the data regarding the phosphate minerals and the distribution of phosphate rock, etc., repeated here.

[3]W. C. Phalen, "The Production of Phosphate Rock in 1913." Mineral Resources of the United States, Part II, 1914, p. 273.

[4]According to Sellards, actual mining began in 1867.

[5]*Op. cit.*, p. 86.

is to be obtained only by extensive and expensive prospecting and sampling.

"The materials above the phosphate deposits include pale yellow incoherent sand and in some localities clayey sand. The incoherent sands are variable, an average thickness being from 5 to 15 ft., although as much as 30 ft. have been observed.

"The land pebble phosphates of southern Florida are much more uniform in their manner of occurrence than are the hard rock deposits. The phosphate is in the form of pebble rock imbedded in a matrix of clay, sand and soft phosphate. Although variable from place to place, the phosphate bed has an average thickness of from 8 to 10 ft., its maximum thickness being from 18 to 20 ft. The overburden, which consists largely of sand and sandy clays, with local indurated or calcareous ledges, has an average thickness of from 10 to 14 ft.

"The best grade of land pebble rock, when properly washed, dried and selected, permits a guarantee of 75 or 76 per cent tricalcium phosphate. Other grades on the market range from 62 to 75 per cent. The hard rock phosphates range from 79 to 83 per cent, although selected samples run as high as 84 or 85 per cent tricalcium phosphate.

"Practically all of the hard rock phosphate mined in Florida is exported. Of the land pebble phosphate produced, over 40 per cent was exported in 1913.

Phosphate Deposits of Tennessee

"In Tennessee several more or less distinct types of phosphate occur, only two of which, however, blue rock and brown rock, are being mined at present. The blue phosphate occurs as a bedded deposit within, but forming the lowest member of, the Chattanooga formation of the Devonian age, and resting directly upon Ordovician limestone. The blue phosphates are said to vary in grade from about 30 to 85 per cent tricalcium phosphate. Iron and aluminum in the better grade of rock aggregate less than 3 per cent. The beds vary in thickness from 0 to 50 in., although the bed furnishing high-grade rock rarely exceeds 20 in. in thickness.

"The brown rock of Tennessee is at the present time (1914) of greater commercial importance than the blue rock. This rock occurs in irregular deposits lying near the surface and resting on limestone. The overburden consists usually of residual material including clay, some phosphate, and a limited amount of sand. Its thickness is extremely variable, although averaging 8 or 10 ft. The phosphate consists of a shelly rock, breaking up into pieces of varying size, and of small variegated pebbles which in mass have a dark brown color. Locally the small pebble rock predominates, forming a scarcely coherent mass having a brownish color. A phase of the material, known locally as 'muck' deposit, consists of a mass of small pebbles, often not exceeding a pinhead in size."

TABLE I. PHOSPHATE ROCK MARKETED IN AND EXPORTED FROM THE UNITED STATES, 1913–1917

Year	Proportion of Exports to Domestic Production (Per Cent)	Marketed Production (Long Tons)	Exports (Long Tons)
1913	44	3,111,221	1,366,508
1914	35	2,734,043	964,114
1915	14	1,835,667	253,421
1916	12	1,982,385	243,678
1917	6	2,584,287	166,003

The phosphate deposits of Tennessee are in the central part of the state. According to J. S. Hook, the centers of production lie in Maury, Hickman, Lewis, and Giles counties. The most important deposits are those in the vicinity of Mount Pleasant, in Maury county, eleven miles southwest of Columbia, the county seat. Further information regarding the phosphate rock deposits of Tennessee can be found in the April (1914) issue of "The Resources of Tennessee."[6]

Extensive deposits of phosphate rock are known to exist in Utah, Idaho, and other Western states, but as late as 1917 the West produced only 0.6 of 1 per cent of the entire output of the country for that year. That the output for 1917 (15,096 tons) represented an increase of 786 per cent over the production for 1916 indicated, however, a tendency toward increased activity in that section.

Table I[7] illustrates in eloquent manner the marked effect of the European war on the phosphate industry of this country.

The rapid decline in the exports of phosphate rock from this country is shown graphically on the accompanying diagram (Fig. 1).

Naturally, as Florida is the largest producer of phosphate rock, the brunt of the stagnation of the export business was borne by that state. The summary[8] of the shipments of phosphate rock from Florida from 1913 to 1918, inclusive, (Table II) is interesting, in comparison with Table I.

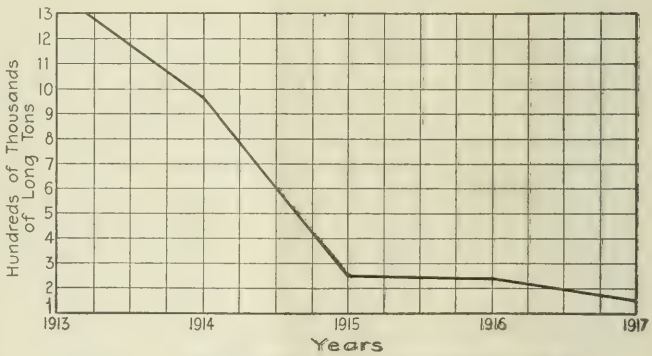


FIG. 1. EXPORTATION OF PHOSPHATE ROCK

It is apparent, from statistics furnished by the United States Department of Commerce, that during the first half of 1919 the export business in phosphate rock showed some signs of improvement. Exportations of phosphate rock for the fiscal year ended June 30, 1919, are given in Table III.

It will be noted that all of these statistics refer to shipments. The shipment tonnages are never the same as the tonnages of rock mined, for there are variable amounts in storage at the end of each year. The tonnage of rock mined in 1918 shows a decrease of 443,247 long tons from that mined in 1917, the diminished output being a reflection of conditions due to our entry into the war, such as difficulty in securing labor, restrictions placed on fuel distribution and shipping facilities, etc.

[6] J. S. Hook, "The Brown and Blue Phosphate Deposits of South-Central Tennessee," "The Resources of Tennessee"; State Geological Survey, vol. 4, No. 2, p. 51.

[7] American Fertilizer Hand Book, 1919, p. C-6.

[8] Compiled from the American Fertilizer Hand Book, 1919, and "Statistics on Mineral Production in Florida During 1918," by Herman Gunter, State Geologist. Press Bull. No. 11, Oct. 6, 1919, p. 5.

TABLE II. SUMMARY OF SHIPMENTS (IN LONG TONS) OF PHOSPHATE ROCK IN FLORIDA, 1913-1918 INCLUSIVE

Year	Pebble Rock			Hard Rock			Pebble and Hard Rock Combined		
	Exported	Domestic	Total	Exported	Domestic	Total	Exported	Domestic	Total
1913	887,398	1,168,084	2,055,482	476,898	12,896	489,794	1,364,296	1,180,980	2,545,276
1914	625,821	1,203,381	1,829,202	303,172	6,517	309,689	928,993	1,209,898	2,138,891
1915	185,846	1,122,635	1,308,481	43,314	6,816	50,130	229,160	1,129,451	1,358,611
1916	172,427	1,296,331	1,468,758	28,045	19,042	47,087	200,472	1,315,373	1,515,845
1917	138,010	1,865,081	2,003,991	12,403	6,205	18,608*	150,413	1,872,186	2,022,599
1918	64,559	1,932,288	1,996,847	57,771	12,612	70,383*	122,330	1,932,288	2,067,230

* Includes soft rock phosphate.

The total value of the shipments in 1917 was $5,464,493, and in 1918, $6,090,106. The total production of phosphate rock in Florida since the beginning of mining it in 1888 to the close of 1918 is estimated to be 35,210,314 tons, with a total valuation of over $129,000,000[9].

The principal uses of phosphate rock are for export as such, for the manufacture of "ground phosphate rock," and for the manufacture of acid phosphate. Smaller quantities of the rock are used in other industries, such as the manufacture of matches, and the manufacture of various chemicals—phosphoric acid, ammonium and sodium phosphates, etc.

Within recent years the use of ground phosphate rock as a fertilizer has been strongly advocated, and its use has been recommended in some quarters as a substitute for acid phosphate. The producers of phosphate rock have a direct interest in promoting the demand for the raw product, which they can afford to sell for a much lower price than acid phosphate can be sold for. On the other hand, the manufacturers of acid phosphate and of sulphuric acid are directly concerned with increasing the demand for acidulated rock. Much argument has therefore arisen, pro and con, regarding the real value of ground phosphate rock as a fertilizer. As a factor tending toward a decision of the subject in dispute, by a disinterested authority, the following extract from the Georgia Department of Agriculture is to the point:[10]

TABLE III. PHOSPHATE ROCK EXPORTED FROM THE UNITED STATES, YEAR ENDED JUNE 30, 1919

Kind of Rock	Tons	Value
Land pebble	78,027	$448,855
High-grade hard rock	80,834	715,104
All other	30,227	328,575
Total	189,088	$1,492,534

"Ground phosphate rock gives very small returns in soils deficient in organic matter, hence the poor results obtained when used on clay soils. It does much better in sandy soils containing much organic matter. Soil acids and rotting organic matter are regarded as making the phosphoric acid of the rock slowly available for plants.

"The ground rock can be mixed with compost or in the manure pile, or even sowed in the furrow with six or eight times its weight of manure, and then it will give some returns. Even on cotton lands that have very little organic matter present in their soils, the use of phosphate rock is better than the entire omission of all fertilizers. But for this crop, acid phosphate will net much richer returns even if bought at much greater prices.

"It is not to be concluded from the foregoing statements that ground raw phosphate is without any value. It most assuredly is of value on certain types of soil. But the farmer should be cautioned against indiscriminate buying at extravagant prices because of extravagant claims of agents and dealers in this material."

Acid Phosphate

The first acid phosphate to be made by the modern method of treating phosphate rock with sulphuric acid was made in England in 1841.[11] The manufacture of acid phosphate is a simple chemical process. Approximately equal parts (the precise proportions being determined by the composition of the rock and the strength of the acid) of ground phosphate rock and 52-53 deg. sulphuric acid are mixed in a cast-iron pan equipped with agitators or stirrers, and the mass is then dumped into bins or "dens." The equipment of an acidulating plant consists chiefly of rock mills, screens, mixers, acid tanks, and dens. On account of the scarcity of labor the tendency among manufacturers is to adopt modern labor-saving devices, such as traveling cranes and belts, overhead trolleys or tracks, Link-Belt or Jeffrey loaders, Thew shovels, grab buckets, etc., whereby large quantities of bulk materials may be handled quickly and cheaply.

The phosphate rock is ground so that 90-98 per cent will pass through a 60-mesh screen, a weighed quantity of the "dust" is delivered, together with an accurately weighed or measured quantity of sulphuric acid of known strength, onto a mixing pan of one or two tons capacity, a usual size being 7 ft. in diameter and 2 ft. deep. The mass is stirred by mechanical stirrers until an intimate mixture is obtained, and is then dropped into dens, where it is allowed to remain for at least 12 hr. If, after a night in the den, the acid phosphate is found to be in a reasonably dry state, it is removed from the den and placed in a large pile, where it is left for 30 days or more to "condition" (during which time the excess of moisture escapes), after which the acid phosphate, or superphosphate, is ready for shipment or to be used for making complete fertilizer.

Acid phosphate will ordinarily show on analysis the following composition:

	Per Cent
Water-soluble phosphoric acid	14
Reverted phosphoric acid	2
Insoluble phosphoric acid	1

The exports of acid phosphate, for the fiscal year ended June 30, 1919, were 51,405 tons, valued at $1,548,678. It is estimated that about 4,000,000 tons of acid phosphate were manufactured in the United States in 1917, and that in 1918 about 4,500,000 tons were manufactured, the value of the product for the latter year being estimated at $76,500,000. For the manufacture of this huge tonnage of acid phosphate, large quantities of sulphuric acid have been required. But the

[9] "Statistics on Mineral Production in Florida During 1918," by Herman Gunter, State Geologist. Press Bulletin No. 11, Oct. 6, 1919, p. 5.

[10] Bulletin No. 76, Georgia Department of Agriculture, 1918, p. 40, ff.

[11] Sellards, *op. cit.*, p. 87.

sulphuric acid industry is dependent on the mineral industry for its principal raw material, and the development of the pyrite and sulphur deposits of the South has resulted from the demand for sulphuric acid.

Sulphur

Up to the year 1918, two companies, the Union Sulphur Co., Sulphur, Calcasieu parish, La., and the Freeport Sulphur Co., near Freeport, Brazoria county, Tex., produced more than 99 per cent of the sulphur mined in the United States. A small amount of sulphur was produced in three Western states—Nevada, Wyoming and Colorado—but it is noteworthy that without the product from the Southern states named the output of brimstone from the United States was practically nil. During 1918 a third large producer—the Texas Gulf Sulphur Co., whose plant is at the mouth of the Colorado River, at Matagorda, Tex.—and again a Southern one, entered the field.

The production of brimstone in the United States for the year 1918 was reported as 1,352,283 tons.[12] The estimated production for 1917 was given as 1,137,000 tons. The tonnage for 1917 was said by the United States Geological Survey to have been nearly 50 per cent greater than in 1916, while during that year the production of brimstone was several hundred per cent greater than in any year before the war.[13]

The character of the sulphur deposits in the Southern states has been described by Philip S. Smith.[14] As is well known, these deposits are mined by the ingenious process developed by Herman Frasch. The original Frasch patent of Oct. 20, 1891, having expired and the later patents having recently been declared invalid,[15] the process, heretofore considered to be an exclusive one, appears now to be open to general use.

Besides the manufacture of sulphuric acid, the principal use of sulphur is in the manufacture of paper. Smith[16] states that paper manufacturers report a consumption of one-eighth of a ton of sulphur for each ton of sulphite pulp manufactured. According to census returns, the sulphite pulp industry in the United States consumed 136,456 short tons of sulphur in 1914.

Prior to the war, very little sulphur was used in this country for the manufacture of sulphuric acid. But owing to the combined effect of increased demand for acid for the manufacture of munitions and the diminished supply of ships for the transportation of pyrites from Spain, the quantity of sulphur used for the manufacture of sulphuric acid has very greatly increased. The producers of acid report that 463,364 long tons of domestic sulphur were used by them in 1917.[17] Obviously, most of this must have come from the South.

Pyrites

Pyrites, or pyrite, whose main use is for the manufacture of sulphuric acid, was prior to the war imported into the Southern states in large quantities from Spain. The exigencies of the war stopped most of this importation, and it was expected that the production of domestic pyrites would be greatly stimulated.

Virginia takes first rank among the states as a producer of pyrite, both as to quantity and value of output. In 1916 this state produced 148,502 long tons, valued at nearly one million dollars. Virginia's production in 1917 was 170,382 long tons. According to the Virginia State Geological Survey, the pyrite producers at present are:

The American Agricultural Chemical Corp., operating the Cabin Branch mines, Prince William county.

Grasselli Chemical Co., operating the Arminius mine, Louisa county.

Sulphur Mining & Railroad Co., operating a mine three miles north of Mineral, Louisa county.

The General Chemical Co., operating a mine at Monarat, Carroll county.

Two mines in Louisa county, one owned by the Armour Fertilizer Co. and the other by Boyd-Smith Mines, Inc., were reported not operating in 1919. The Ohio Sulphur Mining Co., operating near Proffit, Albemarle county, reported development work in progress, and the Western Pyrites Corp., operating near Garrisonville, Stafford county, reported that it expected to resume production about the first of December.

Among the Southern states, Georgia ranks second as a producer of pyrite. Georgia contributed 23,242 long tons in 1917. Besides Virginia and Georgia, the Southern states producing were Alabama, Kentucky and Tennessee.

The total production of domestic pyrites in 1917 was reported by the United States Geological Survey as 462,662 long tons, an increase of 10 per cent over the 1916 production. The expected increase in pyrites production for the year 1918 did not materialize. This failure is attributed to the difficulty in securing labor, to the war-time restrictions placed on the delivery of mining equipment and other supplies, etc. The production for 1918 was estimated at 453,637 long tons[18], about 10,000 tons less than in 1917, or a loss of about 2 per cent.

Pyrrhotite and Copper Sulphides

Pyrrhotite, while it is, like pyrite, an iron sulphide, is considered separately, as it is found associated with copper sulphides and has been treated along with the copper sulphides, primarily for the recovery of copper. The method of producing the sulphur dioxide from the sulphur, applied to these ores, is different from the method applied to pyrite. Otherwise the process of making the acid is practically the same.

The pyrrhotite deposits used for the manufacture of sulphuric acid and found associated with the sulphides of copper are mined in the Ducktown district in the southeastern corner of Tennessee, just north of the Georgia line and just west of North Carolina. These deposits have been worked for many years for their copper values, and since 1907 sulphuric acid has been made as a byproduct from the escaping fumes of the copper blast furnaces. There are two companies operating in the district—the Ducktown Sulphur, Copper & Iron Co., Ltd., and the Tennessee Copper Co.—and the total tonnage of ore mined annually by the two companies is in the neighborhood of half a million tons. The developed ore reserves at the mines of these companies is sufficient to permit the continuance of operations at the above rate for a number of years.

The process of smelting is the usual one for copper-iron sulphides, and consists of two operations: (1) smelting the ore in blast furnaces (in either one stage

[12] American Fertilizer Hand Book, 1919, p. 34.

[13] Philip S. Smith, "Sulphur, Pyrite and Sulphuric Acid in 1917," Mineral Resources of the United States, 1917, Part II, p. 19.

[14] Philip S. Smith, *ibid.*, p. 22.

[15] "Sulphur Mining Freed of Patent Monopoly," *Chemical Age*, July, 1919, p. 32.

[16] Philip S. Smith, *op. cit.*, p. 23

[17] Philip S. Smith, *op. cit.*, p. 23.

[18] American Fertilizer Hand Book, 1919, p. 32.

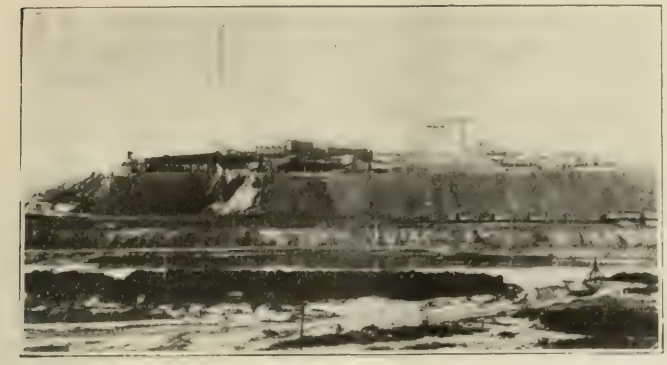


FIG. 2. GASES ESCAPING AT THE TENNESSEE COPPER CO. PLANT

or two stages) for copper matte, containing 30 to 40 per cent Cu; (2) blowing the matte to blister copper in basic lined converters. The amount of copper marketed is about 13,000,000 to 14,000,000 lb. annually.

Sulphuric Acid

According to the United States Geological Survey, the numbers of sulphuric acid plants operating in the several Southern states in 1916 were as follows:

Alabama	12	Mississippi	5
Arkansas	1	North Carolina	12
Florida	5	Oklahoma	1
Georgia	30	South Carolina	15
Louisiana	3	Tennessee	6
Maryland	11	Texas	3
		Virginia	9
Total, Southern states			113
United States (1917)			221

As fifteen plants were undistributed, the above total for the Southern states is probably slightly too low. The value of the acid produced in Virginia, Maryland and Georgia in 1917 was more than $5,000,000 for each state.

During 1917 and 1918 many new sulphuric acid plants were built in the Southern states, some of them of unusual size. A chamber plant of 600 tons daily capacity had been barely completed at Little Rock, Ark., when the armistice was signed, and had not yet been put into operation. At Brunswick, Ga., a chamber plant for the manufacture of 800 tons per day of 60 deg. Bé. acid was 40 per cent completed on Nov. 11, 1918, but work on the plant was stopped after the signing of the armistice. A large contact plant at Nashville, Tenn., was 75 per cent completed on the day of the armistice, and construction work on this plant also has been stopped.

Even before these large plants were designed, however, the South already had the largest sulphuric acid plant in the world—larger than either the Little Rock or the Brunswick plant—in the 6,500,000 cu.ft. of chamber space owned and operated by the Tennessee Copper Co., at Copperhill, Tenn. The average daily capacity of this plant is 1,000 tons (60 deg. Bé.), but the output often falls short of this amount, owing to fluctuations in the supply of gas. It has produced, for ten consecutive days, a daily average of 960 tons of 60 deg. Bé. acid, and there have been single days when over 1,100 tons of acid were reported.

FIG. 3. FUMELESS OPERATION AT THE TENNESSEE COPPER CO.

For a long time the plant operated on the waste fumes of the copper blast furnaces only. Up to this year, no practical means had been developed of utilizing the waste fumes of the copper converters, and the equivalent of fifty tons or more daily of sulphur had for a long time escaped. Recently it has been found possible to utilize the converter gas, in addition to the blast-furnace gas, without any addition whatever to the size of the acid plant. The gases from both sources (furnaces and converters) are combined in one common flue, and by means of lead fans of unusual size are drawn into the capacious chambers, and are there condensed into acid. By this means practically all the sulphur volatilized, by furnaces and converters, is recovered as acid. The sulphur recovery for the months of October and November this year was 90 per cent, based on total sulphur volatilized. Since a recovery of 95 per cent of the sulphur, for a plant built exclusively for the purpose of making sulphuric acid, is considered good practice,

FIG. 1. ARMOUR ACID PHOSPHATE PLANT

it is apparent that the sulphur loss at this huge byproduct plant is approaching an irreducible minimum. The dense white fumes, formerly seen escaping from the tall chimney, the irritating gases, which in past years had swept the furnace charging floors, a detriment to successful furnace operations and a serious handicap to the furnace tenders, are today conspicuous by their absence. The atmosphere in the vicinity of the smelter is almost entirely free from sulphurous gas, and the 325-ft. chimney, which formerly poured forth vast volumes of sulphurous gases, stands today cold and empty —a monument to the waste of the past. The accompanying photograph (Fig. 2) illustrates the effect "before," Fig. 3 shows the effect "after," instituting the recent improvements in operating methods.

Fertilizer

As the manufacture of acid phosphate is dependent on the sulphuric acid industry, so the vast fertilizer business of the United States is dependent on the acid phosphate industry. The three largest manufacturers of chemical manures are the American Agricultural Chemical Corp., the Virginia-Carolina Chemical Co., and the International Agricultural Corp. Most of the plants of these concerns are located in the Southern states, and in addition there are scattered throughout the South

many fertilizer plants owned and operated by the well-known meat packing concerns—Swift, Morris and Armour—as well as many owned by independent concerns, some large, such as the Royster Guano Co., and some smaller ones.

The manufacture of complete fertilizer consists in mixing acid phosphate in suitable proportions with nitrogenous materials, such as dried blood, tankage, fish scrap, or cottonseed meal, and potash salts. Sometimes the nitrogen or the potash is omitted, in which case the product becomes either "alkaline goods" (acid phos-

FIG. 5. MORRIS & CO. FERTILIZER PLANT

phate with potash) or "ammoniated superphosphate" (acid phosphate with nitrogenous material).

The complete fertilizer containing phosphoric acid, nitrogen, and potash, contains these ingredients in some definite proportion, such as 8 parts of the first to 2 parts of the second to 2 parts of the third—in which case the fertilizer would be known as "8-2-2" grade.

The manufacture and sale of fertilizers in the Southern states is regulated and controlled by state laws, supported by state chemists and their laboratories.

Table IV shows the amount of fertilizers consumed in the Southern states in 1918, compared with the total consumption for the United States.

TABLE IV. CONSUMPTION OF FERTILIZERS IN THE SOUTHERN STATES AND IN THE ENTIRE U. S. FOR THE FISCAL YEAR ENDED IN 1918*

States	Tons Consumed	States	Tons Consumed
Alabama	289,990	Mississippi	104,700
Arkansas	88,500	North Carolina	921,962
Florida	197,954	Oklahoma	25,000
Georgia	923,020	South Carolina	1,064,886
Kentucky	128,000	Tennessee	113,000
Louisiana	81,025	Texas	58,000
Maryland	173,000	Virginia	430,549
Total, South			4,599,586
United States			6,991,743

*Compiled from American Fertilizer Hand Book, 1919, page 20.

Figs. 4 and 5 show the Armour Co. and Morris & Co. fertilizer plants, both of Atlanta. In each case, the sulphuric acid plant can be seen at the left.

The statistics given will serve to show the magnitude of these industries of the South. There are many other Southern industries—mineral, chemical, and metallurgical—which will compare, as to capital involved and value of product, with the phosphate, sulphuric acid, and fertilizer industries, and some, perhaps, will surpass these. The coal and iron of Alabama, the coal of Kentucky and Tennessee, the marble of Tennessee and Georgia, the oil of Oklahoma and Texas, the naval stores and cottonseed oil industries, the hardwood industries of the Appalachians—a study of all these would prove profitable to those who are interested in the progress of the South.

504 Citizens & Southern Bank Bldg.,
Atlanta, Ga.

World's Sugar Crop Estimates*

The world's cane-sugar of 1918-19 is estimated to be 340,371 tons less than the production of 1917-18, according to the latest estimates of Willett and Gray. The beet-sugar production is estimated to have decreased by 642,184 tons, making a total estimated sugar shortage of 982,555 tons, as compared with 1917-18. Tables I and II give the final statistics for the years 1916-17 and 1917-18, and the estimates for 1918-19.

TABLE I. CANE SUGAR PRODUCTION

	1916–17, Tons	1917–18, Tons	1918–19 Tons
United States:			
Louisiana	271,339	217,499	250,802
Texas	6,250	2,009	3,125
Porto Rico	448,567	405,174	375,000
Hawaiian Islands	575,510	515,035	520,000
West Indies—			
St. Croix	7,787	5,400	6,500
Cuba	3,023,720	3,446,083	4,000,000
British West Indies:			
Trinidad	70,891	45,256	50,000
Barbados	55,456	65,230	80,000
Jamaica	28,331	34,300	40,000
Antigua	17,046	9,409	11,900
St. Kitts	15,048	8,846	10,000
Other	7,906	16,745	10,000
French West Indies:			
Martinique (exports)	31,443	20,881	35,000
Guadelupe	36,160	28,000	25,000
Dominican Republic	130,171	145,000	165,000
Haiti	.....	.....	18,000
Mexico	50,000	40,000	40,000
Central America	25,000	25,000	30,000
South America:			
Demerara (exports)	101,650	114,007	93,902
Surinam	12,000	10,000	12,000
Venezuela (exports)	18,428	15,000	15,000
Ecuador	7,000	8,000	7,000
Peru	276,000	265,000	250,000
Argentina	87,699	130,266	240,000
Brazil	150,051	148,958	260,000
Total in America	5,456,453	5,721,107	6,548,229
British India (consumed locally)	2,728,000	3,311,000	2,337,000
Java	1,596,174	3,311,000	2,337,000
Taiwan and Japan	436,026	397,618	415,678
Philippine Islands	202,655	216,260	150,000
Total in Asia	4,962,855	5,715,942	4,572,315
Australia	192,831	325,900	226,000
Fiji Islands	95,900	70,800	80,000
Total in Australia and Polynesia	288,731	396,700	306,000
Egypt	101,832	79,450	82,000
Mauritius	209,035	225,466	252,000
Reunion	42,152	50,000	50,000
Natal	114,494	106,250	144,000
Mozambique	55,000	50,000	50,000
Total in Africa	522,513	511,166	578,000
Europe: Spain	4,584	6,000	6,000
Total cane-sugar crops	11,235.136	12,350,915	12,010,544

TABLE II. BEET SUGAR PRODUCTION

	1916–17, Tons	1917–18, Tons	1918–19 Tons
Europe:			
Germany	1,603,920	1,570,578	1,411,900
Czechoslovakia, etc	944,500	668,250	700,000
France	184,191	200,265	109,783
Belgium	135,031	131,000	75,000
Netherlands	269,180	199,295	164,981
Russia, Ukraine, Poland, etc	1,321,600	1,028,580	700,000
Sweden	150,000	125,000	119,000
Denmark	112,800	115,000	115,000
Italy	140,000	110,000	100,000
Spain	125,540	134,955	135,000
Switzerland	4,000	4,000	4,000
Bulgaria	15,000	11,000	8,000
Total in Europe	5,005,762	4,287,923	3,642,664
United States	734,577	682,867	674,892
Canada	12,500	11,250	22,300
Total beet-sugar crops	5,752,839	4,982,040	4,339,856
Grand total cane and beet sugar	16,987,975	17,332,955	16,350,400

Importance of the Soap Bubble

R. S. Williams calls attention in the *Journal* of the Society of Chemical Industry in an article on the theory of flotation to the fact that the forces at work in a soap bubble are of such technical importance that 60,000,000 tons of ore are annually treated by their application.

**Fortnightly Information Review* of American Chamber of Commerce in France, Sept. 15, 1919, p. 273.

Some Aspects of Cheap Cyanide Processes*

Review of the Developments Made in Cyanide Synthesis—Improvements Made in the Ferrocyanide Process—Reactions Between Nitrogen, Carbon and Alkaline Bases—Fixation in the Electric Arc—Cyanamide Process

BY HERBERT PHILIPP
Consulting Chemical Engineer

THE possibilities of cyanide manufacture cover practically the whole field where cyanogen products can be or are produced, because in one way or another alkali cyanide can be formed from almost any compound containing cyanogen. This accounts for the varied processes proposed by inventors and chemical engineers.

Cyanogen products are deserving of interest; they are on the boundary between inorganic and organic chemistry, in fact, they are on both sides of the fence, which often creates some inconvenience.

An alkali cyanide (RCN) has all the properties of an inorganic salt, like an alkali halide. yet from an organic point of view it must be considered as the nitrile of formic acid, and its chemical behavior bears it out.

For instance, if a cyanide is hydrolyzed under proper conditions we get a formate:

$$NaCN + 2H_2O = NaOOCH + NH_3$$

or if hydrogen cyanide is reduced we get methylamine

$$HCN + 2H_2 = H_3CNH_2$$

The same applies to cyanogen (C_2N_2), which is the nitrile of oxalic acid, NC.CN, ethane dinitrile.

History of Cyanogen Products

Cyanogen products hold several historical records. C_2N_2, cyanogen, was isolated in a pure state by Gay-Lussac in 1815, which is the first recorded instance of the isolation of a compound radical. Another record, which I shall refer to a little later, is the fact that the first commercial process in the world for using atmospheric nitrogen to form a chemical compound was a process for the manufacture of ferrocyanides.

By the word "cyanide" in this paper I refer to an alkali cyanide, which has reference today chiefly to sodium cyanide, potassium cyanide being met with scarcely any more in the commercial world, except as a pharmaceutical and laboratory chemical.

When cyanide first became a commercial article, it was in the form of potassium cyanide, and as the art developed mixtures of sodium cyanide and potassium cyanide became the commercial article, while today sodium cyanide of high purity is universally used.

Since the user of cyanides really only wants the cyanogen ion (-CN), it is not so important whether sodium or potassium is the carrier. Since the largest users of cyanide are located long distances from points of manufacture, the more -CN a product contains the lower the freight charge on the cyanogen bought, therefore the lower the atomic equivalent weight of the carrier of the cyanogen ion the better the consumer likes it.

Thus lithium cyanide would be a very desirable product if it could be manufactured cheaply enough, and even calcium cyanide would be better than sodium cyanide. Owing, however, to the instability of calcium cyanide, it is doubtful whether it will ever have a commercial future.

Uses of Ferrocyanides and Cyanides

Originally, ferrocyanides were manufactured to make prussian blue, which was, and still is, used as a coloring matter. Alkali cyanides became important only after the McArthur and Forest researches around 1890 showed such astonishing results in the working up of low-grade gold ores. The cyanide industry obtained an impetus and vitality at that time which made it acquire rapid development, and as its production price decreased, more and more uses for cyanide have been found, so that there is every reason to believe that the demand for cyanide will still increase. Despite the fact that the flotation process in the mines has decreased the use of cyanide, the other uses of cyanide are continually increasing, so that as far as the disposition of cyanide is concerned, its use in the mines will soon be of secondary importance.

In Fumigation and Industries

Fumigation with hydrocyanic acid has developed into a large industry, and possibly the largest consumption of cyanide must be credited to this industry. A short time ago fumigation with hydrocyanic acid was done by generating the gas where the fumigation took place, but now liquid hydrocyanic acid is used direct and there are two plants in California manufacturing the acid. The greatest use of hydrocyanic acid is for an insecticide (originally for killing the San José scale) in the orange groves, and I believe today every orange coming from California has undergone a fumigation with hydrocyanic acid. Hydrocyanic acid is perhaps the best insecticide known, and can be used for fumigating plants and foods without detriment. Buildings and vessels can be fumigated with advantageous results, in fact the United States Government has already used this process on many ships. The difficulties regarding the transportation of hydrocyanic acid, which I have no doubt will be overcome, prevent this material being more extensively used.

The electroplating industry, which also includes the metal cyanides, are also important users of cyanides. The casehardening of steel, where sodium cyanide and also ferrocyanides are used, has grown extensively with the increased production of motor vehicles and other mechanical arts. Smaller uses include submarine paint, fluxing powders for brazing and welding, organic chemicals, pharmaceutical and laboratory reagents.

Consumption of Cyanides

It is very difficult to give any exact data regarding the consumption of cyanides in this country, as the

*Paper read before the New York Section, American Electrochemical Society, Jan. 23, 1920.

Government statistics generally include other chemicals, owing to the fact that for many years there has only been one producer. Therefore, the figures given here can only be considered approximately. In 1898 the consumption in the United States was about 3,000,000 lb.

The consumption was practically trebled in the next year (1899). The consumption has continually grown, about 16,000,000 lb. per year being manufactured in the United States between 1914 and 1918, according to Government statistics, while previous to the war an additional 9,000,000 lb. per year was imported. Of course during the war very little of European goods found their way here. During 1917 about 1,500,000 lb. came here from England. There appears therefore to be a market here for about 25,000,000 lb. per year.

Commercial Cyanide Processes

Originally potassium cyanide was manufactured from ferrocyanides, by just heating the same.

$$2K_4Fe(CN)_6 = 8KCN + 2FeC_2 + 4N$$

Here was a large loss of nitrogen, and a great improvement occurred when the ferrocyanide was melted up with potassium carbonate.

$$2K_4Fe(CN)_6 + 2K_2CO_3 = 10KCN + 2KCNO + 2CO_2 + 2Fe$$

Here the finished product was contaminated with cyanate, which, however, did not offer any detriment to the extraction of gold from the ore.

Over twenty-five years ago Hamilton Y. Castner produced metallic sodium comparatively cheaply and this allowed the cost of the above process to be considerably lowered. Instead of using potash for making a melt with the ferrocyanide, sodium was used, thus giving all the nitrogen as cyanide.

$$K_4Fe(CN)_6 + 2Na = 4KCN + 2NaCN + Fe$$

Sodium or potassium ferrocyanide we will always have with us as long as the gas industry lasts. In the gas industry a large number of complex cyanogen and ferrocyanogen products are collected, which are converted to ferrocyanides. There is a good market for sodium ferrocyanide today, and the price is too high to allow it to be used as a raw material for making sodium cyanide.

Castner and Pfleger's Process

Soon after this an entirely new process for the manufacture of cyanides was developed, using Castner's metallic sodium as a basis. The process was developed by Castner and Pfleger, and is important, as it is the predominant cyanide process of today.

The process is chemically very simple:

$$2Na + NH_3 + C = 2NaCN + 3H_2$$

This reaction, however, takes place in three steps.

(1) $2Na + 2NH_3 = 2NaNH_2 + H_2$

(2) $2NaNH_2 + C = Na_2CN_2 + 2H_2$

(3) $Na_2CN_2 + C = 2NaCN$

The process is very interesting and deserves the greatest consideration for anyone developing a new process. The commercial manufacture of cyanide by this method is very clean, and as the finished product is a melt and is cast direct into forms, very little handling is required and no loss by decomposition is endangered, as in the case where solutions are handled. It has none of the disadvantages or expenses encumbering a process where cyanide has to be separated from liquids.

The expensive raw materials are ammonia and metallic sodium. As regards ammonia, we all know that a synthetic process for making cheaper ammonia will soon be realized. Metallic sodium is made by the Castner process by electrolyzing caustic soda, and this process has been considerably improved in the last decade by Dr. H. R. Carveth and his assistants. There is also another sodium process in commercial operation in West Virginia, where sodium chloride is electrolyzed. This process was developed by R. J. McNitt. I especially bring these points out, because cyanide manufactured by this method is not burdened by any leaching or dissolving process, which in the case of cyanides is quite an expensive and unpleasant operation, and even with the higher cost of raw materials a synthetic process where the finished product has to be leached out must be very efficient to offset the higher priced raw materials in the present process.

The Schlempe Process

Another process which is worthy of mention is the so-called "Schlempe process." This process uses the residues from beet sugar manufacture (vinasse). This process has been in operation in Germany at the Dessauer Refinery since about 1900 and was developed to a commercial success by Bueb. Owing to the large distance separating the various beet sugar factories here, it has possibly been found impractical to install such a plant, because a small plant could easily use the residues from several beet sugar plants.

The vinasse consists chiefly of potash salts. The vinasse is distilled and the vapors contain ammonia and trimethylamine. This latter is passed over heated porcelain and decomposed at a temperature of 1,000 to 1,100 deg. C. into HCN.

$$N(CH_3)_3 = HCN + 2CH_4$$

The gases have to be moved rapidly, otherwise the hydrocyanic acid gas decomposes:

$$HCN + 3H_2 = NH_3 + CH_4$$

The hydrocyanic acid is absorbed by caustic soda solution and evaporated *in vacuo*, and at a temperature of 30 deg. C., cyanide separates out. The carbonized residue left in the distilling retort is leached to obtain potash salts.

Recovery of Alkali Cyanides From Aqueous Solutions

Just a word on the recovery of alkali cyanides from aqueous solutions. Owing to the easy decomposition of aqueous solutions containing alkali cyanide, many of the earlier processes failed.

The two following reactions are likely to take place where cyanides are in solution:

(1) $NaCN + H_2O = HCN + NaOH$

(2) $NaCN + 2H_2O = NH_3 + NaCOOH$

If cyanide solutions are contaminated with salts, other than small quantities of the hydroxide or carbonate of the alkali, recovery by crystallization is very difficult and generally impossible. Therefore it has frequently to be converted into ferrocyanide and crystallized.

When a solution is obtained by saturating a pure caustic solution with hydrocyanic acid, a little excess of caustic should always be allowed to remain. Such a solution can be evaporated *in vacuo* and cooled, when crystals of cyanide ($NaCN, 2H_2O$) will appear. These crystals are centrifuged and dried *in vacuo*, when a white loose powder of anhydrous cyanide will remain. The powder can be compressed into briquets at a pressure of about three tons to the sq.in. These treatments

require that the cyanide has to pass through several costly steps, and the longer the cyanide is in solution the greater the loss by decomposition.

New and Proposed Processes

We now come to a discussion of some of the possible new fields for the development of future cyanide processes. The future development in this direction will use atmospheric nitrogen as the basic raw material, and the processes can be divided into two main groups, namely, direct synthetic formation of cyanides and the indirect formation of cyanides.

The first group (I) is divided again into two subdivisions, (*a*) cyanides from nitrogen, alkali, and carbon, and (*b*) fixation of hydrogen, carbon (or hydrocarbons) and nitrogen in the electric arc or at high temperatures.

The second main group (II) consists of making cyanides indirectly from carbides, nitrides and combinations of these compounds.

Cyanides From Nitrogen, Alkali and Carbon

The formation of alkali cyanide by passing atmospheric nitrogen over heated alkali carbonate and carbon is very old.

Already in 1839 Lewis Thompson spoke before the British Society of Arts on making prussian blue by passing atmospheric nitrogen over carbon and potash under favorable conditions, and in 1843 Possoy and Boissierre (Br. Pat. 9,985) erected a factory near Paris to make potassium ferrocyanide by passing atmospheric nitrogen over strongly heated charcoal saturated with potassium carbonate. Owing to the excessive fuel requirements the process was moved after one year to Bramwell & Co.'s works at Newcastle, England, who were manufacturers of prussian blue. Several improvements were introduced, and cheaper fuel obtained. Iron ore was added to the charge in the retorts, and the process was in operation for two years and is reported to have manufactured one ton potassium ferrocyanide per day. The process was not a commercial success and was abandoned on account of the large amount of fuel used and the short life of the retorts.

The Possoy and Boissierre process is of great historical interest, as it is the first commercial process on record where atmospheric nitrogen was used as a raw material and entered into the reaction, and the value of iron as a catalytic agent was recognized even before the publication of Bunsen and Playfair's investigations (*Brit. Assoc. Report*, 1845, p. 185) on the formation of potassium cyanide in the blast furnace.

Many Experiments With Small Variations

Since that time a host of experimenters have taken up this subject and with small variations have endeavored to find a process for making cyanide by an inexpensive process.

In 1862 Marguerite and Sourdeval replaced the potash with barium hydrate and carbonate, which appeared to be a great step forward, as barium products, especially barium carbide, have great affinity for nitrogen and further, the barium oxide and carbonate do not fuse as easily as the corresponding alkali compounds. The nitrogen was exceedingly well absorbed, but no cyanide was manufactured, only ammonia, as steam was passed over the mass at 300 deg. C. Mond (U. S. Pat. 269,309), in 1892, tried to improve this process by mixing calcium carbonate, magnesium carbonate, strontium carbonate to the mass, with the idea of increasing the ammonia yield.

V. Adler's patents (Ger. Pat. 12,351 *et al.*), 1881-1885, are worthy of mention and show that he did quite a lot of work to accomplish commercial results, and if the engineering art had been as far advanced then as it is today he would have possibly achieved far better results.

However, many attempts have been made and much money has been spent on these efforts to manufacture cyanides from the nitrogen of the air by these methods, and a large number of patents exist for more or less improvements, but in spite of all efforts none of these methods has become commercially successful.

Even today similar processes are being developed, but as far as I know no product by these processes is yet on the market.

The Bucher Process

This method of forming cyanides has been very thoroughly brought out recently by John A. Bucher (*Amer. Inst. Chem Eng.*, 1916, p. 335). The work of Prof. Bucher has been widely quoted and his laboratory work is very creditable to him. The Bucher process is very similar in principle to the older processes and recognizes that large quantities of iron must be present to obtain satisfactory results. This process was recognized at the beginning of the war by our Government as worthy of development, and a plant was erected at Saltville, Va., to manufacture cyanide by this method. Although the plant was not put in operation during the war, the Government officials reported that the process could be considered commercially successful. However, as far as I know no material by this process has reached the market. Very similar work is being undertaken by the Air Reduction Co.

The reaction taking place is as follows:

$$Na_2CO_3 + 4C + N_2 = 2NaCN + 3CO - 138{,}500 \text{ cal.}$$

The advantage of such a process compared with the present one is the use of cheap raw materials. The most important steps in the manufacturing process are the fine grinding of iron and charcoal, impregnating the mass with sodium carbonate, making it up into uniform size pieces and very thoroughly drying the formed mass. These pieces are then introduced into a retort externally heated, and reacted on with atmospheric nitrogen at temperatures below 1,080 deg., as above that temperature the formed cyanide decomposes in the presence of iron.

$$2NaCN + Fe \text{ above } 1{,}080 \text{ deg. C.} \rightarrow FeC_2 + 2Na + N$$

The cyanided mass in the retort must be either allowed to cool in an atmosphere of nitrogen in the retort or else taken out of the same without allowing the heated mass to come in contact with the air, as in the latter case decomposition takes place by the burning of the cyanide and the formation of iron cyanogen compounds, which would necessitate converting the cyanide products formed into ferrocyanide. When the mass is cold the soluble cyanide and unconverted carbonate is lixiviated with water, great care being used to prevent formation of ferrocyanide. It is advisable to have a slight amount of unconverted sodium carbonate present, as this helps prevent the formation of ferrocyanide.

The further steps represent the separation of the sodium cyanide from the aqueous solution, which I have already described. Efforts have been made to use organic solvents to extract the cyanide instead of

water, which would be very desirable, but this adds to the expense.

The disadvantages offered by this process are the number of steps involved, the short life of the retorts, the inability to use the finely divided iron many times, owing to the accumulation of impurities, and the separating the sodium cyanide from aqueous solution. It will therefore be seen that the expense incurred to overcome the many disadvantages considerably offsets the advantage of using cheap raw materials. In connection with lixiviation it is practically impossible to dissolve out all the sodium cyanide from the mass, and 0.5 to 1 per cent cyanide remains undissolved. This could of course be extracted, but the time involved and the extreme diluteness of the solution obtained makes such a step uneconomical.

The R. & H. Developments

In 1894 H. Y. Castner (U. S. Pat. 239,643) described a process for the formation of sodium cyanide by passing a current of nitrogen over heated charcoal upon which the alkali metal flows. As far as I have been able to ascertain he did not conduct any experiments in this direction, expecting later to undertake the investigation which his early death prevented him from carrying out. However, during the last decade considerable work in this direction has been carried on by the Roessler & Hasslacher Chemical Co. By the direct combination of the elements sodium, charcoal and nitrogen, sodium cyanide is formed. This reaction is exothermic and on a small laboratory scale gives very efficient results.

In developing this process to a commercial scale a large number of difficulties have had to be dealt with. In this process a simple end product is desired, as in the present process where ammonia is used instead of atmospheric nitrogen, that is, the finished furnace product must be a pure melt of sodium cyanide.

The desired reaction is as follows:

$$2Na + 2C + N_2 = 2NaCN + 46{,}200 \text{ cal.}$$

If nitrogen gas and sodium vapor are passed over heated charcoal, sodium cyanide is easily formed. Even at temperatures as low as 650 deg. C., the cyanide is formed. With a rise in temperature the reaction is speeded, and if temperatures over 1,080 deg. are obtained no iron retort must be used, as otherwise the iron will decompose the formed cyanide and the retort will gradually go to pieces. Of course catalytic substances, like iron, will help speed the reaction at lower temperatures, but in that case the cyanide would have to be lixiviated, which disadvantage would easily offset any advantages over the present process, where ammonia is used.

The great difficulty experienced is not in obtaining a suitable material for a retort, but in separating the formed sodium cyanide from the charcoal. Although sodium cyanide melts below 600 deg. C., it is held fast by the charcoal, in which it is absorbed, and surrounds the particles of charcoal so that sodium vapor and nitrogen cannot come in contact with it. Of course a large amount of formed cyanide will drip off the charcoal mass, but a cyanided mass will by degrees fill the retort.

The alternative of this difficulty is to distill off the formed cyanide, which is feasible, as there are no other substances present which could distill over. In the case where sodium carbonate or chloride is present it is not easy to distill the cyanide, as both these salts are more volatile than sodium cyanide. Sodium cyanide can be heated to a high temperature without decomposing. Temperatures of 1,250 to 1,300 deg. C., about which temperatures sodium cyanide distills, do not decompose it. Sodium cyanide can be volatilized at a much lower temperature in a current of nitrogen gas.

The process consists of feeding finely divided charcoal into a retort or electric furnace, which must be heated initially to start the reaction. This reaction, being exothermic, can be self-sustaining. Sodium vapor can be produced inside of the furnace or else conducted from the outside into the carbon mass. The nitrogen of course must be led from the outside. The finished product, which is distilled off, can be melted again and cast into forms or can be used as taken from the condensers.

The advantages such a process would show are an exothermic reaction, continuous operation of furnace, little or no expense on finished furnace product, and few steps in the operation.

The disadvantages are the high cost of one of the raw materials, namely, metallic sodium. I do not think sodium cyanide from such a process is regularly reaching the market, although quite a quantity in the past has been produced. The process is not yet far enough advanced to be considered a commercial success.

Fixation in the Electric Arc

The commercial development of making hydrocyanic acid gas at high temperature was started only shortly before the war, although laboratory experiments date back to the latter part of last century.

The electric-arc furnaces have for their object the synthesizing of hydrogen and carbon (or a hydrocarbon) with atmospheric nitrogen. Much of the experience gained by the work done to combine the nitrogen and oxygen in the arc has considerably helped the development of such processes, although as early as 1879 James Dewar showed that gaseous mixtures containing nitrogen and hydrogen passed over heated carbon formed hydrocyanic acid.

Whether hydrocyanic acid or cyanogen is formed synthetically is not of such great moment, as they can both be converted into cyanides by absorbing them over or through a fused alkali or solution of alkali hydrate, although hydrocyanic acid is the most desired product. Dewar considered the temperature of the electric arc was necessary to combine these elements; Smith and Hutton of the University of Manchester showed by laboratory experiments that hydrogen and nitrogen in contact with carbon at temperatures above 1,800 deg. C. produced hydrocyanic acid to a very marked extent, the formation of hydrocyanic acid increasing rapidly with the increase of temperature.

The Lipinski Process

The work of A. V. Lipinski (*Z. Elektrochem.*, vol. 17, p. 761) is certainly deserving of interest. He investigated the formation of hydrocyanic acid by reacting methane and nitrogen in the high potential arc, and just previous to the war this process was developed to a commercial scale at Neuhausen, Switzerland. The process was in 1914 declared to be working well, and the trouble which had been originally experienced by carbon depositing on the electrodes was reported to have been overcome. It is reported that the methane was completely converted into hydrocyanic acid according to the following equation:

$$2CH_4 + N_2 = 2HCN + 3H_2$$

The use of hydrocarbon of course overcomes the use of hydrogen as a raw material. However, Lipinski obtained the best results by using a mixture consisting of 13 to 24 per cent nitrogen, 5 to 10 per cent methane, 66 to 81 per cent hydrogen. It was reported that 30 g. HCN per kw.-hr. were obtained.

To overcome the use of hydrogen as a raw material experiments were conducted to use richer hydrocarbons, which of course would increase the possibility of carbon deposits on the electrodes and other parts of the apparatus. This is one of the great objections in all high-temperature processes where hydrocarbons are used. The carbon deposited at high temperatures is extremely dense and seems to be of a graphitic nature, and it packs so hard that it is often extremely difficult to remove. This is corroborated by looking over the patent literature, where one will note the suggestions made to obviate carbon deposits. Whether Lipinski's process has continued to prove commercially successful I am unable to say, as no news regarding it has reached this country during the last four or five years.

The use of catalyzers and contact substances to reduce the reaction temperature has also received considerable attention; in fact, Lipinski used metallic vapors in his arc and also vapors of salts, like calcium chloride. P. A. Starke (U. S. Pat. 1,306,862) considerably lowers the temperature of synthetically combining hydrogen, nitrogen and hydrocarbon by passing the same over catalytic masses containing iron, nickel and cobalt, together with an earth alkali oxide, but offers no figures as to results obtained. His work is possibly still in an experimental stage and no doubt considerable difficulties have to be overcome to make such a process commercial. Starke uses no arc, but claims temperatures between 800 and 1,000 deg. C.

It is very probable that quite a lot of work has been done with arc furnaces for making cyanides and hydrocyanic acid of which little has been published. This field offers certainly a possible solution for the formation of cheaper cyanides.

If results of 30 g. HCN can be obtained per kw.-hr., such a process would prove very valuable for making cheap cyanides. Even with power at $20 or over per kw.-yr., a large margin is left for the working up of the cyanide solutions. Experiments in working out such developments are possibly no more expensive than the cost of developing some of the processes now being experimented with, and this field holds out one of the hopeful ways to the future production of cheap cyanides.

Cyanides From Carbides, Nitrides and Combinations of These Compounds

In making cyanide indirectly from other products containing combined nitrogen, fixed from atmospheric nitrogen, work has chiefly concentrated on converting the atmosperic nitrogen, combined to calcium carbide, in calcium cyanamide into sodium cyanide.

The manufacture of cheap cyanide from cyanamide is now an accomplished thing and has been developed in this country. As soon as the impetus was given to the cyanide industry, Frank and Caro in 1895 studied the possibility of absorbing nitrogen by passing the same over heated carbide. The affinity of barium compounds for nitrogen had already been recognized, and this perhaps explains why the experiments were started with barium carbide. Nitrogen gas is absorbed easily by barium carbide at comparatively low temperatures, but the resulting product consists of a mixture of barium cyanide and barium cyanamide, $Ba(CN)_2 + BaCN_2$, this material, according to G. Erlwein (1903, Fifth Inter. Cong. of Appl. Chem., vol. 1, p. 646) if used with sodium carbonate and carbon converts all the nitrogen into cyanide. By this method sixth-sevenths of the nitrogen absorbed could be recovered as sodium cyanide. The idea was to convert the barium residues again into carbide and use it over and over again, but owing to the impurities remaining in the carbide and continually increasing, the reaction product had to be discarded after a few operations. This method proved too costly and the process was abandoned. The experiments were continued, using calcium carbide as the reaction material, and in this case no cyanide was formed, the product being calcium cyanamide, $CaCN_2$. Erlwein and Frank tried to convert this material into cyanide by fusing it with sodium chloride, but only traces of cyanide were formed.

The following reaction is supposed to take place by fusing calcium cyanamide with sodium chloride:

$$CaCN_2 + 2NaCl \rightleftharpoons CaCl_2 + Na_2CN_2$$

As commercial calcium cyanamide already contains carbon, it was expected that the following reaction would take place:

$$Na_2CN_2 + C = 2NaCN$$

but this reaction did not take place and no results were obtained. It was then suggested by Freudenberg of Frankfort to use the calcium cyanamide material in the fertilizing industry.

Commercial Process Developed by Dr. Landis and His Staff

P. Kruger (Ger. Pat. 246,064) stated in 1910 that charcoal must be added to the calcium cyanamide-sodium chloride fusion to convert the cyanamide nitrogen into cyanide. It remained, however, for Dr. Landis and his staff to develop a commercial process in this direction.[1] It is true the product is only a low per cent sodium cyanide-containing mass (35 per cent NaCN), yet it is finding extensive use. It is very probable that experiments are being conducted to obtain a higher percentage product. It will not be an easy matter to distill off the cyanide, as the other salts present in the mass would volatilize with the sodium cyanide.

The advantages of such a process are cheap raw materials, and the disadvantages are the large number of steps in the process, the fact that the furnace must operate intermittently and the low per cent product obtained.

Another field open for investigation lies in the formation of certain metallic nitrides or carbonitrides. It is well known that several elements, like titanium, magnesium, aluminum, etc., form combinations with nitrogen and carbon. It appears that small experiments along these lines have been conducted; but nothing of any definiteness has yet been published which offers anything that could be construed as conducive to allow immediate hope for any development here to produce cheap cyanides. The field is still wide open and a lot of scientific investigation must preface such work, to study conditions of formation of nitrides and carbonitrides, their properties and possibilities of converting the combined nitrogen into a cyanide-containing material.

Industrial Laboratories.
New Brunswick, N. J.

[1] See W. S. Landis, "A New Cyanide," Chem. & Met. Eng., vol. 22, No. 6, Feb. 11, 1920, pp. 265-268.

Tests on Small Engines at High Back Pressures

By Alan E. Flowers, R. J. Pepper and Crosby Field

CALCULATIONS based on theoretical considerations covering a wide range of probable operating conditions such as it would be necessary to make in an attempt to get full rated output when employing high back pressures are given by one of the authors in Chemical & Metallurgical Engineering, Jan. 1, 1919, page 18, vol. 20. Results of tests on small steam-driven compressors operating under conditions different from those given therein, and yet which are frequently found in chemical plants, indicate that the curves may be applied as an approximate method of calculation to these conditions. The increase in steam consumption with an increase in back pressure from

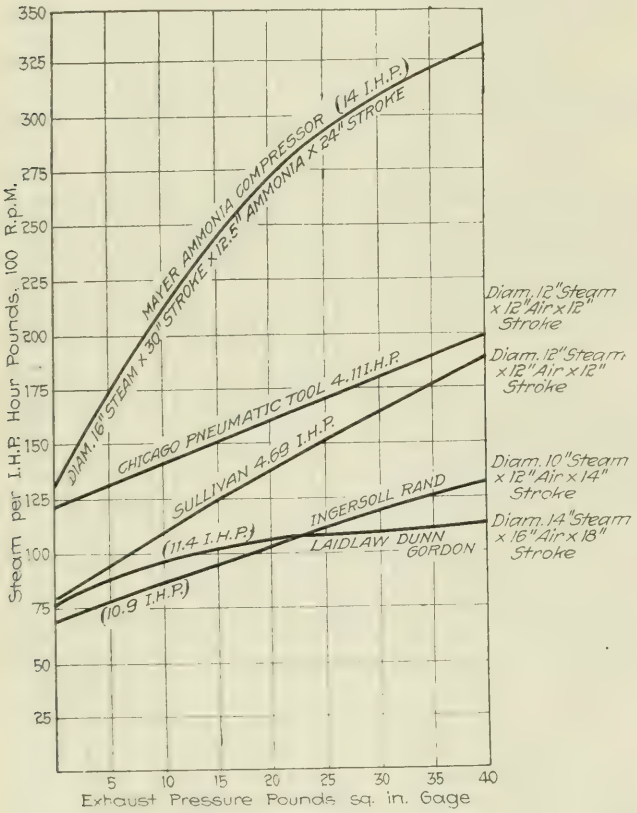

Steam per I.H.P. Hour Pounds, 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR (14 I.H.P.)
DIAM. 16" STEAM x 30" STROKE x 12.5" AMMONIA x 24" STROKE
CHICAGO PNEUMATIC TOOL 4.-111 H.P.
SULLIVAN 4.69 I.H.P.
(11.4 I.H.P.)
INGERSOLL RAND
LAIDLAW DUNN GORDON
(10.9 I.H.P.)
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 10" Steam x 12" Air x 14" Stroke
Diam. 14" Steam x 16" Air x 18" Stroke

FIG. 1. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT NO LOAD

atmospheric to 40-lb. gage in five widely different types of machines varied from 33 per cent to 58 per cent, with an average of 49 per cent. The governors operated on the throttling principle with cut-off constant, but all varied in design, and the quality of the steam varied, whereas the curves in former articles were based on either boiler steam pressure adjustment or variable cut-off and saturated steam. Nevertheless the figure for the increase in steam consumption on the curve most nearly applicable to these conditions was 50 per cent, which compares favorably with the 49 per cent average value found. The actual results found are given in the curves herewith.

The units varied from 12.3 to 80.5 indicated hp. per 100 r.p.m. at full load, the average inlet steam pressure was 120-lb. gage, the average quality of the live steam was 99.2 per cent, while that of the exhaust steam was between 87 and 90 per cent.

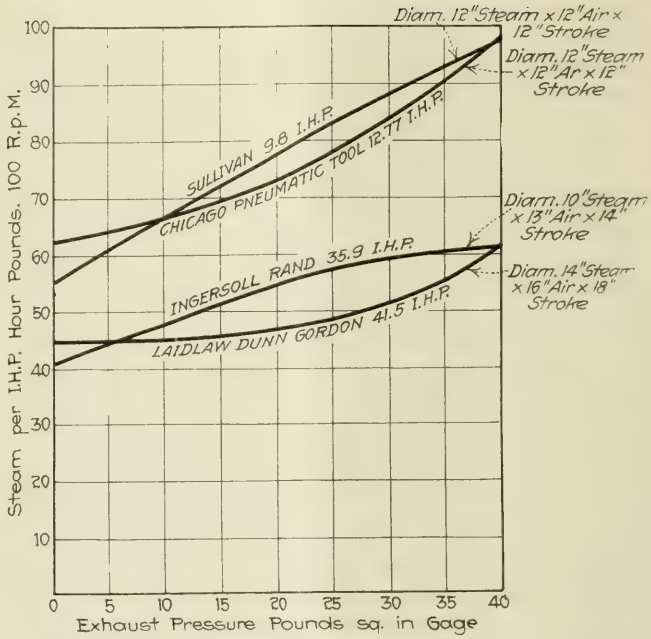

Steam per I.H.P. Hour Pounds, 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
SULLIVAN 9.8 I.H.P.
CHICAGO PNEUMATIC TOOL 12.77 I.H.P.
Diam. 10" Steam x 13" Air x 14" Stroke
INGERSOLL RAND 35.9 I.H.P.
Diam. 14" Steam x 16" Air x 18" Stroke
LAIDLAW DUNN GORDON 41.5 I.H.P.

FIG. 2. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT HALF LOAD

TOTAL STEAM CONSUMPTION—FULL LOAD

Name of Compressor	I.hp. per 100 r.p.m.	Total Steam Consumption at Atmospheric Pressure and 100 r.p.m.	Total Steam Consumption at 40 Lb. Back Pressure and 100 r.p.m
Ingersoll-Rand	51.9	2,025	2,690
Sullivan	12.3	685	1,087
Chicago Pneumatic	18.1	930	1,410
Laidlaw-Dunn-Gordon	59.7	2,150	3,140
Mayer	80.5	5,360	8,440

RATE OF STEAM CONSUMPTION

Name of Compressor	Steam per i.hp. at Atmospheric Pressure	Steam per i.hp. at 40-Lb. Back Pressure	Increase in Per Cent
Ingersoll-Rand (air)	39	51.8	33
Sullivan (air)	56	88.5	58
Chicago Pneumatic (air)	51.5	78	52
Laidlaw-Dunn-Gordon (air)	36	52.5	46
Mayer (ammonia)	66.5	105	58

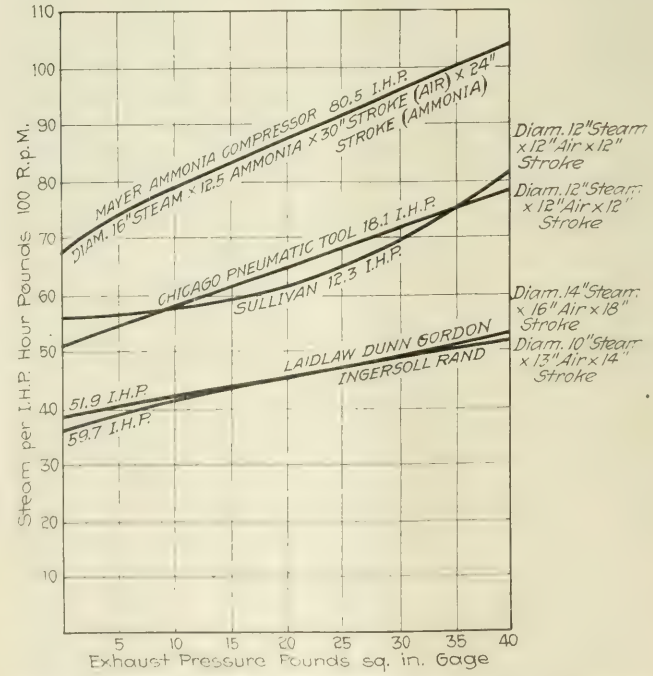

Steam per I.H.P. Hour Pounds 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR 80.5 I.H.P.
DIAM. 16" STEAM x 12.5 AMMONIA x 30" STROKE (AIR) x 24" STROKE (AMMONIA)
CHICAGO PNEUMATIC TOOL 18.1 I.H.P.
SULLIVAN 12.3 I.H.P.
LAIDLAW DUNN GORDON
INGERSOLL RAND
51.9 I.H.P.
59.7 I.H.P.
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 12" Steam x 12" Air x 12" Stroke
Diam. 14" Steam x 16" Air x 18" Stroke
Diam. 10" Steam x 13" Air x 14" Stroke

FIG. 3. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT FULL LOAD

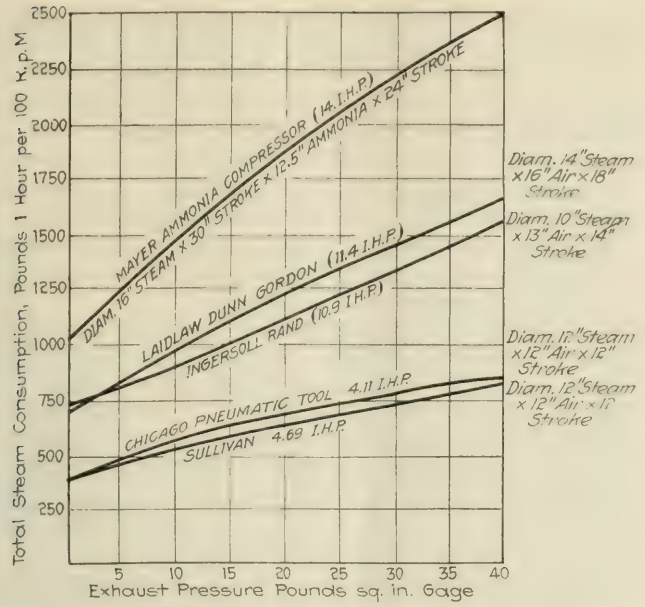

Total Steam Consumption, Pounds 1 Hour per 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR (14. I.H.P.)
DIAM. 16" STEAM x 30" STROKE x 12.5" AMMONIA x 24" STROKE
LAIDLAW DUNN GORDON (11.4 I.H.P.)
INGERSOLL RAND (10.9 I.H.P.)
CHICAGO PNEUMATIC TOOL 4.11 I.H.P.
SULLIVAN 4.69 I.H.P.
Diam. 14"Steam x16"Air x18" Stroke
Diam. 10"Steam x 13"Air x 14" Stroke
Diam. 12"Steam x12"Air x12" Stroke
Diam. 12"Steam x 12"Air x 12" Stroke

FIG. 4. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT NO LOAD

The equipment tested consisted of steam-driven air and ammonia compressors of several different makes and ratings. These units were operated exactly as they had been in normal plant operation except that the exhaust pressure was regulated and held constant at the three chosen values of 5, 20 and 40-lb. gage and the load held constant. Normal power plant units operate in actual service at 40-lb. gage back pressure, and these units have been successfully giving the service demanded of them during several years of operation. Air compressor units are equipped with fly ball type throttling governors, the output remaining fixed. One unit had its governor equipped to be controlled by the pressure of air in the compressed air system.

During the tests the air pressure was controlled by a valve manipulated by an observer stationed at a gage on the compressed air system.

During normal operation, the back pressure was governed by the demand for steam in the 40-lb. steam pressure system, additional steam being supplied when needed for the chemical processes either through an automatically operated reducing valve admitting live steam at 125-lb. pressure to the 40-lb. system or by manually operated valves. On the other hand, when the power demands were such that the exhaust steam of the power units was in excess of the immediate demands of the chemical processes, the plant operator discharged the excess into a hot well, where its heat energy was conserved in warming water. Any desired degree of closeness of control can be obtained by these means.

No heat reservoir was used in connection with this 40-lb. steam system other than that afforded by the volume of the pipe mains. Reservoirs filled with hot water at the temperature of average steam pressure have been used in connection with low-pressure exhaust steam-driven turbo units, and the use of some such

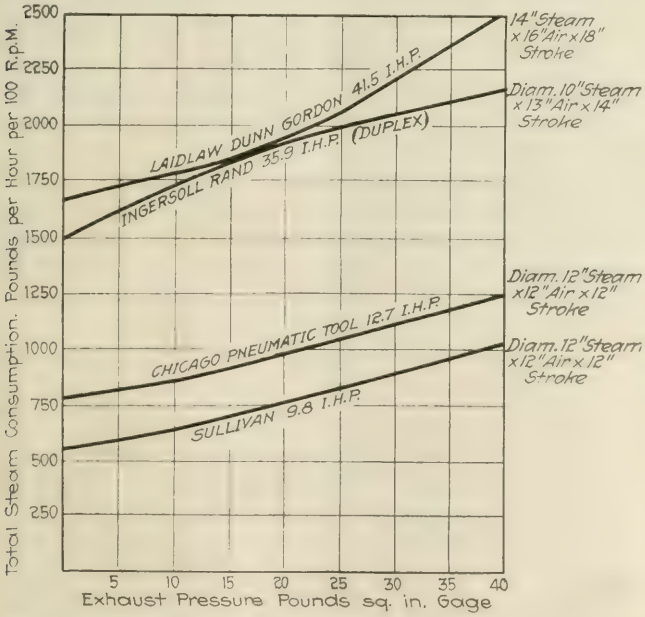

Total Steam Consumption. Pounds per Hour per 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
LAIDLAW DUNN GORDON 41.5 I.H.P.
INGERSOLL RAND 35.9 I.H.P. (DUPLEX)
CHICAGO PNEUMATIC TOOL 12.7 I.H.P.
SULLIVAN 9.8 I.H.P.
14"Steam x16"Air x18" Stroke
Diam.10"Steam x 13"Air x 14" Stroke
Diam.12"Steam x12"Air x12" Stroke
Diam.12"Steam x12"Air x12" Stroke

FIG. 5. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT HALF LOAD

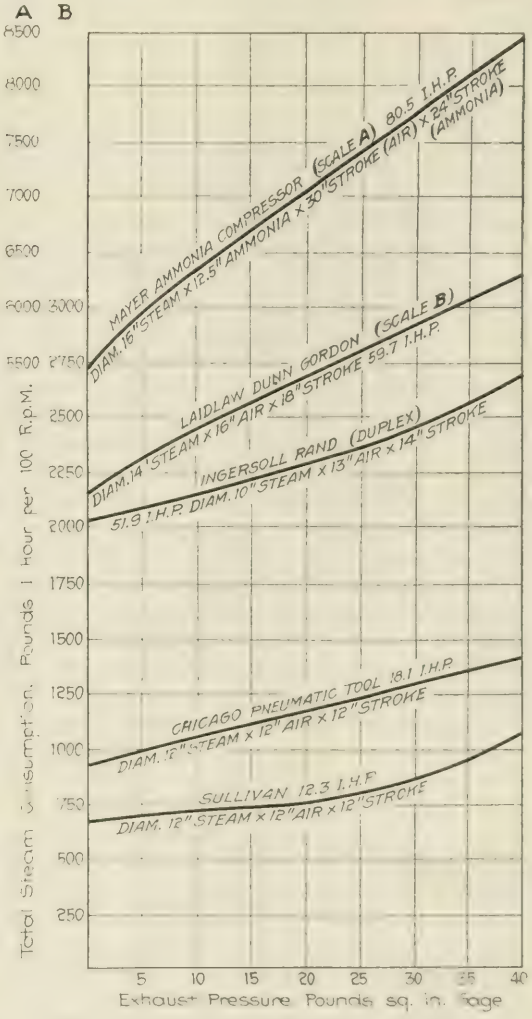

A B
Total Steam Consumption. Pounds 1 Hour per 100 R.p.M.
Exhaust Pressure Pounds sq. in. Gage
MAYER AMMONIA COMPRESSOR (SCALE A) 80.5 I.H.P.
DIAM. 16"STEAM x 12.5" AMMONIA x 30"STROKE (AIR) x 24"STROKE (AMMONIA)
LAIDLAW DUNN GORDON (SCALE B)
DIAM. 14"STEAM x 16" AIR x 18"STROKE 59.7 I.H.P.
INGERSOLL RAND (DUPLEX)
51.9 I.H.P. DIAM. 10"STEAM x 13" AIR x 14" STROKE
CHICAGO PNEUMATIC TOOL 18.1 I.H.P.
DIAM. 12" STEAM x 12" AIR x 12" STROKE
SULLIVAN 12.3 I.H.P.
DIAM. 12" STEAM x 12" AIR x 12" STROKE

FIG. 6. EFFECT OF BACK PRESSURE ON TOTAL STEAM CONSUMPTION AT CONSTANT FULL LOAD

reservoirs should be given serious consideration in any future installation. It should also be noted that moist steam, where the moisture is scattered throughout the distribution system, must act in a similar way in providing heat storage and consequent re-evaporation when needed even more effectively than a tank, because of the greater amount of evaporating surface available, provided the condensate be not completely removed from the system as fast as formed, but remains to some extent along the bottom of the steam mains or, still better, distributed in fine particles through the body of the steam.

The Mayer ammonia compressor was equipped and

regularly operated with a fly ball governor acting through Corliss valve gear actuating an adjustable cut-off. This is the only unit tested equipped with a variable cut-off governor. During the test this unit was controlled in the same manner as the rest by throttling the steam. (One full load run on the Mayer ammonia compressor unit was made with the adjustable cut-off governor in action, resulting in a steam consumption about one-half that obtained with the throttle control.)

The general dimensions and data of the units tested are as follows:

Name of Unit	Steam Cylinder Diameter, Inches	Air Cylinder Diameter, Inches	Stroke, Inches	Piston Rod Diam., Inches	Steam Pipe Diam., Inches	I. hp. per 100 r.p.m.	Air Cyl. Displacement in Cu.ft. per 100 r.p.m.
Ingersoll-Rand	*10	13	14	1¾	3	51.9	215.5
Sullivan	12	12	12	1¾	3	12.3	155.6
Chicago Pneumatic	12	12	12	2	3	18.1	155.6
Laidlaw-Dunn-Gordon	14	16	18	2½	4	59.7	468.0
Mayer	16	..	30	2 5/16	6	80.5	.....
(Ammonia)	..	12.5	24	2 5/16	..	....	340.0

* Duplex.

Operating speeds were usually from about 100 to 150 r.p.m. for the air compressors and about 35 r.p.m. for the Mayer ammonia compressor.

Steam was obtained from boilers that were supplying the entire plant, and the pressure varied somewhat during the tests, the amount of variation being determined by the usual works operating conditions. The average of the values for the steam pressure was used in working up the test results. It should be borne in mind that the load and exhaust steam pressures were closely observed and held constant, so that necessarily the same weight of steam was taken into the steam cylinder at each stroke regardless of the slightly variable boiler pressure. The only effect of a change in boiler pressure would be a corresponding change of speed. The test results have, therefore, been reduced to a common constant speed and may be truly said to represent the steam consumption for the pressures recorded. This conclusion with regard to steam consumption derived from theoretical considerations, as stated above, has also been checked and confirmed by plotting a number of the individual test values obtained at different boiler pressures and corresponding speeds. All the test results are based upon the carefully checked weights of condensed steam. The scale accuracy was checked with standard weights before the tests were begun. The weight readings were checked throughout the course of each run by keeping the scale beam floating constantly and recording the values at each 6-min. interval and comparing these with the total.

A totalizing revolution counter was used and readings were taken in three different ways. First, the speed was noted for 1 min. following each 6-min. interval, i. e., the difference between totalizing counter reading at beginning and end of each seventh minute. Second, the difference in totalizing counter readings at the beginning and end of each 6-min. interval was obtained. Lastly the total revolutions during the test were obtained as difference between readings at start and finish. The readings for 1-min. intervals were used only for check and the values used in working up the test results were the average obtained from the total reading for each run.

Before the beginning of the test, the condenser was tested for tightness of joints, and for leakage with 40-lb. pressure. Indicator cards were taken at each 6-min. interval and the indicated horsepower calculated from cards.

Surface Versus Bunsen Combustion in Gas-Fired Furnaces

IN AN address made recently to the Gas Engineering section of the Western Society of Engineers at Chicago, Prof. O. L. Kowalke, of Wisconsin University, outlined some experiments he had made in co-operation with the members of the Wisconsin Gas Association to determine the relative efficiency of the ordinary bunsen combustion as practiced in most gas-fired furnaces and the so-called surface combustion.

The problem was to determine what temperature could be attained using the gas-air mixture in each type of furnace and the relative ease with which given temperatures might be maintained. It was also desirable to discover how much oxidation would occur on the metal in the furnace when the atmosphere was either oxidizing or reducing, and the extent of structural change in the metal when heated to fairly high temperatures in strong reducing atmosphere.

Experiments were conducted in an American Gas Furnace Co. No. 5 gas furnace, 15 in. wide, 12 in. high and 18 in. long with ¾-in. gas inlet and 1-in. air inlet pipes. The muffle was removed to simulate conditions found in an ordinary heat-treating furnace. Quartz to pass ½-in. mesh was laid on the floor of the furnace with an angle of slope of 35 deg. A carborundum brick was introduced to serve as an object at which to look with the optical pyrometer.

Various mixers of gas and air were tried, the regular American Gas Furnace mixer, and the McKee mixer being principally employed. Great care is exercised by the manufacturers in constructing these mixers.

The gas was used at a 4- to 6-in. water column pressure and the air at about 5 in. of mercury, or say 2½ lb. A small blower produced the air pressure, while the gas was supplied from the commercial mains. This latter was carbureted water gas with an average B.t.u. of 600, and metered separately to the furnace.

Temperatures Reached

The furnace operating for 3 hr. without quartz bed and with unregulated supply of gas and air reached a maximum temperature of 1,420 deg. C. During this time 990 cu.ft. of gas was consumed. With the bunsen combustion, i.e., where the blast of air aspirates in the supply of gas driving the mixture to mouth of the burner, it was also hard to get high temperature in a short time.

The quartz was introduced to give surface combustion and the air was carefully regulated with an American mixer to give an excess of oxygen of about 0.1 per cent on the average and no carbon monoxide. With a gas consumption of 745 cu.ft. in 2 hr. and 36 min. a temperature of 1,420 deg. C. was obtained.

The McKee mixer was then tested, using bunsen combustion and removing quartz. The air supply was regulated to no CO and about 0.1 per cent oxygen in excess. In 1 hr. and 6 min. with 975 cu.ft. of gas the maximum temperature of 1,591 deg. C. was attained. The fireclay lining began to melt at this temperature and the furnace was shut down.

In the next test the quartz was placed in the furnace, and still using the McKee mixer, in 1 hr. 56 min. the temperature reached 1,700 deg. C. The quartz in front of the orifices melted down. One thousand cu.ft. of gas was consumed.

These experiments seemed to demonstrate that the intimacy of mixtures of air and gas, with a careful regulation of the air supply, is a factor of great importance, and it is a question which may be debated as to whether it is not fully as important as the impingement of the gas on an incandescent surface. In support of this an experiment made several years ago with producer gas giving about 145 B.t.u. per cu.ft. with a certain mixing device produced a temperature of 1,425 deg. C.

Maintaining Temperature

A series of experiments was made in which the temperature was raised to about 900 deg. C. so that an optical pyrometer of the disappearing filament type could be used. This insured certainty of calibration of pyrometer remaining constant.

With the ordinary bunsen combustion and old style mixer a temperature from 985 to 995 deg. C. consumed 125 cu.ft. of gas in 1 hr.

The same mixer and furnace, but with the quartz introduced to give surface combustion, maintained a temperature of 988 to 994 deg. C. for 1 hr., with a gas consumption of 109 cu.ft., or a saving of 16 cu.ft. over the former method.

The test with the McKee mixer, venturi type, used 105 cu.ft. of gas per hr. in maintaining the furnace at a temperature of 883 deg. C.

Oxidation of Metal

Specimens of 0.95 per cent carbon steel, ½ in. diameter, 2 in. long, with flat spots for making measurements, were left in furnace for various periods of time, removed, quenched in water, oxide film just removed and calipered.

In from 5 to 15 min. heat with a 19 per cent carbon monoxide mixture the diameter reduction was 0.0003 in. With a 1 per cent carbon monoxide mixture the loss was about the same. With 0.4 per cent oxygen the loss was slightly increased, and with 1.3 per cent of oxygen the loss in diameter was doubled.

It was found that in a 4 per cent atmosphere of carbon monoxide, acting on 0.95 carbon steel over a period of an hour and a half the specimen was severely decarbonized and the product was practically soft iron.

Woodine

"Woodine" is the new name for wood alcohol which has been suggested by manufacturing chemists in communications to the Commissioner of Internal Revenue. The Commissioner is drafting a bill to govern the manufacture and sale and to safeguard the use of wood alcohol. The chemists suggest that the presence of the word alcohol in the name carries with it the suggestion that it can be substituted for ethyl alcohol. It is also suggested that all wood alcohol be required to carry a label on which appears the words "A poisonous compound."

Secret of German Success in Chemical Works

In a report lately made in Glasgow by D. A. Bost on a visit to the Rhineland chemical works, he attributes the success of German chemical industries to cheap raw materials, cheap power, cheap carriage, discipline among process workers, the business capacity of the chemists, co-operation of chemists and engineers, and the willingness of the manufacturer to spend money because he had faith in the ultimate results.

Legal Notes

By Wellington Gustin

Liability of Stockholders—License to Make and Sell Patented Article Construed

A CASE involving some interesting points of law was recently decided in the Court of Appeals of New York. Here the defendant was sued as a holder of capital stock, not fully paid, by a creditor of the Tear Off Bottle Seal Co., under section 56 of the Stock Corporation Law of New York, which provides as follows:

"Every holder of capital stock not fully paid, in any stock corporation, shall be personally liable to its creditors, to an amount equal to the amount unpaid on the stock held by him, for debts of the corporation contracted while such stock was held by him." (Bottlers' Seal Co. vs. Rainey, 122 N. E., 200.)

It was alleged in the complaint that the debt of the corporation which plaintiff is seeking to enforce arose from the following facts. In December, 1909, the plaintiff granted to one Horner the sole right and license to manufacture, use and sell certain patented bottle caps for a period extending from date of the agreement to July 1, 1913, and in consideration for the granting of such license and patent rights, Horner agreed to pay plaintiff a license fee or royalty on all bottle caps and seals sold, further agreeing to pay and guaranteeing specified minimum sums each year should the aggregate royalties fall below these sums.

After making this agreement and on or about Dec. 29, 1909, Horner, with the consent of plaintiff, transferred all his interest in the agreement to the Tear Off Bottle Seal Co., which assumed and agreed to perform all its terms as agreed by Horner. It failed to perform, however, by failing to pay the amounts agreed upon when they became due. The defendant in this suit became a holder of stock not fully paid on Jan. 10, 1910. His contention is that the debt was contracted on Dec. 28, 1909, when the assignment was made. The plaintiff contended that upon the assignment of the agreement a contingent liability was incurred which ripened into a debt only as bottle caps and seals were manufactured, sold, and the payments fell due.

When Stockholders Must Pay

Said the court, the proper definition of the term "debt contracted," under the statute above quoted, is to be sought in the legislative intent to enforce the obligation to pay for stock which is assumed by one who becomes a stockholder. Under such statutes courts generally hold that a sum payable upon a contingency is not presently a debt and does not become a debt until the contingency has happened. Such decisions have had the result of relieving from liability those who were directors when the agreement creating the liability was signed, because it is said their cases were not fairly within the language of the statute. The same rule of construction must be applied to impress liability as is applied to avoid it.

The court held that the agreement transferred no more than a mere license, giving the right to make, use and sell the patented article for a period less than the full term of the patent. Properly speaking, the transaction was not an assignment of patent. The payments to be made under the contract were for the right to manufacture and sell free from interference for in-

fringement of patent. An agreement to pay such royalties is contingent and creates no debt until the time stipulated for payment arrives, said the court. Because in the meantime before the obligation to pay matures, the rights of the licensee may be lost by the interference of the licensor, or by assertion of a paramount right by a third party, or the license may be abandoned or assigned, with the consent of the licensor, or under conditions terminating the obligation to pay royalties.

When Duty to Pay Royalty Ceases

Nevertheless, as to the minimum payments, as fixed in the license agreement, it was urged the full liability of the corporation was fixed when the assignment was made and that as to such amounts the debt was then contracted. But, said the court, the promise to make such payments is not absolute. In legal contemplation, the enjoyment of the undisturbed use of the patent, not the mere execution of the grant of patent right, is the consideration for the royalties. The debt is not "contracted" until the consideration is furnished. If the right to make, use and sell the patent terminates meanwhile, if the licensor does not respect the right, if it had no right to transfer, then the duty to pay royalties ceases, the time for payment never arrives, and the debt is not contracted.

The debt is not "contracted" until it becomes a fixed liability, absolutely owing, established under the terms of the contract. Citing analogous cases for the rule of law, the court said that when a lease is signed, calling for fixed payment of rent, no debt is contracted until the premises are used or the rent becomes due. Hence the judgment against the stockholder was reversed.

Judgment to Deliver in Writing Unwritten Secret Formulas Is Impossible of Enforcement

From California comes a case dealing with the sale of secret formulas and showing why it is impossible to compel a seller to perform his agreement to deliver his secret formulas in writing. The Supreme Court of that state lays down the correct rules in transactions of this kind (Berry vs. Moulie, 179 Pac., 686).

It appears from the facts that plaintiff and defendant entered into an agreement by which the plaintiff was to purchase from the defendant his business as a manufacturing chemist and his secret formulas for manufacturing his products. This contract was partly carried out, and the business was moved from Florida to California and there established. A year later, difficulties having arisen between the parties, they entered into the contract dated June 30, 1915, which was the basis of this action, for the purpose of settling such differences. This latter contract plaintiff sought to have enforced by a decree of specific performance. Upon trial, findings and judgment were entered in favor of the plaintiff. However, later, this judgment was changed by the court after changing its conclusions of law, upon motion of the defendant. From the new judgment plaintiff appealed.

Courts Will Not Order a Performance It Cannot Enforce

On the appeal the court went into the merits of the contract to show why it would be impossible to enforce a specific performance of such contract. Now it must be understood the courts will not order a performance which it cannot enforce. By this contract the defendant transferred all the property described in the first agreement, dated June 17, 1914, and agreed in addition thereto, upon payment of a certain sum of money, "to immediately deliver possession of all and singular the formulas, recipes, and prescriptions in writing for the manufacture" of the products referred to in said contract of June 17, 1914, and the party of the second part (the plaintiff) thereupon agreed to assume the control, ownership, and management thereof, and to carry on and conduct the business, and to employ the party of the first part (the defendant) as manufacturer of the products on a certain specified salary, such employment to continue until the payments provided to be made by the second party were fully paid.

Plaintiff further agreed that he would use every effort to make the business profitable and successful, and that he would carry the trade marks and name of the seller on all the products, and that in the event that the business be sold one of the conditions of such sale should be the perpetuation, in the business so sold, of the original firm name and every trade mark adopted by it.

Findings of the Court

The court found as a fact "that defendant did not on the 30th day of June, 1915, have, nor has he since had, any written formulas, recipes, or directions for the manufacture of the products mentioned in the written agreement, but that defendant is able to reduce the same to writing, but he would, in order to reduce same to writing, be required to perform personal services and exercise his individual skill for a period of three weeks." The court also found that plaintiff was willing to employ the defendant, but that the defendant refused to perform any service whatsoever for the plaintiff.

Said the Supreme Court, the difficulty of enforcing such a contract specifically is well illustrated by the first judgment entered in the case, wherein it was decreed that the defendant should "write out or cause to be written out and authenticated when so written out" the formulas and recipes referred to in the contract and deliver the same to the plaintiff within 30 days. It was provided that upon writing out such formulas defendant was to receive $1,622, but in the event that he did not do so the plaintiff should be released from this payment. The defendant was also enjoined from engaging in the business of manufacturing such products within the State of California for the period of five years.

Agreement Not Sufficiently Certain

That portion of the decree which sought to compel the defendant to deliver or write out secret formulas is impossible of enforcement, said the court. The agreement to deliver such formulas was "an agreement, the terms of which are not sufficiently certain to make the precise act which is to be done clearly ascertainable." The contract itself was uncertain as to the secret formulas, and apparently the evidence was equally so. The secrets remained within the breast of the defendant, and he alone would know whether or not he had complied with the judgment which required him to deliver the formulas. Again the agreement specifically provided for the employment of the defendant. This agreement "to employ another in personal service" could not be specifically enforced by the defendant. That being true, said the court, there was no such mutuality of remedy between the parties as would permit specific performance.

The Personal Element in a Safety Program for the Foundry*

By M. F. Gartland

WE STATE a fact and we don't need to prove it when we say that the foundry can never be made as safe as a parlor. We may have the most expensive and most modern machinery and equipment that money can buy, our buildings may be models of perfection so far as light and ventilation and general arrangement are concerned, we may coerce our men in the matter of wearing molders' shoes, leggings, and goggles, but the fact remains that a splash of hot iron will still cause a burn when it comes into contact with the human body. A casting or a piece of pig iron will still mash a foot or break a toe if it drops at the right spot at the right time.

Our high-grade equipment will do a great deal to eliminate the splashes and other accidents due to machinery, but beyond that there is yet another element. Improved methods of handling the product will eliminate a great deal of the danger that arises from this source, but no piece of machinery or equipment has ever been made that is entirely fool-proof. We must seek yet further for the final analysis of our safety problem. We shall still have our accidents in spite of all these good things.

Elements of Danger in a Foundry

If we could operate a foundry by machinery from the pig iron yard to the shipping platform without the touch of a human hand, we should have no foundry accidents. But we can't do that; we must have men. Our foundries must be alive with men through every part of every working day. Again, if we had the men of our foundries engaged in the task of making mud pies by hand, we should have no foundry accidents. The element of danger that lies in the nature of our product would be eliminated. But we are not in the mud pie business and we are not making and shipping castings by machinery. We are making our product from pig iron and scrap. To put it on the market we must have men. Men must unload the iron, the coal, and the sand. Men must charge the furnaces and heave in the coal to heat them. Other men must draw off the molten charge and pour it into the molds, and still other men must dump the castings from the molds and follow them step by step through the finishing processes and then put them on board the cars for their destination. In each of these operations from beginning to end there is a certain element of danger from the very nature of the materials and because of the fact that human hands must direct each one of them. This element of danger or hazard can be lessened but never eliminated entirely by the installation and use of more modern equipment.

The Human Element

We are asked to discuss today the strides that have been made in the progress of safety work for foundries. Perhaps the greatest stride possible has been made when we recognize the true nature of our problem and put our hands to the task of its solution. We may say with confidence that the foundries of the country have recognized the problem and that they have set about solving it. We may find conclusive evidence of this fact in every new safety device that is installed and in every piece of so-called welfare work that is being undertaken for the workers in our plants. Owners and managers everywhere are beginning to recognize the human element that enters into their safety problem and they are all striking out, some of them blindly, perhaps, to find its solution. We have housing plans. We have gardens by the thousands for our employees. We have clubs and classes. We have entertainments and socials. We have free clinics and visiting nurses and social service workers. We have bonus systems and plans of profit sharing and a score of other lines of welfare work all trying for the one goal of making the worker a more efficient and better satisfied man. All of these things are good and should have a great deal more of our attention. They should be encouraged among our workmen and should be given larger appropriations of money. We have but to look into our own lives to see how easily men are thrown off their guard. We know that a night without proper rest is fatal to our highest efficiency on the day following, and we know that a long stretch of hard work without periods of proper relaxation and recreation will bring about a breakdown in our better judgments. We may not suffer a broken foot from a falling pig of iron or a burned ankle from a splash of molten metal, but we have accidents in our mental processes which are just as painful and a great deal more costly in dollars and cents. Perhaps we should have a great deal more serious accidents than the foundry laborer has if we carried our load and worked where he works and under the same conditions.

Mental Contentment a Great Safety Factor

We know that everything we do in our leisure time has its effect upon our lives while we are at work. The thing that is true of the executive who works in ideal surroundings is still more true of the man who labors with his hands and earns his living in the heat and smoke and confusion of our foundries. To a very large extent he is made or unmade by the things which happen to him outside of his workday life. So then we may say that a divorce suit in a local court may be more dangerous to the man involved than an open pit near his work bench. A threatening landlord may produce more injuries in our foundry than our worst hazard of equipment. In other words, the man whose mind is ill at ease or who isn't properly housed and fed may make our plant more unsafe than it would be if we removed every safety device in the whole place. The man who was just born careless and never outgrew it is more dangerous to our plant when he is in there at work than he would be if he stood off at a safe distance on the outside and hurled firebrands into it three times a day.

The Misfit

Now let us look at some of these men of ours who are so prone to injury. Let us make up our minds to help them if we can. The effort will pay for itself in many ways. First, there is the man who is a misfit. We didn't know there was such an animal a few years ago, but we are beginning to recognize him now. There are men in all of our foundries who ought not to be there. They have been drawn into our employ through a chain of circumstances and it is hard for them to break away. They belong there just about as much as the members of the National Safety Council belong in the business of deep-sea diving. They have about as much sympathy for our business as the average safety

*Abstract of paper read at the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, October, 1919.

engineer has for the business of the steeplejack. Not having interest in their work, they lack the incentive to become efficient workmen. They drag through the day without enthusiasm and leave when the whistle blows with a full quota of accidents piled up behind them. These are the men who make our State Industrial Commissions keep one eye on our accident charts. It is because of such men as these that we have a high rate of industrial insurance for our foundries of all types.

Need of a Better Understanding of the Men's Abilities

But they are there. Our foreman can point out half a dozen of them any time we ask him. We know they are there, but what are we going to do with them? That question is easier to ask than it is to answer. Perhaps the easiest thing would be to give such a man the opportunity to find work somewhere else. We would have done that in the old days, but we hesitate to do it now; not that we love the man any more than we did, but it is not so easy to replace him with a better man. Another and better solution is to give him his opportunity in some other part of our own plant if possible. We know this plan will work, because we can all call up a great number of individual cases where it has worked. The trouble is that very few if any of us have adopted it as a principle for everyday application. The consistent application of this principle will eliminate a great many of our misfits. It will make careful and efficient workmen out of a great many of our accident makers and will often be the means of keeping a valuable man on our payroll. Of course we can't do this by merely saying that it will be done. If we believe it we must work it day after day, week in and week out. It will call for a closer co-operation between our different production departments and between all foremen and the employment department.

We cannot lay down any rules for the application of this principle. Each case must be handled in its own way. We shall understand our men better; at the very least, our men will understand us better and in this we shall have more of their loyalty and devotion.

The Man With Personal Troubles

The next man who is a great maker of accidents is the man whose mind is ill at ease. He is not so easy to recognize and not so easy to deal with when we do find him. He may be troubled about any one of a score of things and very often there seems to be a combination of nearly all of them. He may be, under ordinary conditions, a very careful and loyal workman, but when "troubles a ton" fall upon him he loses his sense of proportions and all thought of safety for himself or others is crowded out of his mind. The secret of his trouble is that his mind is focused on his own personal problem, so, of course, it cannot be focused on his work. His own personal problems must be met and solved. Every plant needs a squad of sharpshooters who can hit the spot every time. Call them what you will: visiting nurses, social service workers or what not, but first find your men and women who have common sense and good judgment and then turn them loose with authority enough to ride over every precedent and break every rule of the plant if this be necessary to supply the one and only remedy for the worker who is in trouble. These personal contacts with the individuals of our work forces are important and should be carried out just as systematically as our contracts with our best customers.

The next man who makes us lie awake at night wondering what is going to happen next is the careless man. He was born that way or his life has been such that he has grown that way. Nearly all of us are careless to a certain degree, but we find men in all walks of life who are dangerously and criminally careless. We have all known men who continually keep others in trouble on account of their carelessness, but who seem to live under a lucky star and never get hurt themselves.

Educating the Careless Man

The fortunate thing about the careless man is that we can educate him both as an individual and *en masse*. We can appeal to him on the basis of loyalty to his family and the safety of those who work with him. The careless man of our plants can be helped with the "shotgun prescription" in the form of safety bulletins and various other educational activities. A downward curve on the accident chart may be made a matter of pride to them. The most careless man we have may become the most careful if he should suffer a serious hurt as the result of his folly or if he should inflict an injury upon a fellow worker. It should be said, however, that he probably will not rise to this new degree of efficiency on his own account, but that he may be led into it after a heart-to-heart talk with some member of the executive staff. Here again the personal contact is the thing that is most effective in gaining the desired end.

As we shall find some misfits who cannot be "fitted" and some personal problems we cannot solve, so we shall find some careless men we cannot cure. When we find a man like this, the best gift we can bestow is the pay-off slip. Our business has in it so many unavoidable hazards that we cannot afford to be hampered by the man who will not help us to make it as safe as possible.

Environment

Environment is directly related to efficiency and efficiency is a half-brother to safety. The man who works at a rate of speed which is normal to him as an individual will have fewer accidents than he would if he worked a great deal faster or a great deal slower. The piece worker, who, naturally, is interested in maintaining a high degree of personal efficiency, will have fewer accidents than the day worker who takes occasion to kill a block of time now and then. The one is keyed up to his normal pace with mind alert and with attention centered in his task, while the other takes the pace that will keep him out of trouble with the foreman. His mind may be a blank and his attention may be focused anywhere but on his work. It is not difficult to see the relation that exists between each of these men and the accident record of the plant where they work.

We may say with confidence that everything which has a bearing on the productive labor of our men has also a bearing upon our accident experience. Everything which takes the attention of our men from their work will be reflected in the number of accidents we have and everything we do to improve working conditions will mean not only a higher rate of production but also a lower rate of injury.

Responsibility for the environment of the plant does not rest upon the management alone. All who work in the plant have their share in this. The foreman who keeps his department as neat and clean as possible will produce more and better castings than the foreman who allows his men to work in a place that is constantly out of order. Just as the executive will do better work

in a well-appointed office that is kept clear of rubbish, so will the molder and laborer do better work if they are not compelled to climb over miscellaneous piles of slip boxes, bottom boards and broken ladles every time they move about the shop.

Proper Instruction

A man may be a good workman, even a master of his trade, but if he does not know *our* methods of doing work in *our* foundry he may cause any number of accidents to himself and others before he learns. No man should be turned loose alone on a job until he has learned all he can be taught about it. He should know all of its hazards and should be shown how his work is to be related to other work throughout the plant. He will work with more understanding and with a more sympathetic attitude of mind. These have a direct bearing on the question of his making a safe and efficient workman for us. The task of giving him this information should be assigned to a definite group of qualified men and the new man's acknowledgment of having received such instruction be made a part of his record.

All of these problems were greatly minimized in the old days when the workman lived in the home of his employer. The complexities of modern life will never permit us to return to this condition, but we must approach the ideal of the constant personal contact with our workmen if we would seek to minimize the problems of this our present day.

That there is nothing that is entirely new or original in the subject matter of this paper is well known to the writer. It is only hoped that by bringing these same things to our attention again and again we can be brought to see anew our obligation to those who work for us and with us. There is nothing new to be brought forward in this problem. It is the old problem of the relation between men. We have not entered into any new obligation to our men in this new day of great industrial activity. Our obligation is the same if we have one man or a thousand men working for us. It is that we shall give them all we can of ourselves so long as they are faithful and loyal and continue to give us the best that is in them.

Marion Gray Iron Foundry,
Marion, Ind.

Lewis Impact Machine

LIEUTENANT COMMANDER A. G. ZIMMERMANN, of the United States Naval Gun Factory, presented a very important discussion of Dr. F. C. Langenberg's paper on "Experimental Data Obtained on Charpy Impact Machine," during the recent Chicago meeting—briefly mentioned in CHEMICAL & METALLURGICAL ENGINEERING, Oct. 8, 1919 (vol. 21, p. 461). Mr. Zimmermann's remarks in which he describes the theory and operation of the curve-drawing vertical-drop machine devised by Lieutenant G. Q. Lewis, U. S. N., follow at length:

Dr. Langenberg's work serves to demonstrate the correctness of two principles which should be the basis of all inspection by the consumer of materials subject to shock where impact testing machines are not available or where the data on results with impact testing machines are not considered conclusive enough to form the basis for specifications.

These two principles are: (*a*) Acceptance of forgings need not necessarily be based on the performance of test bars pulled in the direction of the stresses that will be applied in service. (*b*) Material that has normal ductility in its weakest plane is a good shock-resisting material.

The first principle follows the fundamental idea that if the most unfavorable test of the material is definitely known, the inspector has good grounds for assuming that the remainder of the forging is as good or better, when viewed from any other angle, as the results on which he accepted the forging. This is the more reasonable since, as pointed out by Dr. Langenberg, it is not always safe to say that no transverse stresses will be set up when, theoretically, the stresses of service are longitudinal.

If the location of test specimens is to be determined beforehand, irrespective of the method of forging, there would be an undue incentive to the manufacturer to do excessive forging in the direction of the test specimen. It is undoubtedly true that the more forging material receives in one direction, beyond a certain point, the less will be its ductility at right angles to this direction—and this effect is much more marked in basic steel than in acid steel. Since sudden shock appears to search out the weakest plane of a forging, it is apparent that normal ductility in one direction should not be sacrificed for a good showing in ductility in another direction.

Naval Bureau of Ordnance Uses Langenberg's Principles

Dr. Langenberg's results, showing that the impact test follows somewhat the course indicated by the results of the transverse static test, are borne out by the fact that the Naval Bureau of Ordnance has been following the above principles of inspection for some time and a consultation of the records fails to disclose any failures of material in service that have been traceable to the failure of accepted material under normal shock conditions. However, impact tests should be the principal criterion of any shock-resisting material, and it is hoped that their use in both commercial and ordnance work will rapidly come into favor. It is considered imperative, however, for the general use of such a test, that conditions should be standardized in the beginning, so that no confusion or change of equipment will result upon the incorporation of a standard test in the specifications.

Standard Practice for Impact Test

It is considered that there should be an early decision as to standard American practice in the following particulars, in order that the impact test may become a part of the routine procedure of buying materials subject to sudden stresses:

1. A selection of either the pendulum or the vertical-drop type of impact testing machines.
2. A selection of either notched or unnotched bars.
3. If notched bars are selected, the immediate selection of a standard notch, so that the practice of playing with various types of notches, such as has been done in other countries, be nipped in the bud, and some consistent data will quickly be assembled.
4. If possible, the adoption of an impact test whereby the resistance of the material can be reduced to an

equivalent of lb. per sq.in., which will have a more definite meaning to the ultimate consumer of this country and will obviate the necessity of a tabulation of new units in the customary reports of physical test.

This last point is not so far removed from possibility as it may seem at first glance. What appears to be a very workable arrangement has been devised at the United States Naval Gun Factory, for use with a vertical-drop machine, by Lieutenant G. Q. Lewis, of the Navy, who was assigned this task in connection with the contemplated activities of the enlarged physical laboratory of the Gun Factory.

Description of Lewis Machine

The essential features of the apparatus consist of a weight *A*, Fig. 1, which is guided by a central shaft *B* and can fall from any predetermined height, striking a hardened plate *D* and rupturing in tension the standard test bar *C*, the ends of which are screwed into the lower end of the shaft *B* and the plate *D*, respectively. A bracket *E* suitably secured to the weight *A* engages a plunger *F* of a device that amplifies the vertical movement of the weight just before and during the period of rupture. A pencil record of the amplified movement is made upon a paper cylinder mounted on a drum *G*, which is rotated at a known constant speed by the motor *H*. The object of the amplification is to obtain a space-time curve of such

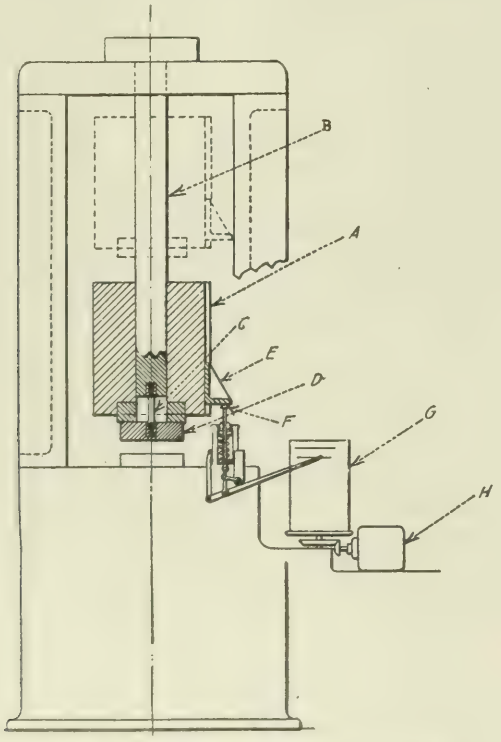


FIG. 1. VERTICAL DROP MACHINE

proportions that a graphic or protractor analysis may be conveniently and accurately made and the resisting value of the material tested derived in terms of lb. per sq.in.

Relation Between Elongation and Time

The curves obtained show the relation of the elongation of the test bar with reference to time. For a typical curve (see Fig. 2), the elongation would be measured vertically and the time horizontally to known scales, depending on the amplification and surface speed of the drum. The weight, being released from a suitable predetermined height, accelerates uniformly and attains maximum velocity at a certain point *J* where the pencil line crosses a horizontal base line *KL*, previously scribed on the drum with the weight resting on the plate *D*, Fig. 1, which is screwed to the lower end of the test bar. The tangential motion of the paper drum being to the left, the rupture curve is drawn

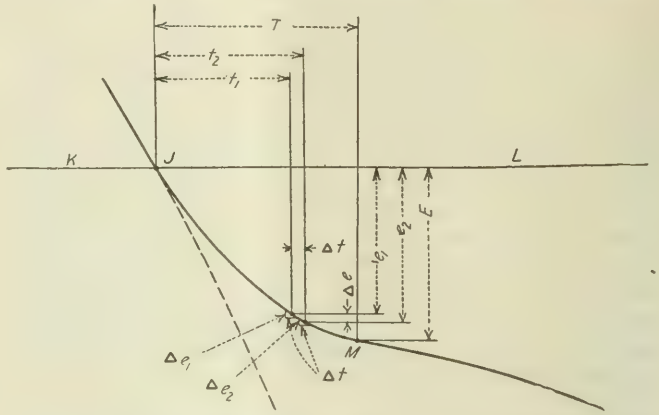


FIG. 2. RELATION OF ELONGATION OF TEST BAR WITH REFERENCE TO TIME

downwardly and to the right. Above the base line is recorded the last portion of the parabolic free fall of the weight and below is recorded the movement of same as retarded by the resistance of the test bar. The curve reverses after crossing the base line and the slope of the same decreases as the bar elongates, owing to the reducing velocity of the weight. After rupture occurs at M, the curve reverses and the weight again accelerates, due to gravity.

Analysis of the Results

Analysis of the curve between the initial and the final points of test-bar resistance gives the average forces of retardation corresponding to increments of elongation, Δe, measured normally to the base line. To determine the average retarding force during any time increment Δt, the slopes or tangents of the curve are first obtained at the beginning and the end of the time increment Δt, to determine the corresponding instantaneous velocities of the weight at these points. Thus the tangent to the curve or its equal, the instantaneous velocity of the weight at the beginning of time increment $\triangle t$, is $\frac{\triangle e_1}{\triangle t}$ and at the end is $\frac{\triangle e_2}{\triangle t}$. The acceleration during the period $\triangle t$ is $\frac{\triangle e_2 - \triangle e_1}{\triangle t^2}$.

The average force of retardation F, in pounds, during any increment of time Δt, therefore, equals the product of the mass and the acceleration, or $K\frac{\triangle e_2 - \triangle e_1}{\triangle t^2}$, where K is a constant depending on the mass of the weight and the units employed in measuring Δe and Δt. F will be algebraically negative because the acceleration is negative. Thus the stress, exerted by the test bar to resist the retardation force of the weight W, will be $+F$, since it is equal but opposite in direction to that imposed by the weight. The total stress in the bar will then be algebraically equal to $W + F$, where W is the number of pounds in the weight, also resisted by the test bar because of gravitation.

It is not to be assumed that calculations of this description will be necessary for each specimen pulled,

as a protractor has been designed which will integrate the space-time curve throughout the entire elongation period of the specimen and thus permit a ready selection of critical values, read directly in lb. per sq.in.

Advantage of the Lewis Testing Method

While Lieutenant Lewis, who has now returned to his former activities in the supplying and testing of railroad materials, had the benefit of previous research in connection with railroad shock absorbers, it is considered that this method of analysis is considerably different from any performed before, in that it goes further and gets an expression of the strength of material, in pounds per square inch, which is a function of the amount of energy expended in rupturing the specimen.

Oil Pipe Lines*

By S. A. Sulentic

THE object of this paper is to show the advantages of the oil engine as a means of transporting oil for long distances through pipe lines, to compare the cost of pipe-line transportation with that of rail and canal transportation, and to derive simple formulas that will make it comparatively easy for any one to make quick calculations of the pressure, net horsepower and brake-horsepower necessary for the transmission of any quantity of oil per day through a pipe of known diameter.

The cheapest method of overland transportation of oil is by pipe line. The cost in comparison to rail transportation is low, and yet when the rail cost is based on everyday practices, the amount seems very small. For instance, the management of an Eastern railway, wishing to impress upon its clerical employees the importance of economy, posted the following notice: "For every lead pencil you waste we have to haul one ton of freight one mile."

The cost of a pencil has always been regarded as being insignificant, but when it is considered that it is equivalent to the cost of the above-mentioned haul, a similar comparison with pipe-line transportation should be interesting. The carrying of one ton of freight for one mile at the cost of a lead pencil is very cheap transportation. One or two cents per ton-mile is a low rate. Canal transportation, after allowing for the proper fixed and maintenance charges, may be lower than the rail charges by 60 per cent or even more.

In order to make a very crude estimate of the cost of transporting oil by pipe line when using equipment of the highest economy, assume a single line operating under the following conditions at a load factor of 80 per cent for 300 days per year:

Size of line, in.	8
Length of line, miles	33
Pressure of line, lb. per sq.in.	700
Rate of discharge, bbl. per hr.	900

At this rate the discharge would be 21,600 bbl. per day, or 6,480,000 bbl. per year of 300 days. Assuming 6.5 bbl. per ton, the yearly discharge would approximate 1,000,000 tons. The work equivalent of this discharge would be 33,000,000 ton-miles, calling for the continuous expenditure of 257 hp. Assuming the mechanical efficiency of the engine to be 75 per cent, the actual horsepower necessary to install would be 257 ÷ 0.75, or 342.

The assumed costs would be as follows:

Line: 33 miles at $1.65 per ft.	$287,500
Right of way at $0.25 per rod	2,640
Freight: 79 cars at $250	19,750
Haulage: 900 tons at $14.50	13,050
Laying pipe at $0.075 per ft.	13,060
Burying pipe at $0.20 per ft.	34,850
Engines, pumps, installed accessories	68,500
Pump stations, buildings and foundations	30,000
Tanks { Two 55,000-bbl. at $18,500 each	37,000
Tanks { Two 500-bbl. at $500 each	1,000
Telegraph line: 33 miles at $550	18,150
Superintendence	2,500
Incidentals	6,000
Total assumed costs	$534,000

The operating expense, including fixed charges based on the total assumed costs, would be as follows:

Interest at 6 per cent	$32,040
Depreciation at 5 per cent	26,700
Administration	10,000
Attendance at pump stations and lines	11,500
Repairs to equipment, lines, etc.	4,000
Fuel for pumping—3,000 bbl. at $2.65	7,950
Total operating expense	$92,190

Hence the cost of operation per ton-mile under the assumed conditions would be $92,190 ÷ 33,000,000 = $0.0028, or two and eight-tenths mills per ton-mile. As the relation between the cost of pipe-line transportation and rail transportation is in the ratio of 1 to 10, it is easily seen that the waste of a lead pencil in a pipe-line enterprise would be the equivalent of the cost of transporting 10 tons of oil one mile.

Considerations in Estimating Cost

It should be noted, however, that almost all of the pipe-line costs are fixed and are mainly independent of the amount of oil pumped. As a result, the transportation cost per ton-mile will vary almost inversely with the load factor of the line. If this hypothetical pipe line should be operated only one-tenth of the time assumed, the unit transportation cost would equal the rail cost. Furthermore, these figures are based on a life of 20 years (5 per cent amortization). A railroad would probably be used for various classes of freight as long as it existed, but a pipe line is of service only as long as oil is presented for transportation. If the pipe line in question were to become obsolete in ten years through the exhaustion of the oil fields or other causes, the ton-mile cost would be greatly increased.

These figures have not been presented as those of an average case but only offered as "food for thought." In further consideration of the subject, however, it will not be out of place to give a few figures and examples showing the relations existing between pressure, capacity, diameter, length of line and power required.

Disregarding viscosity, the general hydraulic formula for friction head in a pipe discharging a uniform volume is

$$F = k\frac{v^2 L}{2gD} \qquad (1)$$

in which

F = friction head in feet of water = lb. per sq.in. ÷ 0.433
k = friction coefficient for 38 gravity oil = 0.024
v = velocity of flow, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec. per sec.
L = length of line, ft.
D = diameter of line, ft.

The formula for pressure in the line may be stated as

$$P = 0.433k\frac{v^2 L}{2gD} \qquad (2)$$

in which P = pressure in line in lb. per sq.in.

*Presented at the annual meeting, Dec. 2-5, 1919, of the American Society of Mechanical Engineers, New York.

The discharge Q of the line, cu.ft. per sec., can be easily derived and stated as

$$Q = \frac{\pi D^2 v}{4} \qquad (3)$$

in which Q varies directly as v. Since P varies directly as v^2 in Formula (2) and Q varies directly as v in Formula (3), it follows that P varies directly as Q^2.

The net horsepower required for a pipe line may be most readily calculated if we note that the pressure per sq.ft. is equal to the number of foot-pounds required to displace 1 cu.ft. of oil, or

$$\text{Hp.} = \frac{144PQ}{550} \qquad (4)$$

For 1,000 bbl. per day against a pressure of 1,000 lb. per sq.in., the net hp. necessary by Formula (4) would be

$$\text{Hp.} = \frac{144 \times 1{,}000}{550} \times \frac{1{,}000 \times 5.61}{24 \times 60 \times 60} = 17$$

where 5.61 = cu.ft. per bbl.

Assuming a pump efficiency of 85 per cent, the horsepower of the engine would be 17 ÷ 0.85, or 20. Here we have a very simple rule for calculating the horsepower from bbl. per day and pressure in lb. per sq.in.; namely,

Net hp. = 17 × thousands of bbl. per day × P ÷ 1,000

B.hp. = 20 × thousands of bbl. per day × P ÷ 1,000

For example, for a discharge of 8,000 bbl. per day against a pressure of 600 lb. per sq.in., the brake-horsepower required would be 20 × 8 × 0.6, or 96. Since the horsepower varies directly as PQ and P varies directly as Q^2, it follows that hp. varies directly as Q^3. To sum up:

Velocity varies directly as the line discharge.

Pressure varies directly as the square of the line discharge.

Horsepower varies directly as the cube of the line discharge.

Another relation of value in making rapid pipe-line calculations is the ratio between the diameter D and length L, with the discharge Q and the pressure P remaining constant.

From the friction formula (2) it will be seen that P varies directly as $v^2L \div D$. Assuming P constant, L varies directly as $D \div v^2$. For the same discharge, Formula (3), that is, with Q constant, v varies directly as $1 \div D^2$. Therefore v^2 would vary directly as $1 \div D^4$. Substituting this value for v^2 above, it is seen that L varies directly as $D \div (1 \div D^4)$, or in other words, L varies directly as D^5.

This means that for the same discharge and pressure, i.e., the same friction, the length of the line would vary directly as the fifth power of the diameter. Taking a diameter of 6 in. as unity, the fifth powers of several different diameters are as follows:

D =	6	8	10	12
D^5 =	1.0	4.2	12.8	32

An example will show how easily these relations are utilized. Let a proposed pipe line be made up as follows:

Two 6-in. lines, 8 miles long (Y-branch).
One 6-in. line, 6 miles long.
One 8-in. line, 10 miles long
One 12-in. line, 12 miles long.

With the particular oil to be transported the pressure per mile when pumping 10,000 bbl. a day through a 6-in. line will be assumed as 20 lb. per mile. What, now, will be the pressure for 17,000 bbl. per day through above line and what will be the net hp. and b.hp. required?

Since P varies as Q^2, the pressure for 17,000 bbl. will be $(17{,}000 \div 10{,}000)^2$, or 2.89 times the pressure for 10,000 bbl. The pressure in the line would then be 2.89 × 20, or 57.8 lb. per mile.

Inasmuch as the velocity is halved when using two 6-in. lines for the 8-mile section, each line carrying an equal amount of oil, the equivalent length of 6-in. line for each branch would be only two miles, the length varying directly as the square of the velocity. The length of 6-in. line equivalent to the 8-in. pipe would be 10 miles divided by the ratio of the fifth powers of the diameters 6 in. and 8 in., or 10 ÷ 4.2 = 2.38 miles. In a like manner the length of 6-in. line equivalent to the 12 miles of 12-in. pipe would be 12 ÷ 32, or 0.37 mile. In other words, the equivalent length of 6-in. pipe in the line under consideration would total 12.75 miles. Under a pressure on the line of 57.8 lb. per mile, the total pressure on the line would be 12.75 × 52.8, or 737 lb.

Making use of the simple formula for hp. already derived we have

$$\text{Net hp.} = 17 \times \frac{17{,}000}{1{,}000} \times \frac{737}{1{,}000} = 213$$

$$\text{B.hp.} = 20 \times \frac{17{,}000}{1{,}000} \times \frac{737}{1{,}000} = 250$$

No doubt many other useful relations could be derived for the purpose of expediting pipe-line calculations, but those which have been presented are among the most useful.

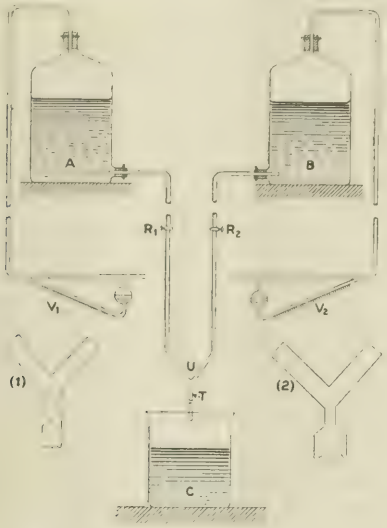
In illustration of the foregoing the following data in regard to the 36-mile, 8-in. Alton pipe line operating between Carlton and Wood River, Mo., should prove of interest. This line, constructed in 1913, has four stations, in each of which are installed four units each consisting of a 100-hp. type F. H. De La Vergne oil engine direct-connected to a 6-in. by 18-in. National Transit Co. herringbone-geared power pump with 8-in. suction and 6-in. discharge. The performance of one station equipment (three units) is given below:

Oil pumped during 10 days, bbl.	140,000
Oil pumped per day, average, bbl.	14,000
Pressure maintained in line, lb. per sq.in.	700
Brake horsepower, average	196
Pump efficiency, estimated, per cent	85
Fuel consumed by engines during 10 days, bbl.	65.8
Fuel consumed by engines per day, lb.	2,020
Brake-horsepower-hours per day = 196 × 24	4,704
Fuel consumption per b.hp.-hr., lb.	0.43
Ft.-lb. of work per day developed by the engines = 196 × 33,000 × 24 × 60	9,320,000,000
Ft.-lb. of work per day in oil pumped = 9,320,000,000 × 0.85 (85 per cent efficiency)	7,900,000,000
B.t.u. in fuel consumed per day = 2,020 × 18,000	36,000,000
Ft.-lb. of work per 1,000,000 B.t.u.	217,000,000
Daily operating cost:	
Fuel oil: 6.58 bbl. at $1.50	$9.87
Lubricating oil: 2 gal. at $0.22	0.44
Cylinder oil: 1.6 gal. at $0.21	0.34
Attendance: Total salaries of 2 engineers, 2 assistant engineers, 1 chief engineer and 2 telegraph operators	41.50
	$52.15
Cost per b.hp.-hr. ($52.15 ÷ 4,704)	$0.011
Cost per bbl. of oil pumped ($52.15 ÷ 14,000)	0.0037
Bbl. of oil pumped per bbl. of fuel consumed (14,000 ÷ 6.58)	2,130

In conclusion it may be said that the comparatively small amount of power involved in pipe-line transportation lends itself admirably to the efficient use of the oil engine as a prime mover. And unless some other form of power can show better results in the immediate future, the oil engine bids fair to hold its present superiority as a means for the transportation of oil.

Synopsis of Recent Chemical and Metallurgical Literature

Homogeneous Liquid Mixtures.—PIERRE JOLIBOIS has devised a very convenient apparatus for producing a homogeneous mixture of liquids in a very short time. The principle of the apparatus is described in the Dec. 8, 1919, issue of *Comptes Rendus*. The accompanying illustration shows the principle involved. The quantities of the liquids used are measured by the graduated venturi tubes, V_1, V_2. The diameter of the tube T and its shape have a great influence on the time required for homogeneous mixing.



APPARATUS FOR PRODUCING QUICKLY A HOMOGENOUS MIXTURE OF LIQUIDS

To render this visible to the eye he used in A a solution of potassium permanganate (1.58 g. per liter) and in B a solution of ferrous sulphate (15 g. $FeSO_4$, 50 c.c. conc. H_2SO_4 and 10 g. $MnSO_4$ per liter). The rapidity of the flow of liquids from the bottles A and B is regulated by the valves R_1 and R_2.

With a flow of 500 c.c. per min., the following data were obtained:

Dia. of Tube, Mm.	Length of Still Colored Liquid in Tube T, Cm.	Time Required to Obtain Homogeneity, i. e., When the Liquid Becomes Colorless, Sec.
2.5	4.0	0.04
3.2	6.5	0.08
4.8	10.0	0.2
6.2	22.5	1.0
8.5	33.0	1.2

The influence of the shape of the Y tube is shown by the following results:

Shape	Dia. of Tube in Mm.	Length in Cm. of Still Colored Liquid in Tube T	Time to Obtain Homogeneity, Sec.
Straight Y	6.2	22.5	1.00
1	6.2	4.0	0.12
2	6.2	2.6	0.01

The shape 2 has been adopted. This apparatus will be of great help in the study of the rapidity of reactions between liquids.

Catalytic Preparation of Ether.—The preparation of ether from alcohol by the use of moderately calcined commercial alum catalyzer has been studied experimentally by A. MAIHLE and F. DE GODON, in order to determine the influence of temperature, degree of alcohol and amount of catalyzer, and is described in the October, 1919, issue of *Bulletin de la Société Chimique de France*. The catalyzer is placed in a glass tube and heated, alcohol drips into the tube and vaporizes, the outgoing vapors are condensed and the ether is extracted from the catalyzed product.

Influence of Temperature. There was catalyzed 100 c.c. of 95 deg. alcohol in a glass at 175, 185 and 190-195 deg. C. The amounts of 0.725 density ether obtained were 10, 15, 20 c.c.; i.e., 11.8, 17.7 and 23.6 per cent efficiency respectively. This indicates that the best working temperature is 190-195 deg. C.

Influence of Degree of Alcohol. The following results were obtained when working on 100 c.c. of different degrees of alcohol under the same conditions of temperature and catalyzer:

Deg. Alcohol	Ether 0.725 Dens.	Efficiency
95	42	49.8
90	38	47.7
80	28	39.6
60	17	32.2

This shows that although 95 deg. alcohol gives the best results, it is possible to obtain relatively fair results from lower degrees of alcohol.

Influence of Amount of Catalyzer. When using the same amount of catalyzer but spread on a larger area, the results are not improved. By increasing the amount of catalyzer the efficiency increases as follows: 100 c.c. 95 deg. alcohol at 195 deg. C. gives with a 34-g. catalyzer 23.6 c.c. 0.725 ether; with a double 34-g. catalyzer 42 c.c. ether; with a quadruple 34-g. catalyzer 53 c.c. ether, and with a quadruple 42-g. catalyzer, 60 c.c. 0.725 ether, i.e., respectively 23.6, 49.8, 63 and 71.3 per cent efficiency.

The conclusions to which they arrived are:

1. Possibility of use of a cheap catalyzer, such as commercial alum.

2. Use of relatively low temperature, 195 deg. C. being the highest and at the same time the best suited for efficient results.

3. The ether obtained is pure, with no formation of ethylene and only traces of aldehyde.

4. Alcohols of even 55 to 60 deg. can be used with relatively fair efficiency.

Production of Hydrocyanic Acid.—The December, 1919, issue of *Helvetica Chimica Acta* contains a description of the research work of E. BRINER and A. BAERFUSS on the production of hydrocyanic acid. All the hydrocarbons mixed with nitrogen give HCN under the action of electric discharges. They have used pure methane and nitrogen with and without the admixture of hydrogen. The mixture of gases circulate at a rate of 8 to 10 liters per hr. in a chamber in which electric discharges take place. By using platinum electrodes spaced 7 mm. apart and with a current of 0.02 amp. under varying compositions of the gaseous mixture, voltages and pressures, the following results were obtained:

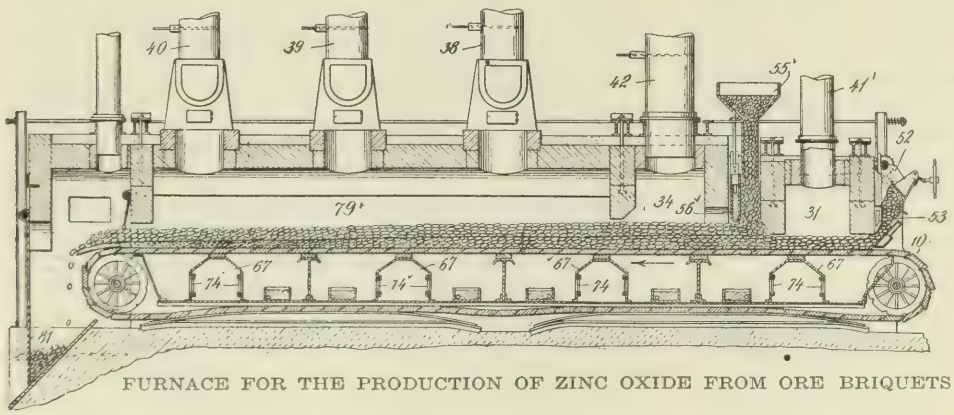
Composition of the Gaseous Mixture	Voltage	Pressure of Gaseous Mixture, Mm. Mercury	Efficiency G. per kw. hr. HCN	Efficiency G. per kw. hr. NH_3	Concentration HCN per Cent Volume
$12CH_4 + 23N_2 + 65H_2$....	1,020	635	0.46	0.14	0.08
$11CH_4 + 54N_2 + 25H_2$....	1,030	600	2.15	0.01	0.38
$CH_4 + N_2$.....	450	100	3.88	0.44	0.80
$CH_4 + 3.5N_2$.....	500	100	5.12	0.52	0.44
$CH_4 + 5N_2$.....	505	100	7.39	0.48	0.75
$12CH_4 + 23N_2 + 65H_2$....	420	100	1.75	0.44	0.12

They conclude that when working on a mixture with an excess of nitrogen under low pressures the results are far more satisfactory than when working under high pressure.

Recent Chemical and Metallurgical Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Production of Zinc Oxide.—A series of patents assigned to the New Jersey Zinc Co. disclose improvements in the production of metal oxides and other compounds of metals by volatilization. In the production of zinc oxide by means of the Wetherill process the furnace grate is charged with a layer of "buckwheat" anthracite, which is ignited by the residual heat of the previous charge and a rapid combustion of this coal produced by forcing a blast of air through the perforated grate. Upon this ignited bed of coal is charged a mixture of finely divided coal and zinkiferous material termed the "working charge." The air blast is continued and when the volatilization is begun the fume is conveyed through cooling towers and collected in a baghouse. There are certain defects in this method. The formation of blowholes in the charge produces hot spots, making it necessary to work the charge by hand rabbling; in this way dust is carried off with the fume. Further, the necessity of maintaining a porous charge limits the fineness of the materials that can be used successfully. These and other objections are overcome by briquetting the fuel, which may be any carbonaceous material such as the smaller sizes of buckwheat coal, colliery washings or coke breeze, and also briquetting the zinkiferous material with the necessary amount of similar carbonaceous material. The fuel briquets are charged on the grate in the same manner as the "buckwheat" anthracite and after ignition the "working charge" briquets are added. (F. G. BREYER, J. A. SINGMASTER and A. E. HALL, 1,322,088; Nov. 18, 1919.)



FURNACE FOR THE PRODUCTION OF ZINC OXIDE FROM ORE BRIQUETS

As the Wetherill process is usually conducted, from 15 to 25 per cent of the total carbonaceous material is charged as the fuel bed, the remaining 85 to 75 per cent being mixed with the zinkiferous material. All of the ash of the coal is mixed with the residue; this residue has a value depending somewhat upon the amount of ash with which it is contaminated for the recovery of metals that are non-volatile under furnace conditions, also for the production of spiegeleisen, etc. When using the fuel and ore in the form of briquets, only 15 to 25 per cent of the fuel need be briquetted with the ore, the remainder being used as fuel briquets. Under these conditions the work-off ore briquets retain their original shape and can be readily separated from the ash of the fuel. This not only increases the value of the residue but increases recovery to about 90 per cent, which is about 20 per cent greater than with the usual method. (F. G. BREYER, A. E. HALL, G. R. WALTZ. 1,322,089; Nov. 18, 1919.)

The details worked out as above are applied to the production of sublimed lead and leaded zinc oxide and other compounds of metals as well as to zinc oxide. (F. G. BREYER, A. E. HALL, G. R. WALTZ. 1,322,090; Nov. 18, 1919.)

It is possible to briquet a certain amount of ore containing zinc or lead or both with the fuel briquets, or to briquet the ore without the addition of a reducing agent. These and other combinations are incorporated. (F. G. BREYER, J. A. SINGMASTER, A. E. HALL. 1,322,091; Nov. 18, 1919.)

The usual Wetherill process for the production of zinc oxide is conducted in a block furnace containing several grates, with the idea of providing zinc oxide continuously by controlling the sequence of operations, the operation on the individual grates being intermittent. The use of the fuel and ore in the form of briquets simplifies the design of a furnace in which the operation can be carried out continuously. Such a furnace is shown in the figure. The chain or other similar grate 10 is moved in the direction of the arrow about 7 ft. per min. The fuel briquets are charged through hopper 52, being spread by a water-cooled gate 53, the vertical movement of which controls the amount of feed. The charge is ignited and the gases escape through flue 41. The ore, also in the form of briquets containing 15 to 25 per cent carbonaceous material, is fed through hopper 55, being spread by a water-cooled gate 56, which also controls the amount of feed. Products of combustion, together with a small amount of metal oxides, are carried off through flue 42. The major portion of the metals is reduced, volatilized and oxidized in the fume chamber 79, which is about 18 ft. in length, and is carried off through flues 38, 39 and 40. Air under pressure is supplied beneath the grate through tuyeres 74 in the side of air-box 67. The worked-off ore briquets are discharged into hopper 81 in substantially their original form. The ash from the fuel briquets is in the form of disintegrated clinker and may be readily separated from the ore briquets. The bed of fuel briquets used is about 6 in. deep and the bed of ore briquets about 3 in. deep. Chamber 31 is maintained at a temperature of between 800 and 850 deg. C., which is a minimum temperature for uniform ignition. Satisfactory working temperatures for chamber 34 are from 1,000 to 1,050 deg. C. and for the fume chamber 79 from 1,100 to 1,250 deg. C. The temperature is controlled by slide dampers located in the air flue leading to air chambers 74 and also by dampers in the flues 38, 39, 40 and 42. A recovery of about 90 per cent of the volatile metals is obtained at a considerable reduction in labor. The quality of the product is also improved due to the avoidance of dust. (J. G. SINGMASTER, F. G. BREYER and E. H. BUNCE. 1,322,142; Nov. 18, 1919.)

The furnace and details are applied to the production of sublimed lead, leaded zinc oxide and other compounds of metals as well as to zinc oxide. (J. G. SINGMASTER, F. G. BREYER and E. H. BUNCE. 1,322,143; Nov. 18, 1918.)

Electrolytic Oxidation of Benzene to Quinone.—The oxidation of benzene to quinone is accomplished in the anode compartment of an electrolytic cell. The lead anode is provided with a large number of staggered projections so that the benzene, which is introduced through a perforated tube near the bottom of the electrode, is forced to follow a devious course in rising to the surface of the electrolyte (10 per cent sulphuric acid). A current density of 0.5 amp. per sq.dm. is used and the temperature is kept below 12 deg. C. An excess of benzene is used, so that the quinone formed remains in solution. This solution of quinone in benzene is removed to a reduction tank, where it is treated with sulphurous acid. The quinone is reduced to quinol (hydroquinone), which may be recovered from the aqueous solution by evaporation. The excess benzene is returned to the electrolytic cell. (1,322,580; FREDERICK T. KITCHEN, of West Brighton, N. Y., assignor, by mesne assignments, to K. & T. Chemical Corp.; Nov. 25, 1919.)

Pickling Baths.—WILLIAM H. ALLEN, of Detroit, Mich., notes that an ordinary pickling bath, as of sulphuric acid, attacks clean iron so much more rapidly than its adherent scale that sheets often emerge badly corroded. In order to reduce these higher iron oxides so they may more readily go into acid solution, he recommends the addition of about one-fifth the amount of sulphurous radical, by bubbling SO_2 or adding sodium bisulphite or hyposulphite. Other reducers which may be effectively used in the ordinary baths of sulphuric, hydrochloric or phosphoric acid are phosphorous acid, H_2S, Na_2S, or phosphides of iron or zinc. All of these produce active reducers, but great care is necessary in their use, as some products are violently poisonous or highly explosive. (1,321,182; Nov. 11, 1919.)

Book Reviews

STORING, ITS ECONOMIC ASPECTS AND PROPER METHODS. By *H. B. Twyford.* 252 pages, 6 x 9. 112 charts, diagrams and forms. New York, 1918: D. Van Nostrand & Co.

This work brings out splendid points in favor of giving the store department more consideration and attention than it usually receives from the managers of most industrial firms. The proper receiving, storing and distribution of supplies are an important factor in the welfare of any business institution.

On page 81 the author states that material can be placed on the shelves "at any time to suit conditions," while he contradicts on page 98 with "Prompt handling of all material as it arrives is an essential feature of successful storekeeping." The latter, of course, is true.

Prominent organizers of store departments of large concerns differ with the author in that they are opposed to the use of the perpetual inventory. The receiving clerk should not be separated from the store department, as recommended, but should report receipts to the storekeeper, who, in turn, notifies the purchasing agent. Excellent ideas are advanced for records of receipts of material. Provision for return of such goods as are not immediately used to the storehouse is also good.

The careful study of this book by the younger members of the store department forces would yield them valuable information, but discretion must be used in accepting any of the technical theories advanced. E. G. WALKER.

* * *

SELENIUM CELLS AND HOW THEY ARE MADE. By *Samuel Wein.* 34 pages. New York: Progress Publishing Co.

This small book is of tablet form and contains a chronological survey of information concerning selenium and selenium cell construction. It has been written expressly for the investigator who is interested in the variation of the electric conductivity of selenium in the presence of light. While it may be justly criticized because of being overly concise, it does contain a great amount of valuable data as well as bibliography for the guidance of the reader.

WALLACE SAVAGE.

Personal

ALBERT BRETON, formerly vice-president of the Guaranty Trust Co., New York, has been elected president, to succeed GRAYSON M. P. MURPHY, who resigned to assume the presidency of the newly-formed Foreign Commerce Corp. of America.

ARTHUR R. CADE, formerly instructor in chemistry at the University of Minnesota, Minneapolis, Minn., is now associated as research chemist with the National Carbon Co., Fremont, Ohio.

JOHN J. CARTY, vice-president of the American Telephone & Telegraph Co., lectured under the auspices of the National Research Council on Feb. 6. The subject was "Science and the Industries."

Dr. VIRGIL COBLENTZ, formerly professor of chemistry in the New York College of Pharmacy and later chemical director of E. R. Squibb & Sons, Brooklyn, N. Y., and N. W. KEMPT, chemical engineer, will engage in professional consulting practice, with offices at 119 Nassau St., New York City.

Dr. HARRY A. CURTIS has resigned his professorship at Northwestern University, Chicago, to accept a position with the International Coal Products Co., New York.

WALTER S. ERNST, formerly employed as a chemist at the U. S. Nitrate Plant No. 1, Sheffield, Ala., is now chief chemist for the Ironton Portland Cement Co., Ironton, Ohio.

J. A. L. GALLARD, who was mining editor of the *Financial Times* for eighteen years, has joined the staff of the *Mining Magazine* as associate editor.

HAROLD GRAY, who has been on the research staff of Eli & Co. of Indianapolis, Ind., for the past four years, is now on the research staff of B. F. Goodrich Co., Akron, Ohio, in the organic development department.

G. P. HULST has resigned as assistant general manager of the East Chicago plant of the International Lead Refining Co. and will be succeeded by GUNNARD E. JOHNSON.

MILO W. KREJCI has become works manager for the Parish-Pool Co., Cleveland, Ohio. During the past few years Mr. Krejci has developed an electrolytic process for making a white lead and supervised the construction and operation of a commercial plant working under this process for the International Lead Products Co.

CLARENCE E. MEISSNER has accepted a position with the Inspiration Consolidated Copper Co., Inspiration, Ariz.

CHARLES F. RAND, who has been president of the United Engineering Society since 1917, has retired, his term having expired. By constitutional limitation he was not eligible for re-election. As an appreciation of Mr. Rand's services the board of directors of the American Society of Mechanical Engineers presented him with engrossed resolutions. J. VIPOND DAVIES succeeds Mr. Rand.

Provost EDGAR FAHS SMITH, of the University of Pennsylvania, has tendered his resignation, to take effect at the end of the present academic year, which will complete his forty-fourth year as a teacher.

E. K. SOPER, who has been with the Trinidad Petroleum Development Co. at Port of Spain, Trinidad, is now located at 120 Broadway, New York City, with the Sinclair Oil & Refining Co.

GEORGE J. YOUNG, Western editor of *Engineering and Mining Journal*, is in New York City to attend the meeting of the American Institute of Mining and Metallurgical Engineers.

Current Market Reports

The Non-Ferrous Metal Market

New York, Feb. 16—Copper market steady with little new business. Tin has advanced ¼c. over last week's quotation. Slight advances in lead, tin and silver.

	Cents per Lb.
Copper, electrolytic	18.75
Aluminum, 98 to 99 per cent	31½@32½
Antimony, wholesale lots	11.50
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	57.75
Lead, New York, spot	8.87½
Lead, E. St. Louis, spot	8.55
Zinc, spot, New York	9.05
Zinc, spot, E. St. Louis	8.70
Silver (Dollars per oz.)	1.34½

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Magnesium	lb.	$1.75@1.90
Cadmium	lb.	1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	80.00

SCRAP METALS

	Cents per Lb
Aluminum, cast scrap	23¼@24¼
Aluminum, sheet scrap	22¾@23¾
Aluminum clippings	25½@27
Copper, heavy machinery comp	14½@14¾
Copper, heavy and wire	13¾@14
Copper, light and bottoms	12½@12¾
Copper, heavy cut and crucible	15¾@16
Brass, heavy	7½@ 8½
Brass, casting	10½@10¾
Brass, light	5¾@ 6¾
No. 1 clean brass turnings	8⅛@ 8¾
No. 1 comp. turnings	12 @12¼
Lead, tea	5½@ 5¾
Lead, heavy	6¾@ 7
Zinc, scrap	4¼@ 4½

The Iron and Steel Market

Pittsburgh, February 13, 1920.

The rate of production mentioned last week for January (85 per cent) has fallen off if anything, due to continued transportation difficulties. Deliveries of coke and metal have been even worse last week than previously, bringing some plants to a point where hand-to-mouth conditions exist between stock-pile and furnaces, while more than one stack has been banked over the week end to conserve materials for the ensuing week's operation. In addition to this, the excessively bad weather throughout the Atlantic and New England states has resulted in embargoes at many important points. Notably, the heavy storms in New York during the last week have paralyzed truck haulage in that vicinity and resulted in an embargo on everything for shipment east of Newark. Such a combination of events is discouraging to mills overwhelmed with insistent demands for prompt material; some mills are not getting enough supplies to operate on, and the others with ample reserve stocks, cannot get cars or engines to move the finished product.

Such conditions are food to a bull market. Buyers are more and more insistent for metal; the sky is almost the limit for small lots of prompt tonnage. Quotations are therefore impossible. The Steel Corporation is still holding to the March 21 schedule; its recent statement of unfilled tonnage indicates a booking rate fully 50 per cent above capacity, with orders now in sufficient volume to carry to December. A fortnight ago a rough average of prices being offered to independents would probably approximate what are known as "Jan. 1" prices, those to which the war-time figures were reduced shortly after the armistice. Despite the effort of one of the largest of the independents to maintain this general level, business is being done at $5, $10 and even $25 a ton above the fixed prices for the war period.

PIG IRON AGAIN UP

Pig iron is again up, following a short period of very heavy buying. Foundry is now at least $41, valley, with basic $43 taken for large tonnage and a disposition to charge even more for left-overs. Bessemer is about $42, valley. Southern foundry has been sold in Cincinnati territory during the week at $42, Birmingham, and this price is being quoted by a number of furnaces for the first half, but at least two of the larger interests are still booking for the rest of the year at $40.

The Ferro-Alloy Market

New York, February 13, 1920.

Ferromanganese continues active both in demand and price. One large firm with works in the Pittsburgh district has quoted as high as $170 a gross ton, other quotations varying from $160@$165. Actual sales at these prices are reported heavy and firm. A steady rise to $200 is looked for by men in the New York end of industry.

Spiegeleisen remains firm in price. Demand is rather brisk and a sympathetic rise is looked for soon. The quotation of $55@$60 f.o.b. Pittsburgh is still in force.

There has been slight movement in tungsten, although no actual orders were reported. The cause of this is evidently the desire of buyers to get it at the prevailing low prices. The looked-for settlement of the tariff situation one way or the other will probably send prices rocketing, as tungsten has been at a standstill since the latter part of last year. Present quotations are: Scheelite, 60 per cent WO_3, $10.50; wolframite, $7@$7.50.

Ferrosilicon holds firm on all grades, 50 per cent being $85 a gross ton; 75 per cent, $150, and 10 to 15 per cent, $65@$70, all quotations being f.o.b. Pittsburgh district.

The Chemical and Allied Industrial Markets

New York, February 16, 1920.

The recent storm has seriously tied up the chemical industry. Producers have been handicapped by a still further curtailment in coal supplies and spot trading has been practically at a standstill. Export business, which has been rather heavy on several items, cannot be filled because of shortage of cars for shipping. The willingness on the part of English buyers to do business in this country despite the extremely abnormal rate of exchange gives evidence of the scarcity of supplies in some lines.

GENERAL CHEMICALS

Trading during the past week has been confined mostly to small lots. *Sal ammoniac* remains in the same position, with the English stocks fast decreasing and an upward trend in the domestic material. *Barium chloride* continues active in demand, with stocks rather scarce. The present quotation is $85@$95 per ton, with some producers going as high as $100. *Bleaching powder* is practically off the spot market, with prices firm, varying from 2@3½c. per lb. With the present demand a rise is looked for soon. *Blue vitriol* has been in heavy demand for domestic; while export business has fallen off slightly, present listing is 8¾c. per lb. The export demand on *caustic potash* remains firm, prices are steady and maintain the same level, of 23@32c. per lb., as the previous report. *Soda ash* remains unaffected by the recent drop in exchange, England being willing to meet these adverse conditions in order to obtain the material. This item is unobtainable on spot. The

present quotation is firm at $2.40 per cwt. *Caustic soda* is in the same position as soda ash. Foreign buyers are meeting the American producers' prices in order to obtain material which the extreme coal shortage has cut off.

Coal-Tar Products

The Bureau of Imports, War Trade Board Section, has recently sent out an application form to all dealers in coal-tar products and dyes regarding the importation into this country from Germany of German dyes. The purpose of this application is to restrain the flooding of the domestic market with these colors, thereby running domestic producers out of this industry. In order to obtain the German colors it must be testified to that these dyes are unobtainable in the United States, or if so on terms as to price, quality and delivery as are not considered reasonable. This application is then submitted to the board, which passes or rejects it. It is a question whether this or the tariff regulations is the better plan, but it is the opinion of nearly all that it should be given a trial.

With this question definitely settled a general expansion of plants and increased production is to be expected. *Aniline oil* stands firm, with considerable inquiry during the past week, at 34c. per lb., for forward delivery. *H acid* is unobtainable on spot and difficulty is experienced in getting it on contract, as producers are sold ahead. Prices as high as $1.65 per lb. have been reported. *Benzol* is somewhat easier, with producers offering some material on spot at 25c. per lb. for 90 per cent. *Dimethylaniline* continues scarce. The quotation is nominal, as there is none to be had. Prices as high as $1 per lb. have been reported. There has been no change in the quotation on *toluol*. There seems to be ample stocks of this material, and 28@32c. of last week still holds.

Naval Stores

It is heard on some sides that there is no scarcity in *spirits of turpentine* and that speculation is the cause of the sensational rise in this item to $2.04 per gal. There evidently is ground for holding both opinions. England is still a big buyer despite the high prices and the rate of exchange. The *rosins* are easier, with a noticeable drop in all grades which is caused by a slacking of demand.

Crude Rubber

The crude rubber market remains practically unchanged, but there is a slight undercurrent of firmness inspired by the English and Indian markets. Actual business has been very light, as buyers have shown no inclination to buy even at the comparatively low figures. *Para, up-river fine*, is down to 45@46c. per lb. and the coarse is listed at 33c. per lb. The plantation grades have been extremely quiet with no contract business reported.

Feldspar and Barytes

Feldspar remains unchanged. Manufacturers are reported sold up until end of the year. Difficulties in transportation, cold weather and scarcity of labor are further crippling this commodity. The Government price of $18 still prevails.

Barytes is still scarce. Contracts are not binding, as they may be broken by either party. If the cost of production increases after the contract is made, the producer may raise the price, but the buyer also has the privilege of refusing the goods if the price is too high. Barytes, white floated, $34@$36 per ton; off color, $22@$28 per ton.

Chicago, February 11, 1920.

Pine tar products, which have been under heavy foreign buying pressure for some time, can probably be expected to be a little easier in tone as a result of low exchange, but this reflex is not yet felt in this market.

Plenty of bids are made for goods, but large lots are frequently unobtainable. Short stocks are particularly troublesome as regards *flotation oils* and *fertilizers*, in both of which lines prices remain unchanged at a high level. It is probable that threatened rail labor troubles are causing buyers to proceed slowly also.

Heavy Chemicals: *Alcohol* is the product hardest to obtain, spot stocks of *methyl* being practically exhausted. When obtainable, 95 per cent goes at $1.90@$2 per gal. in small quantities, against a quotation of $1.80 two weeks ago. *Ethyl*, with a nominal quotation of $5.35 a gal. for 190 proof, is very uncertain in delivery. Actual sales of stock on hand have been closed as high as $7.50 in bbl. lots. *Formaldehyde*, which advanced so rapidly last month, is but little easier, current quotation being 45@48c. Small quantities only are available, and demand greatly exceeds offerings. Future orders for formaldehyde are being placed at 25@27c.

Caustic soda has eased off about a quarter of a cent, $4.25 per cwt. in carlots, f.o.b. works, now being quoted for granulated and $3.90@$4 for solid. Export shipments of *bleaching powder* have rendered it short, for immediate delivery, and $3 per cwt. in carloads is the ruling price. *Sodium bichromate* continues to fluctuate, present market being able to absorb all offers at 23@25c. per lb.

No other changes of moment are noted. The increase recently recorded in *roll sulphur* (brimstone) holds good, spot stock in bbl. being quoted at 5c., and carloads from factory at $3.80@$3.90 per cwt. *Acids* seem to have slightly more strength, *sulphuric* 66 deg., being quoted at $22 a ton in cars and *oxalic* at 42c. per lb. in bbl., against prices of $20 and 40c., respectively, two weeks ago. Threatened rail troubles which cause uncertainty in the steel industry tend to prevent much activity in the market for acids.

Coal-Tar Products: Quieter demand for crudes has eased up prices all along the line, and this condition is accentuated by freer offering of supplies. If no further interruption occurs to production or transportation, it is evident that prices will be appreciably lower than those ruling at present. *Benzol* in drums is back to 27c., from an earlier quotation of 33c., and *toluol* is changing hands at 28c. in tanks. *Anilines* are slightly easier, for spots, 34c. being the ruling price on oil and 44c. on salts. Demand seems light on these items, probably on account of the high price.

Benzoic acid now brings, in wholesale quantities, 90c. for U. S. P. and 75c. for technical grade, these items showing reductions of 5c. and 3c., respectively. *Salicylic acid* remains at the former quotation of 44c. for technical and 55c. for U. S. P. As expected, *picric acid* has advanced until it has now reached a price of 25c., which seems reasonable.

Vegetable Oils: Linseed is unchanged in price. There is but little trading. The condition seems to be that, with an Argentine crop of unknown proportions approaching, buyers do not care to invest heavily at present prices, and with flaxseed selling at better than $5, crushers cannot reduce prices. Present Chicago quotation on oil is around $1.75 per gal. in carlots and $1.98 in bbl. *Cocoanut oil* is also weak—probably owing to similar conditions—with miller grade in bbl. being quoted at 19c. in this market. *Soya bean oil* is stronger than the rest of the line, demand remaining fairly strong at 17½c., in sellers' tanks, f.o.b. Coast. Offerings in *corn oil* continue to exceed buyers' requirements, and *crude* is now quoted at 18¾c. in bbl., f.o.b. Chicago, *prime summer yellow* at 23@24c.

Flotation Oils; Naval Stores: Continued high prices have caused a marked decrease in turnover, but the market is holding firm. There has been no change in price recorded anywhere in the line. The one item in which stocks are short is *pine oil*. Spot stocks practically do not exist and dealers are uniformly refusing new business and are taking care of regular customers as well as possible at the old price of $1.50 per gal. in cars for both pure and destructively distilled.

Fertilizers: Buyers seem to feel that prices are too high, and as a result the market has been and is very quiet. Supplies are short, but what little changed hands went at record prices, *ground blood* being offered at from $7.90@$8.10 and *unground blood* at $7.75@$7.85. Similar increase occurred in prices asked for tankage, and but little business resulted. Current quotation for high-grade *ground tankage* is $7.65. Similar conditions prevail in trading in *bone meal*, prices ranging from the last quotation of $44 up to $48 per ton, f.o.b. Chicago, in carlots.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0.16 –$0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.25 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 –12.50	13.50 – 15.50
Boric, crystals	lb.	.14½– .15½	.15½– .16½
Boric, powder	lb.	.14½– .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½– .07
Molybdic, C. P	lb.	.....	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½– .08½
Nitric, 42 deg	lb.	.06½– .07	.08 – .09¼
Oxalic, crystals	lb.	.35 – .40	.40 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 –22.00	.....
Sulphuric, 60 deg., drums	ton	.....	.....
Sulphuric, 66 deg., tank cars	ton	22.00 –25.00	.....
Sulphuric, 66 deg., drums	ton	.....	.....
Sulphuric, 66 deg., carboys	ton	.....	.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –30.00	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P	lb.	.....	1.35 – 1.45
Tannic (tech.)	lb.	.....	.42 – .55
Tartaric, crystals	lb.	.....	.69 – .74
Tungstic, per lb. of WO	lb.	.....	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	.....	.76 – .78
*Alcohol, denatured, 190 proof	gal.	.....	.71 – .73
Alum, ammonia lump	lb.	.04½– .05	.05½– .06
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾– .02	.02½– .02½
Aluminum sulphate, iron free	lb.	.02½– .03	.03½– .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾– .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.14 – .15	.16 – .17½
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.22 –	.....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	.....	.10½– .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	.....
Barium chloride	ton	85.00 –95.00	100.00 –110.00
Barium dioxide (peroxide)	lb.	.22 –	.24 – .....
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03¾– .04
Bleaching powder (see calcium hypochlorite)		.....	.....
Blue vitriol (see copper sulphate)		.....	.....
Borax (see sodium borate)		.....	.....
Brimstone (see sulphur, roll)		.....	.....
Bromine	lb.	.90 – .95	.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	.....	.04¾ .05
Calcium chloride, fused, lump	ton	20.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½– .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	.....	2.50 – 3.00
Calcium peroxide	lb.	.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	.....	.75 – .80
Calcium sulphate, pure	lb.	.....	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	..... – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	.....	.75 – 1.00
Caustic potash (see potassium hydroxide)		.....	.....
Caustic soda (see sodium hydroxide)		.....	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	.....	1.50 – 1.55
Copperas (see iron sulphate)		.....	.....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	.....	.65 – .70
Copper sulphate, crystals	lb.	.08¼– .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		.....	.....
Epsom salt (see magnesium sulphate)		.....	3.00 – 3.25
Formaldehyde, 40 per cent	lb.	.....	.42 – .52
Glauber's salt (see sodium sulphate)		.....	.....
Glycerine	lb.	.....	.24½– .26
Iodine, resublimed	lb.	.....	4.10 – 4.30
Iron oxide, red	lb.	.....	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	.....	.13 – .17
Lead nitrate, crystals	lb.	.....	.70 – .80
Litharge	lb.	.....	.09½– .10½
Lithium carbonate	lb.	.....	1.50 – .....
Magnesium carbonate, technical	lb.	.....	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.16 –	.17 – .....
Phosgene (see carbonyl chloride)		.....	.....
Phosphorus, red	lb.	.....	.60 – .65
Phosphorus, yellow	lb.	.....	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .35
Potassium bitartrate (cream of Tartar)	lb.	.....	.56 – .60
Potassium bromide, granular	lb.	.....	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium cyanide, 98-99 per cent	lb.	nominal	
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .42
Potassium iodide	lb.	.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	.....	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	.....	.40 – .70
Potassium sulphate	ton	$225.00 –	.....
Rochelle salts (see sodium potas. tartrate)		.....	.....
Salammoniac (see ammonium chloride)		.....	.....
Sal soda (see sodium carbonate)		.....	.....
Salt cake (sodium sulphate)	ton	18.00 –21.00	.....
Silver cyanide	oz.	.....	1.25 – .....
Silver nitrate	oz.	.....	.81½– .82¾
Soda ash, light	100 lb.	2.05 –	2.25 – .....
Soda ash, dense	100 lb.	2.25 – 2.50	2.50 – 2.75
Sodium acetate	lb.	.06¾– .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.21½– .22½	.23 – .25
Sodium bisulphate (nitre cake)	cwt.	6.00 – 7.00	8.00 – 10.00
Sodium bisulphite	ton	7.00 – 8.00	8.50 – 9.00
Sodium borate (borax)	lb.	.08½– .08¾	..... – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	.....	4.35 – 4.60
Sodium hyposulphite	lb.	.....	.03¾ .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	.....	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾– .04½	.04½– .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾– .02	.02 – .02¼
Sodium silicate, solution (60 deg.)	lb.	.02¼– .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.....	.05 – .06
Sodium sulphite, crystals	lb.	.03½–	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05¾–	.06 – .....
Sulphur, crude	ton	22.00 –	.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½–	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – .....
Zinc carbonate, precipitate	lb.	.....	.20 – .....
Zinc chloride, gran	lb.	.13 –	.13½– .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.11¾– .12½	.13 – .15
Zinc oxide, dry American	lb.	.....	.09½– .12
Zinc sulphate	lb.	.03½– .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.42
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.05 —	1.25
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.55
Beta naphthol, sublimed	lb.	.65 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.80 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.70 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.90 —	1.15
Dinitrobenzol	lb.	.26 —	.37
Dinitro-chlorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.55 —	.65
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	25 —	.45
Para-amido phenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.12 —	.18
Paranitraniline	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.15 —	3.00
Paratoluidine	lb.	1.75 —	2.50
Phthalic anhydride	lb.	.60 —	1.00
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.43 —	.45
Salicylic acid, U. S. P.	lb.	.55 —	.60
Salol	lb.	.90 —	.95

Solvent naphtha, water-white, in drums, 100 gal..	gal.	$0.22 —	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	....
Xylol, commercial, in drums, 100 gal	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1	lb.	.80 —	.88
Carnauba, No. 2, regular	lb.	.65 —	.78
Carnauba, No. 3, North Country	lb.	.46 —	.48
Japan	lb.	.18¼ —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06 —	.07
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.07
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09¾ —	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$18.15	—$18.50
Rosin E-I	280 lb.	18.50	— 18.75
Rosin K-N	280 lb.	19.00	— 21.50
Rosin W. G.-W. W	280 lb.	22.00	— 24.25
Wood rosin, bbl	280 lb.	17.00	— 17.50
Spirits of turpentine	gal.	.....	— 1.97
Wood turpentine, steam dist	gal.	.....	— 1.70
Wood turpentine, dest. dist	gal.	1.64	— ....
Pine tar pitch, bbl	200 lb.	8.25	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 14.75
Retort tar, bbl	500 lb.	15.00	— 15.25
Rosin oil, first run	gal.	.....	— .91
Rosin oil, second run	gal.	.93	— .94
Rosin oil, third run	gal.	1.10	— 1.12
Rosin oil, fourth run	gal.	.....	— 1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.44 —	$0.46
Upriver coarse	lb.	.33 —	.35
Upriver caucho ball	lb.	.33½ —	.34½
Plantation—First latex crepe	lb.	.50 —	.54½
Ribbed smoked sheets	lb.	.49 —	.51
Brown crepe, thin, clean	lb.	.48 —	.48½
Amber crepe No. 1	lb.	.53 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.18 —	$0.19
Castor oil, AA, in bbls	lb.	.21 —	.23
China wood oil, in bbls	lb.	.23¾ —	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.21 —	.21¾
Cocoanut oil, Cochin grade, in bbls	lb.	.20¾ —	.23
Corn oil, crude, in bbls	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19 —	.20
Cottonseed oil, summer yellow	lb.	.22 —	.27
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	1.87
Linseed oil, raw, tank cars	gal.	1.70 —	1.80
Linseed oil, boiled, car lots	gal.	1.75 —	1.80
Olive oil, commercial	gal.	2.50 —	2.60
Palm, Lagos	lb.	.17 —	.18
Palm, bright red	lb.	.16½ —	.17½
Palm, Niger	lb.	.16 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½ —	.24
Peanut oil, refined, in bbls	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.45 —	1.68
Rapeseed oil, blown, in bbls	gal.	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½ —	.20

FISH

Winter pressed Menhaden	gal.	$1.20 —	....
Yellow bleached Menhaden	gal.	1.23 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.26 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04 —	.05
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00 —	52.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07¾
Graphite, crucible, 86% carbon content	lb.	..... —	.07¾
Graphite, crucible, 87% carbon content	lb.	..... —	.07¾
Graphite, crucible, 88% carbon content	lb.	..... —	.08
Graphite, crucible, 89% carbon content	lb.	..... —	.08¼
Graphite, crucible, 90% carbon content	lb.	..... —	.08¼
Graphite, crucible, 91% carbon content	lb.	..... —	.08¼
Graphite, crucible, 92% carbon content	lb.	..... —	.09
Graphite, crucible, plus 92%		..... —	.12
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine	lb.	1.25 —	....
Shellac, orange, superfine	lb.	1.20 —	1.30
Shellac, A. C. garnet	lb.	1.10 —	....
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.50
Ferro-manganese, 70-80% Mn	gross ton	150.00 —	165.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	55.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25 —	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50 —	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.50 —	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	....
Pyrites, foreign, lump	unit	.17 —	....
Pyrites, foreign, fine	unit	.17 —	....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	....
Rutile, 95% TiO_2	lb.	.11 —	....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	....
Monazite, per unit of ThO_2	unit	42.00 —	....

*Government prices.

Structural Steel

Mill, Fittsburgh

Beams and channels, 3 to 15-in.	100 lb	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

BANNING—The city has granted a franchise to the Twin Cities Gas Co., recently organized by the Union Natl. Bank of Pasadena, J. M. Berkley, engr., Hollingsworth Bldg., Los Angeles, and others, to reconstruct and enlarge the old gas plant and distributing system. Estimated cost, $27,500. Work will probably be done by day labor.

MERIDIAN—The Alameda Sugar Co., 310 Sansome St., San Francisco, plans to build a sugar refinery, here. Estimated cost, $1,500,000.

SANTA ANA—The Holly Sugar Co. has awarded the contract for the construction of a 2-story, 60x100-ft. sugar factory near here, to Leonard & Peck, 721 H. W. Hellman Bldg., Los Angeles. Estimated cost, $70,000.

VENTURA—The Shell Oil Co. of Ventura plans to build a refinery on its Gosnell lease near here. Estimated cost, $60,000.

Illinois

CHICAGO—The Flexible Steel Lacing Co., 522 South Clinton St., is having plans prepared for the construction of a 1-story, 200x200-ft. factory on Polk St. along the Belt Line R.R. Estimated cost, $200,000. W. G. Carnegie, 189 West Washington St., archt.

CHICAGO—H. C. Miller, archt., 112 West Adams St., will soon award the contract for the construction of a 3-story, 120x140-ft. paper box factory at 1701 Superior St., for the Kroeck Paper Box Co., 220 Institute Pl. Estimated cost, $175,000.

Iowa

DEXTER—H. H. Hough, town clk., will receive bids until Feb. 26 for the construction of a sanitary sewerage system and disposal plant. T. S. DeLay, Creston, consult. engr. Noted Sept. 1.

SCRANTON—L. V. E. Peterson, town clk., will receive bids until March 4, for the construction of a sanitary sewerage system and disposal plant. T. S. DeLay, Creston, consult. engr.

Louisiana

NEW ORLEANS—The Simms Oil Co., Shreveport, plans to construct a 20,000-bbl. refinery above New Orleans on the tidewater terminus, including 280 mi. of 8-in. pipe line from here to Sibley, Claiborne Parish. Estimated cost, $12,000,000. C. B. Denning, pres.

Michigan

ANN ARBOR—The University of Michigan has awarded the contract for the construction of a 6-story hospital on East Anne St., including a 3-story, 56x153-ft. administration building; 51x254-ft. surgical wing, 44x58-ft. demonstration wing and a 35x420-ft. main hospital building with 2 wings, 35x112-ft. and 35x88-ft., to Thompson-Starrett Co., 702 Lincoln Bldg., Detroit. Laboratory equipment will be installed in same. Estimated cost, $1,000,000.

DETROIT—The Bd. of Water Comrs. 242 Jefferson Ave., will soon award the contract for the construction of the substructure for a low lift pumping station. This is the first unit in the construction of a filtration plant to cost over $5,000,000 T. A. Leisen, Waterworks Park, engr.

Nebraska

BROKEN BOW—F. M. Skillman, city clk., has awarded the contract for the construction of a sewerage system, including a disposal plant, to Smith & Chambers, Scotts Bluff. Estimated cost, $167,000. Noted Sept. 14.

New York

BUFFALO—The Dunlap Rubber Co., 1808 B'way, New York City, has awarded the contract for the construction of twelve 1- and 2-story factory buildings, to the Foundation Co., 233 B'way, New York City. Estimated cost, $20,000,000.

BUFFALO—The University of Buffalo, 24 High St., plans to construct a 2-story laboratory addition. Estimated cost, $68,000.

NEW YORK—The Standard Lithographing Co., 1100 Brook Ave., will build a 6-story, 50x118-ft. factory at Brook Ave. and 167th St. Estimated cost, $75,000. Work will be done by day labor.

North Carolina

LEXINGTON—The city rejected all bids for the construction of a water system, including filter house, installation of filter tubs, coagulating basin, etc. G. C. White, Durham, engr. Work will be readvertised.

Ohio

ASHLAND—The city is having plans prepared for the construction of a 1-story, 40x60-ft. superstructure for the filtration plant and is in the market for filter equipment. Estimated cost, $60,000. R. Winthrop Pratt, Hippodrome Bldg., Cleveland, engr.

CLEVELAND—The Buckeye Brass Co., 6410 Hawthorne Ave., is having plans prepared for the construction of a 1-story, 30x110-ft. foundry and a 75x75-ft. furnace room on Ashland Rd. Estimated cost, $50,000. Nathan Carl, secy. Allen Sogg, 319 Hippodrome Bldg., archt.

CLEVELAND—The Cleveland Window Glass & Door Co., 209 Champlain Ave., will build a 1-story, 50x72-ft. mill at 2421 Elm St. Estimated cost, $10,000. Work will be done by day labor.

CLEVELAND — Friedman-Blaw-Farber Co., East 37th St. and Perkins Ave., has awarded the contract for the construction of a 6-story, 57x85x127-ft. addition for the manufacture of knit goods, to the Craig-Curtiss Co., 1031 Guardian Bldg. Estimated cost, $200,000.

COLUMBUS—The Bd. Comrs. Franklin Co., Court House, will receive bids until March 4 for the construction of a 2-story tuberculosis hospital on the Infirmary Grounds. Estimated cost, $125,000. W. H. Tremaine, 602 Chamber of Commerce Bldg., archt.

COLUMBUS—The Ohio Wax Paper & Printing Co., 22nd and Frebis Sts., has awarded the contract for the construction of a 1-story, 111x157-ft. factory on Hartford St., to A. H. Leibrand, 262 Donaldson St. Estimated cost, $45,000.

Oklahoma

PAWHUSKA—The Le Flore Oil & Gas Co., Tulsa, plans to build a refinery, here. Estimated cost, $300,000

TULSA—The Petroleum Club of Tulsa plans to construct a 6-story clubhouse. Estimated cost, $250,000.

TONKAWA—The city plans to improve the waterworks system, including the testing for underground infiltration gallery. Estimated cost, $75,000. Johnson & Benham, Firestone Bldg., Kansas City, Mo., engrs.

Pennsylvania

LOCK HAVEN—The Pensylvania Paper Co. plans to construct a 3-story, 100x300-ft. paper mill on North St., to have a daily capacity of 120 tons of paper. Estimated cost, $3,000,000.

PHILADELPHIA—Franklin & Co., archt. and engr., Crozer Bldg., will soon award the contract for the construction of a 2-story, 28x53-ft. factory building at 10th and Pearl Sts., for the Jarden Lithographing Co., 310 North 11th St. Estimated cost, $20,000.

Washington

SEATTLE—The Western Paper Goods Co., Collins Bldg., has awarded the contract for the construction of a 1-story, 90x103-ft. factory at 1401 Dexter Ave., to Johnson Bros., Hoge Bldg. Estimated cost, $15,000.

Wisconsin

MILWAUKEE—The Central Bd. Purchases, City Hall, will soon award the contract for furnishing 35,000 lb. c.p. anhydrous liquid chlorine for the Water Dept.

WAUKESHA—The Waukesha Cement Tile Co., 102 Main St., plans to build 1-story, 132x136-ft. factory. Estimated cost, $45,000. Work will probably be done by day labor.

Ontario

BRANTFORD — The Dominion Steel Products Co. plans to construct a 1-story, 60x80x100-ft. foundry. Estimated cost, $150,000.

TORONTO—The Canadian Natl. Carbon Co. is having plans prepared for the construction of a factory for the manufacture of oxygen, tanks and oxygen products. Estimated cost, $100,000. Leighton McCarthy, 265 Adelaide St., W., pres.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23 to 26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will have a meeting on Feb. 27, the subject for which is "Electric Furnace Reducing Agents." Another meeting will be held on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN INSTITUTE OF MINING AND METTALURGICAL ENGINEERS is holding its spring meeting in New York this week.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CANADIAN MINING INSTITUTE will hold its annual meeting at the King Edward Hotel, Toronto, March 8 to 10.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MATERIAL HANDLING MACHINERY MANUFACTURERS' ASSOCIATION will hold its convention at the Waldorf-Astoria Hotel, New York City, Feb. 26 and 27.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, February 25, 1920 — *Number* 8

Hoover Heads The A.I.M.E.

THE American Institute of Mining and Metallurgical Engineers is honored in the election of Mr. HOOVER to its presidency for 1920. Leadership in the A.I.M.E. has been on a high plane for many years, but in no recent instance has the incumbent of the office been a man who had attained international reputation in the prime of life. In his forty-sixth year Mr. HOOVER has reached an eminence, not only in the engineering profession but in citizenship, which is achieved by few men at the end of the proverbial threescore years and ten. Through him engineering will receive recognition by the public at large and the engineer's training and kind of thinking will be hailed as a power to be reckoned with in public affairs. It goes without saying that the welfare of the Institute will be enhanced under his leadership.

Government Nitrate Plants Should Be Operated

NITROGEN and its compounds comprise one of the most important chemical topics now before the American people, almost regardless of the avenue through which it may be approached—technical, political, commercial or economic. Technically, the fixation processes are receiving the closest study and attention of our chemical engineers. Politically, the subject acquires importance from the fact that the Government owns fixation plants constructed in war time. Commercially, it may affect our relations with other countries. And as for the economics of the matter, the future independence of nations may be bound up in it. In view of the evident importance of the subject, we shall devote to its consideration an unusual amount of space during the next few months, and authoritative articles will be presented on all its phases.

For a clear preliminary view of the economic situation in the United States we refer the reader to an article by ALFRED H. WHITE, published elsewhere in this issue. It merits the serious consideration of all who are concerned with inorganic fixed nitrogen. The author is connected with none of the conflicting commercial and political interests, and expresses independent views. As a Colonel in the Ordnance Department during the war he was in a position to review all the reports and figures bearing on production and research. He is of the opinion that the Government nitrate plants should be operated, and a careful study of the curves which he presents will show how lightly the operation of these plants will affect commercial enterprise.

As a result of an independent editorial investigation we are in accord with Dr. WHITE regarding the advisability of operating the Government's nitrate plants.

The subject has many phases which will develop later, but for the present it is sufficient to note that there is a demand for the operation of the plants as a matter of preparedness and for the development of fixation processes through research. The agriculturists' demand for inorganic fixed nitrogen is rapidly increasing due to the shortage of organic ammoniates. The construction of a new commercial synthetic ammonia plant by the General Chemical and Solvay interests, themselves in the byproduct coke business, refutes the testimony of Mr. ATWATER of The Barrett Company before the Graham House committee, to the effect that byproduct ammonium sulphate will be sufficient for fertilizer needs. Germany and France are proceeding with the operation of their cyanamide and Haber plants and the English Nitrate Committee has just recommended the immediate erection of both types of plant by the British Government. As for Chilean nitrate, producers of that material are not alarmed at possible competition from Government plants, as the farmer is well educated to the use of Chilean saltpeter. The material is an acceptable fertilizer and the supply reliable.

A great deal of dust has been thrown up in political and commercial circles intending to obscure the clear-cut issues of the whole nitrogen problem. But when this is cleared away we believe that one fact will stand out clearly, namely, that the Government should preserve, operate and develop its plants at Muscle Shoals. The facts on which this policy is based will be presented in subsequent issues of CHEMICAL & METALLURGICAL ENGINEERING.

Increased Demand for Laboratory Facilities

THERE is a constant demand in New York for more laboratories by men who want to prosecute research. The Chemists' Club could dispose of twice the number at its command, and at Columbia University there is a constant appeal for laboratory facilities for private research which cannot be granted. Laboratories are generally crowded.

According to an estimate made by Professor MCKEE, approximately 35 per cent of the country's chemical industries are established within commuting distance of New York, while the second largest complex of applied chemical interests is 5 per cent of the whole, to be found in the neighborhood of Niagara Falls and Buffalo. This may explain why so many chemists engage in research in the metropolitan district. It is open to question whether a large laboratory building with the usual facilities for experimental work and small-scale technical apparatus available for try-outs on a larger scale would be a profitable enterprise. Results are often negative, and very few of our business men are chemically intelligent. The worst feature of applied chemistry

in the United States is that men of other than chemical affairs do not know how to discriminate among chemists. Therefore the incompetent man is often set at research and maintained by far too long a time at his task, while the competent man with good ideas cannot get support, or is halted at the very brink of success.

The demand for laboratories, however, is intense, and there is abundant opportunity for someone or some organization to render a service to industry by supplying the needed facilities. What the country needs is some place where tests and experiments could be performed quickly. Time is usually an important element in the development of an idea, and adequate facilities immediately available would conserve time. Given a laboratory with steam, gas, water, electricity, compressed air, and the requisite apparatus, all probably requiring an investment of at least $5,000 if undertaken privately by each investigator, a competent man would be equipped to carry to early completion a line of research already outlined in his mind. The need of such facilities is imminent. Who can be found with sufficient interest to supply them?

The Ideal of National Industrial Independence

FOR the past five or six years the subject of post-war conditions in the world's leading nations has been, and no doubt will continue for some time to be, a fertile topic for writers on sociology and economics. If one is inclined to question the truth of this assertion, he has only to observe the abundance of this kind of literature published both here and abroad, for there has been a wealth of thought devoted to past and future industrial attainments.

The trend of practically all the post-war economic literature has been toward the ideal status of national industrial independence. This is a logical consequence of the fact that nearly every country was brought to a full realization of what industrial dependence implies, when confronted with the abnormal requirements of war. To a degree more or less acute each and every nation found itself in a position of an improvident man who always prefixes his excuses with an "if." If, for example, for a few decades prior to the war American technologists had not limited their progress to industries based mainly on inorganic chemistry, but had broadened their activities to include industrial organic chemistry, how much more favorable our position would have been when we entered the war! Similarly each of the other nations found it convenient to explain some phase of its dependence with an "if." But national development, like that of the individual, does not always take into consideration the extreme emergency; nor is national independence in industrial matters so simple or easy of attainment as might be imagined. The fact is and always will be that we must take into consideration many ethnological, geographical and economic conditions and their numerous corollaries when trying to appraise the actual or prospective development of industry in the different nations.

No doubt each country that was in the war will strive to attain industrial independence and will tax its abilities to the utmost for realization of this aim, but very few, if any, will succeed. Failure will not be due to any lack of determination or initiative, but solely to the inherent difference in conditions just mentioned.

At first sight we may be greatly encouraged by the progress made in the United States and elsewhere in new industries introduced during the period of war, but we have only to realize how abruptly these developments stopped at the end of the war to see that their rapid growth was made at the expense of other more natural and congenial attainments. Evolution and not revolution is the only basis for progress in a sound industrial program.

In our own United States it is apparent that assimilation and not imitation was the reason why the twentieth-century American people—the so-called melting pot product—withstood practically with immunity the acid test of a great nation. The same thought applies to twentieth-century American industry. The logical post-war prospect for industrial achievement will be determined largely by the spirit of the people and the natural resources of the country. Pre-war times furnished abundant examples of our industrial creative ability. War times showed our relatively rapid progress in new industries hastily produced. It now remains for us in the post-war period to assimilate as thoroughly as possible the hastily introduced industries, especially those based on organic chemistry and the allied sciences. It is only by logical assimilation in harmony with the spirit of the American people and America's natural resources that we can ultimately attain the goal of industrial independence.

An Interpretation of Coke Statistics

THE 1919 coke-production figures of the United States Geological Survey, just announced, suggest some interesting possibilities of future development in the coking of coal in this country. We are told that approximately twenty-five million tons of byproduct coke and nearly twenty million tons of beehive coke were made last year in this country. If we assume the same percentage yield of coke from the coal as during previous years, it means that about thirty-five million tons of coal was used in the byproduct process and thirty-one million tons in beehive ovens.

This is the first time that we have had a larger tonnage of coal used and coke produced in the byproduct process than in beehive ovens, and nationally we can congratulate ourselves on this evidence of real progress. The exact figures show an increase from 46 per cent in 1918 to 56 per cent for 1919 of the total coke production by the byproduct method.

It has been estimated, however, that only about 70 per cent of the possible byproduct oven capacity was utilized in coke production last year. This low percentage was, of course, the result of the coal strike and the steel strike, which greatly aggravated the usual causes of interruptions or low-capacity operation. It is rather interesting to see just what it would have meant if the byproduct ovens could have operated at full capacity. If this had been possible, the coal consumption for the year in this process would have been fully fifty million tons, and the coke production over thirty-five million tons, or 80 per cent of the total coke produced and used last year.

Of course no one believes that 100 per cent capacity will ever be attained in any such industrial process, but 85 to 87 per cent has been demonstrated as entirely feasible, and even 90 to 92 per cent has been attained in certain plants or for certain periods throughout the whole country. If 90 per cent capacity had been

attained, forty-five million tons of coal would have produced about thirty-two million tons of byproduct coke, or over 70 per cent of the actual production for the past year.

Any single industry that uses as much as 12 per cent of our total coal production, as was the case last year in coke manufacture, is worthy of our careful thought at any time; and this particular aspect of the case is especially interesting when we see what a large change in operating conditions and results would have been accomplished if industrial conditions had permitted more nearly normal or even above normal utilization of the available byproduct capacity. It is especially interesting to note that of the sixty-six million tons of coal used in making coke last year, nearly a million tons could have been saved had it been possible to utilize the byproduct process to 90 per cent capacity instead of only 70 per cent and have the beehive operation correspondingly curtailed. Naturally, geographical distribution of the ovens and various company connections make any such change as this rather unlikely; but the large economic significance of such change cannot be safely ignored by anyone concerned in the coal business. It is only a question how long such an economic waste will be allowed to continue without the deserved change in practice.

Dr. Edgar F. Smith Offers His Resignation

THE Provost of the University of Pennsylvania, Dr. EDGAR F. SMITH, has tendered his resignation to the trustees and the trustees have refused to accept it, urging him to continue his labors with them. His years of service have been many, he having begun as instructor in chemistry at the same university in 1876, when he was twenty years of age. He took his bachelor's degree in science when he was eighteen, his doctorate in philosophy at Göttingen at twenty, and since then honorary degrees have been showered upon him in abundance but not beyond his deserts. He is now, at the age of sixty-three, in possession of the great wealth of his faculties, and we hope he may long continue to exercise his beneficent gifts in authority, in teaching, in research and in literature.

He is a great teacher of chemistry. In unusual measure he arouses the intellectual curiosity of his students and thus overcomes the contempt for learning that is an ever-present danger in a number of American colleges and universities. He has also the gift of good fellowship along with the charm of social distinction, of *savoir faire*, of elegance and of grace. These qualities increase his influence among students and make manifest to them, at the same time, the pleasures of scholarship as well as its usefulness.

While keenly alive to his responsibilities, he is utterly neglectful of his rewards in money or property. When the alumni presented him with a house, he declared it was too ostentatious for him and proposed that it be leased to help students in need. He has never tried to get rich; his work in hand was always too interesting to bother about returns from that already done. And he is intensely loyal to his boys.

His contributions in research have been of primary importance. He was a pioneer in electro-analysis and his work in mineral analysis is as great a contribution to mineralogy as it is to chemistry. In a number of respects he established present-day laboratory practice.

The city of Philadelphia is a social institution in itself, and it is replete with old ladies of all ages and sexes. There are illusions of Heaven which obtain there that are even more firmly fixed in the public consciousness than the illusions of the mind in Boston, of smartness in New York, of pounds pressure per square inch in Chicago or of authority in London. According to Philadelphia tradition the incumbent of the office of Provost of the University is *ex officio* a member of its heavenly choir; but here also Dr. SMITH has not failed. He is a very acceptable man.

He has drawn aside the veil of yesterday and introduced to us the shades of our own men of weight in chemistry. Without his delightful monographs and biographies we should have left in the limbo of forgetfulness that splendid galaxy who wrought well for American scholarship in science in the late eighteenth and early nineteen centuries. It is no less than a passion with him to do justice to these men. He has no interest in the minor gossip of the day, and so he is probably still unaware of a curious little side reaction which followed his Life of Robert Hare. In it, so far as we remember, he failed to tell how ROBERT got himself into trouble with certain persons of consequence in his native city and lived for the remainder of his days under somewhat of a social cloud. He was invited to be a member of the committee in charge of an annual assembly ball to which only the elect were bidden. He neither accepted nor declined; he did not even answer the letter! Nothing imaginable could excuse such a fault, and it was never forgiven. His relatives bore the burden, probably with fortitude, but, for aught we know, with bowed heads. He left a single daughter who inherited but little from him and who, after a life in modesty, went the way of all flesh in the maturity of her years.

He had, however, many nephews and nieces. The generations continued and they numbered prominent persons, including a famous bishop, but Uncle ROBERT'S name was seldom mentioned. Whatever his merits they were drowned in the overwhelming flood of his fault in regard to The Assembly. They came Dr. SMITH'S book, which showed him to be truly a great man, while chemistry emerged into fashion with the war. So garrets have been ransacked and now the likeness of Uncle ROBERT hangs in glory and reminders of him have prominent place in the houses of those who willingly forgot him a few years ago.

The only thing that would modify our regret if Dr. SMITH should leave the University of Pennsylvania would be for him to come to New York to live, so that we might see more of him.

Acid Fumes On Riverside Drive

IN RESPONSE to the complaint made by the residents along Riverside Drive, New York City, that the acid fumes from the New Jersey factories are obnoxious, the city chemist has investigated with the result that ten gallons of sulphuric acid are found in every 53,790 gallons of rain water falling in this section.

This seems about the proper amount to give a healthy tang to the air. Chemists will agree that acquaintance with the odor may be cultivated until it becomes delightful to the most effete nostril. One should really learn to know and care for our industrial scents. They are inseparable parts of institutions that make Riverside Drives possible.

Readers' Views and Comments

Atomic Structure of Metals in Solid Solution

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the article contributed to the issue of your magazine of Nov. 5, Dr. A. L. Feild pointed out the fact that, in the cases of the binary alloys Ag-Au, Ag-Cu, Cu-Ni and (probably) Ni-Cr, the maximal electrical resistance of the solid solutions are those which would be given by the rule of mixtures, if the resistances of the pure metals were assumed to have the values yielded by extrapolation from above the melting points. This relationship, if it be found to obtain for alloys in general, must possess a theoretical significance; but the conclusion which has been drawn appears to be open to serious objections.

This conclusion is essentially the following: In forming solid solutions the component metals do not wholly crystallize, but remain in part amorphous, with the properties of undercooled liquids, as in the intercrystalline cement of the theory of Beilby and Rosenhain; the resistance of the solid solution results additively from those of its amorphous components, but is not a linear function of the composition of the alloy, since the fraction of each metal which remains amorphous is determined by the proportion in which the other metal is present, the amorphous fraction of A increasing with addition of B, and *vice versa*.

The conception accords, at least, qualitatively, with the arched forms shown by resistance-composition curves. But it explains the relation in question only if it be supposed that, for the composition of maximum resistance, which is approximately 50 : 50 in each instance, suppression of crystallization is complete in both metals, so that such an alloy is wholly amorphous. For unless a 50 per cent alloy contains both metals in an entirely amorphous state there is no evident reason why its resistance should be the mean of the resistances which the components might be expected to possess if in a non-crystalline condition.

This seemingly inevitable corollary renders it very difficult to admit the assumption that suppression of crystallization in the formation of solid solutions is accountable for their low conductivities. For the alloys of mineral conductivity possess a crystalline appearance and character as pronounced as that shown by those of any other composition; and moreover, they do not solidify in the manner to be expected of substances which remain amorphous, but instead freeze at a constant temperature, undergoing the discontinuous changes of properties which characterize formation of a new phase.

If, on the other hand, it be assumed that there remains unaltered, during the formation of solid solutions, some property of the liquid metals other than their "amorphousness," the quantitative relation between the observed and the extrapolated values of electrical resistance may be accounted for in a manner exactly analogous to that just discussed, while at the same time the highly improbable implications of this extension of the hypothesis of amorphous metals is avoided. The property retained might, for example, be a purely chemical (electronic) characteristic, and the chemical forces active in the solid solution might be the cause of its cohesion and hardness.

Whatever may be its explanation, the quantitative relation to which Dr. Feild has called attention is exceedingly striking, and data which will show whether it obtains generally are much to be desired.

Princeton University,
Princeton, N. J.

DONALD P. SMITH.

Contributions by Metallography to L'Art Nouveau

To the Editor of Chemical & Metallurgical Engineering

SIR:—Martin Seyt is right in calling attention to the interesting forms and tones revealed in his microphotographs of metals; but he is certainly wrong in taking the occasion to make public fun of modern art, and his error is in bad taste. What would Mr. Seyt think of an artist who might ridicule metallographic science, though ignorant of it?

What would you think if the editor of some art journal opened his pages to sneering criticisms of reputable scientific achievement?

Modern as well as ancient art can, fortunately, well stand the gibes of those who do not comprehend. The principles upon which they rest endure.

F. B. LEWIS.

Milford, Del.

* * *

To the Editor of Chemical & Metallurgical Engineering

SIR:—Please accept my thanks for copy of the text of Mr. Lewis's communication. What disturbs me far more than his criticism is that he should imagine humor or the making of "public fun of modern art" to be found in my modest contribution. It was an attempt to establish the correlation of Science with Art, more particularly of metallography with painting and sculpture. If Mr. Lewis were familiar with the Dutch language I should recommend to his consideration the much more elaborate efforts in this direction carried out in Holland under the inspiration of my uncle and his collaborator, Adam Seyt and Mohr, of Schiedam.

MARTIN SEYT.

Pure Gum Shellac

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with the greatest interest the excellent article "Pure Gum Shellac," which appeared in your issue of Dec. 10. I am certain the author will allow me to say that in India the well-known letters "T.N." are usually taken as standing for the mark of the firm, well known in its day, which very largely established this grade. The firm in this case was that of Tularam Nataram, which shipped under the initials "T.N."

D. T. CHADWICK,
Indian Trade Commissioner.

Department of Commerce and Industry,
Government of India,
London, England.

German Potash Production and Prices

ACCORDING to the German Potash Syndicate the total production of actual potash (K_2O) for 1919 was 946,000 short tons, of which 264,000 tons were sold abroad, the remainder meeting about 41 per cent of home requirements. These figures are given in *Commerce Reports* for Feb. 11, 1920, in conjunction with a report from The Hague dated Jan. 4, 1920, relating to the potash situation in Germany.

New Increase in Potash Prices

The German potash board, with the assent of the Minister of Economics, has announced a further increase in the schedule of prices of potash for domestic consumption. This is the fourth time that the prices have been raised within a year. The new increase amounts to about 45 per cent. The new prices are about six times as high as the prices in force at the time the war began. The mine owners have for some time been making urgent representations that they be allowed to increase prices, on the ground that the constantly increasing cost of operation had rendered production unprofitable. The failure to export any considerable quantity of potash to the United States, where "dollar prices" might have been obtained, is believed to have been one of the considerations which led the board and the Government to authorize the new increase in domestic prices.

Expressed in terms of marks per American unit (which is 1 per cent of actual potash per short ton of material), the new prices of potash for domestic consumption are as shown in the accompanying table:

	Marks per Unit
Crushed carnalite, 9 to 12 per cent actual potash (K_2O)	4.64
Crushed crude salts, 12 to 15 per cent K_2O	5.45
Manure salts, 20 to 22 per cent K_2O	6.73
Manure salts, 30 to 32 per cent K_2O	7.55
Manure salts, 40 to 42 per cent K_2O	8.82
Muriate, 50 to 60 per cent K_2O	10.46
Muriate, 61 per cent K_2O	11.46
Sulphate of potash, 42 per cent K_2O	13.82

Effect on Prices to United States

There is every indication that the syndicate will base its prices for sales to the United States on market conditions in America rather than on the legally regulated maximum prices for consumption in Germany. Germany is so anxious to secure dollar exchange from sales in the United States that the possibility of dumping large amounts of potash in America at low prices seems rather remote at present, especially in view of the fact that present production is far below normal.

Labor Conditions

Since the conclusion of the general wage agreements in July, 1919, labor conditions in the potash mines appear to have been fairly quiet. It is a well-known fact, however, that the productivity of individual laborers is very much diminished. The underground working day is now 7½ hr. instead of 9, as formerly, and the surface working day is 8 hr. in place of 10. One mine owner estimates that the daily individual productivity is now about 50 per cent of what it was before the war; another places the figure at 66 per cent. The factors which are holding back production at present, however, are inadequate housing facilities for workmen at some of the works, and fuel shortage. The latter factor is by far the more important.

In the last week of October it was reported that of the 210 potash works in Germany no less than 120 were lying idle on acocunt of lack of fuel; on Nov. 12 it was reported that 125 were idle.

Outlook of the Potash Industry

The potash syndicate's monopoly over reports from Germany has been left intact in the new legislation providing for the socialization of the industry. Apparently the syndicate is to have a free hand in the matter of dealing with the new situation which has been created by the loss of the Alsatian group of mines. The only present legal limitation over the syndicate's export activities is contained in section 87 of the new potash socialization law of July 19, 1919, which provides that prices for foreign sales may not be below the maximum domestic price.

Under the present circumstance of the heavy demand for German potash in various countries where the mark is at a great discount the syndicate has, of course, no inclination to charge lower prices for export than are charged for domestic sales. It is impossible to predict what kind of a readjustment will take place when the output of the Alsatian mines has increased so that French potash becomes an important factor in world trade, and when the supply of potash approaches the point of meeting the world demand. It does not seem improbable that attempts will then be made to form an international trust which might prove advantageous for the German as well as the French potash industry.

Hoover Awarded Civic Forum Medal

Herbert Hoover was awarded the Civic Forum's Gold Medal of Honor for Distinguished Public Service at a national testimonial in Carnegie Hall, New York, Feb. 18. The presentation was made by the Hon. Charles Evans Hughes, who stated that Mr. Hoover had created for the United States among European nations a reputation which "even the mistakes of diplomacy cannot obscure." Addresses were made by Ray Lyman Wilbur, president of Leland Stanford University; Horace V. Winchell, retiring president of the American Institute of Mining and Metallurgical Engineers; Dr. Aurelia Reinhardt, president of Mills College for Women, and the Hon. Henry Morgenthau, former Ambassador to Turkey. Mr. Hoover responded in a short speech in which he accepted the medal as trustee for the "great American army of volunteer workers and givers of which I was merely the instrument." The award of the medal may be considered a signal honor, the only former recipients being General George W. Goethals, Thomas A. Edison and Dr. Alexander Graham Bell.

Liquidation of Suspended Government Contracts

The Chemical Warfare Service has liquidated 94 per cent of the uncompleted portions of suspended contracts. These suspended contracts aggregated $38,828,000. The settlement payment was $5,197,000. The Nitrate Division of the War Department has liquidated 98 per cent of its suspended contracts, which totaled $9,090,000. The settlement payment was $1,527,000.

Only 48 per cent of the Ordnance Department contracts have been liquidated. These contracts, however, reached the enormous total of $2,040,288,000. To date, settlement payments aggregating $135,040,000 have been paid.

Prominent Chemists Lecture at West Point and Annapolis

In recognition of the increasing importance of chemistry in modern warfare, the Secretaries of War and the Navy requested the American Chemical Society to designate certain of their members to address the students of the Military and Naval Academies on matters relating to chemistry in warfare and chemical engineering.

The lectures are given under the general direction of the professors of chemistry at the two academies and are intended to supplement the regular courses in chemistry. The appointment of the speakers has been in the hands of Dr. William H. Nichols.

The West Point cadets have already heard talks by Dr. Charles L. Reese on the manufacture of explosives; Dr. William H. Walker on "The Manufacturing Problems of Gas Warfare"; Dr. Charles L. Parsons on "Nitrogen Fixation and Its Relation to Warfare"; Dr. Henry Fay on "The Amorphous State in Metals."

At Annapolis, the following chemists have addressed the students: Dr. William H. Nichols on "Sulphuric Acid—the Pig Iron of Chemistry"; Dr. John Johnson on "The Utilization of Research"; Dr. Arthur D. Little on "Natural Resources in Their Relation to Military Supplies"; Dr. Willis R. Whitney on "Industrial Research."

Other important lectures are to be given at both institutions this year.

Grants for Research by the American Association for the Advancement of Science

The American Association for the Advancement of Science has made a grant of $350 to Dr. Gerald L. Wendt, of the University of Chicago, for the investigation of the photochemical reactions of hydrogen and chlorine. Dr. Wendt has been able to show that under the action of alpha rays and in the vacuum discharge tube hydrogen assumes a form very active chemically, which probably has the formula H_3. From a valence point of view the existence—and even more so the properties and the method of formation—of this gas are of great interest. There is some evidence that chlorine is also activated by exposure to light, but the evidence is contradictory. The mechanism of the effect of ultra-violet radiation on chlorine, including the possibility of the existence of an ozone form of chlorine, will be investigated.

The following grants have also been made for research in physics:

To Prof. A. L. Foley, of Indiana University, $150 for experiments on the speed of sound very close to the source. This investigation is in extension of the important and rather remarkable results which Prof. Foley has recently published in the *Physical Review*.

To Prof. Orin Tugman, of the University of Utah, $100 to meet the cost of a monochromatic source of light to be used in finding the change of conductivity in a thin metallic film when exposed to ultra-violet light —a problem which has acquired new importance in view of the rapidly developing electronic theory.

To Prof. E. M. Terry, of the University of Wisconsin, $150 for work on the modulation of radio-energy employed in wireless telephony.

To Prof. F. C. Blake, of the Ohio State University, $100 for aid in prosecution of a study of electric waves and dielectric constants.

New Plan for Educational-Industrial Co-operation

Realizing that technical schools are not serving to a maximum degree the industrial market to which they owe their existence, the Technology Clubs Associated, through their president, have called a meeting at Drexel Institute, in Philadelphia, on March 25, 26, and 27.

Dr. Hollis Godfrey is now president of the combined Technology Clubs Associated. As chairman of the Engineering-Education Section of the Council of National Defense during the period of the war, he foresaw the alarming shortage of trained men. He saw that there was much waste in present technical education and that to eliminate this waste, industry must be called upon to specify exactly what it requires of the graduating engineer.

A number of industries which saw the need for betterment each contributed $2,500 to carry on the study, and besides gave much of the time of their executives. Educators who were also engineers were sent out into the industry. They made a study of manufacturing processes to determine what knowledge was essential if men were to be successful in the various fields. Their findings and the suggestions of the representatives of plants visited were submitted to a board of educational experts who outlined courses and formulated plans to meet the industrial demand with the possible educational supply.

First Plant to Locate at Nitro

The Director of Sales announces that the first commercial industry to locate at Nitro, W. Va., the War Department's "smokeless powder city," will result from the purchase by the Central Foundry & Supply Co. of Columbus, Ohio, of a factory site from the Charleston Industrial Corp. of Charleston, W. Va. The sale has been approved by the Ordnance Salvage Board and the Director of Sales, in accordance with a contract under which the Government sold Nitro to the Charleston Corp. last December.

The "smokeless powder city" site which was selected by the Central Foundry & Supply Co. consisted of five and one-half acres of land and contained such buildings as a sheet metal shop, a brass and iron foundry, a pipe and electric shop, a welding shop and numerous smaller structures. The purchasers will establish a branch plant at Nitro.

Government Needs Chemists and Other Technical Men

The United States Civil Service Commission announces that the Government service is in need of a large number of chemists. During this period of readjustment, technical men are especially needed. Besides chemists, it is stated that there are openings for physicists, ceramic assistants, laboratory assistants and aids; metallurgical, technical and electrical laboratorians, etc. Further information and application blanks may be obtained from the secretary of the U. S. Civil Service Board at Boston, New York, Philadelphia, Atlanta, Cincinnati, Chicago, St. Paul, St. Louis, New Orleans, Seattle or San Francisco, or from the U. S. Civil Service Commission, Washington, D. C.

Disposal of Government Sulphuric Acid

Sulphuric acid to the extent of 1,832,000 lb., declared surplus by the Ordnance Salvage Board, has been sold to the General Chemical Co. of New York.

New York Meeting of the American Institute of Mining Engineers

Report of Annual Meeting at Which Herbert C. Hoover Was Elected President — Institute Approves Joint Conference Committee Report for National Association of Engineers— Simplified Spelling Killed—Report of Technical Sessions

THE annual meeting of the American Institute of Mining and Metallurgical Engineers was held at Institute headquarters in New York, Feb. 16 to 19 inclusive. The business meeting was held Tuesday morning, at which announcement was made of the election of Herbert C. Hoover to be president of the Institute for the ensuing year. Mr. Hoover's presidential address, which was delivered at the banquet, is published elsewhere in this issue.

An effort made by a few enthusiasts to foist simplified spelling on the Institute was decisively defeated, and it is presumed that this matter has finally been killed and that the membership will not again be called upon to waste time in its consideration.

An amendment to the constitution was adopted raising the annual dues from $12 to $15.

The most important matter considered at the meeting on Tuesday morning was the report of the Joint Conference Committee appointed last year to consider, with representatives of the other national engineering societies, a plan to unite all engineers with respect to their civic and public relations. This joint conference report had already been approved by two of the four national societies and is now being considered by the third. The principle involved is the amalgamation of not only the four national societies but of all local and regional societies in the United States into a representative engineering body. It is intended that this body shall be empowered to act for the engineering professions in the United States as far as concerns relations with the public and the Government.

HERBERT C. HOOVER

The report of the Joint Conference Committee was made by Prof. J. W. Richards, who said in part: "The Joint Conference Committee believes that the greatest value of the proposed organization is in the united effort for the service of the nation, from which effort will result the greatest service to the individual. The committee submits the plan in the confident belief that it will be accepted by the four societies; that they will assume the responsibility of leadership, supporting the movement by virtue of their position in the engineering profession. The following movement by local societies is sure to come. Several attempts have been made to organize such a representative body by other agencies than these four engineering societies. There is one society in particular, the American Association of Engineers, which very actively wishes to assume the leadership in this kind of an organization. If the engineering societies do not take this leadership, it will drive it into the hands of those whom we all believe are less qualified to direct it and to lead it. The four national societies can take the initiative and continue their leadership in American engineering by prompt action, or, by inaction, lose the prestige they now hold."

J. Parke Channing, chairman of Engineering Council, urged the adoption of the report, saying: "A thing that has hampered us has been the feeling all over the country that we were not truly representative; that we represented only the four founder societies and the Society for Testing Materials. If we can have what we may term a larger Engineering Council we will better represent the engineering profession and have a better backing."

After further discussion the motion to approve the principles of the report of the Joint Conference Committee was adopted unanimously.

The plan calls for an organization with the following objects:

1. To render the maximum of service to the nation through unity of action.
2. To give the engineers of the country a more potent voice in public affairs.
3. To secure greater recognition of the services of the engineer and to provide for his advancement.
4. To promote *esprit de corps* among the members of the profession.
5. To provide the machinery for prompt and united action on matters affecting the profession, among which are: Licensing and registration of engineers; National Service Committee; National Department of Public Works; conservation of national resources; publicity; classification and compensation of engineers; general employment bureau; engineering education; international affiliation of engineers; industrial relations.

The Smoker

The smoker was a most enjoyable affair. W. L. Saunders presided as ringmaster and made some humorous references to the fact that this was the first dry smoker the Institute had ever attempted to hold. The committee in charge had nevertheless arranged

for some unusual features to offset the lack of the usual refreshment.

First on the program came Major R. Deere, Fellow of the Royal Hypothetical and Hieroglyphical Society and Inspector General of Nurseries for War Babies. The Major announced during the war it became necessary to discover new tin deposits and that a careful search was made in the Province of Ontario, Canada. The selection of a suitable place for prospecting was arrived at mathematically, using the atomic weights of silver which occurred at Cobalt, gold at Porcupine, nickel at Sudbury and copper in Michigan. A special instrument known as the stanniphone was devised to assist in the search of tin. The peculiar characteristic of this device is that when it is manipulated like a divining rod it reproduces the "cry" of tin. The Major showed a geographical map to illustrate just how effectively the stanniphone had functioned. Another feature of the smoker was a modification of the well-known badger fight in which the dupe pulled Mr. Hoover's hat into the ring. The screen was used for films on mining methods at Chuquicamata, Chile, as well as for reproducing some of the unusual ballots on the simplified spelling proposition. Other entertainment was furnished by a quartet and a magician who mystified with tricks and mind reading.

Banquet

The banquet on Tuesday evening was made the occasion for the retiring address of Mr. Winchell and the inaugural speech of Mr. Hoover. Wit and humor characterized the speeches of Toastmaster Lawrence Addicks, who drew repeated rounds of laughter from the audience at the expense of the speakers whom he introduced. The prospect of having a future banquet otherwise than dry was held by him to be improbable in view of the fact that the new president of the Institute spells his name H_2Over.

Retiring President Winchell reviewed the work of the Institute during the past year and emphasized the fact that civic responsibilities must be more largely assumed by engineers. Mr. Hoover's speech, which is printed elsewhere in this issue, practically comprised a statement of governmental policy with regard to railroads, shipping, and industrial relations.

The speeches of the evening were closed by Dr. James F. Kemp, who was created by Mr. Addicks a member of the Order of the Golden Fleece. Dr. Kemp sped the parting and welcomed the coming president in a most pleasing manner.

There was a large attendance of ladies at the Institute meeting and the customary entertainment of luncheons, teas and theater parties was carried out.

Excursion to Bush Terminal

On Thursday the members were taken to the Bush Terminal in Brooklyn, which is the largest port and warehouse development at any harbor in the world. It covers two hundred acres of ground, has thirty miles of railroad track, has modern steamship piers, each over a quarter of a mile long, at which thirty-five steamships can load or unload at the same time.

The plant includes 122 warehouses, fifteen model loft buildings, containing more than 5,000,000 sq.ft. of space, a million-dollar eight-story reinforced concrete service building, equipped with every modern convenience to handle merchandise, and a coal storage plant of scientific type with 1,500,000 cu.ft. of coal storage space.

Metallurgical Sessions

Non-Ferrous Metallurgy

While but three papers were presented at the Institute of Metals division, they were of great interest to those attending, resulting in a very lively discussion of each. Particularly F. L. Antisell's paper on the "Relationship of Physical and Chemical Properties of Copper" was acclaimed as an informative contribution, especially to the user of electrolytic copper.

Mr. Antisell emphasized that it is much simpler to produce from a refining furnace copper shapes which are metallurgically correct than those that are mechanically satisfactory. Evidently extreme care must be taken with metal cast in an open chill-mold if it is to be rolled or drawn into the thinnest sheet or finest wire without exhibiting any surface defects. After briefly discussing the terms "pitch" and "set," and describing the well known action of copper oxide in metal and particularly its detection by fracture and pitch, the author says:

"Unhealthy copper contains slight quantities of gases, such as hydrogen, carbon monoxide, sulphur dioxide, and carbon dioxide. If an attempt is made to remove the excessive oxygen, the copper will spew; that is, a miniature volcanic action will occur in the shape and the copper will be known as overpoled. Copper in this state will be low in electrical conductivity and have a small reduction in area, due to several reasons, particularly the excess of oxygen. These properties can be improved only by subjecting the entire charge to a refining process, which consists of oxidizing the copper, thus removing the reducing gases, and then poling the copper up to a tough pitch. Unhealthy copper may present either a high or a low pitch, but if an attempt is made to raise the low pitch, the copper will spew.

"Reasons for rejecting refined copper on physical examination are: Low pitch; overpoling; cold sets; spewing; shot; fish (slivers of foreign copper, as the fins from the pouring ladle, etc.); holes of several characters, as water holes, shake holes, shrink holes, gas holes, spew holes, general porosity; foreign substances, such as charcoal, bone ash, dirt, etc.; splashes; fins; cracks; large set marks; water bursts; ridges on surface; shapes cast in rough molds; wrong dimensions; and collective defects. By the last term are meant two or more slightly developed defects, one of which would not be a sufficient cause for the rejection of the shape."

Causes for each of these troubles are then mentioned briefly, particularly with reference to their relation to the modern practice of casting in a traveling series of molds. Electrical conductivity, of course, is a most important test for finished copper; this when supplemented by a bending test on a Capp machine will usually give about all the necessary information desirable for acceptances. The author particularly recommended the bending test as simple and very reliable; however, high arsenic will not be detected by it, but this element is quickly noticed in the conductivity measurements.

"A few general laws may be stated for the tough-pitch period, with reference to the relative properties of copper, which are applicable over a short range only:

"1. As the tensile strength increases, the conductivity decreases.

"2. As the oxygen contents increase, the tensile strength increases.

BANQUET OF THE A.I.M.E., NEW YORK, FEB. 17, 1920

"3. As the tensile strength increases, the elongation decreases.

"4. As the oxygen contents increase, the resistance of bending decreases."

Discussion

In the discussion Mr. Caesar emphasized the importance of annealing practice, too often neglected by the manufacturer of rolled or drawn products. For copper, 700 deg. C. is the limit of temperature without endangering the ductility, which heating, by the way, should be done with an oxidizing condition in the furnace.

Prof. A. L. Walker described some early troubles with mechanical casting. For instance, considerable trouble was experienced with otherwise quite satisfactory wire bars having a crack on their under side in the region where the stream of hot metal was poured into the mold. After much study, it appeared that this location stayed liquid longest in the solidifying bar, finally setting considerably later than the ends. Since the intercrystalline cement in copper is very brittle just below the freezing point, the region in question was unable to draw in the solidified ends, and a shrinkage crack resulted, a condition often observed in many metals after slow cooling. The trouble was obviated in this case by moving the pouring stream from end to end of the open mold.

W. R. Webster, however, felt that the above defect was but another confirmation of his growing idea that the standards of performance of copper refiners now are not as high as they were twenty-five years ago. This probably was an unconscious drift, but doubtless was due to the difference between well-done hand work by skillful refiners and carelessly done machine work where quantity was unduly emphasized. For instance, in the old days the Bridgeport brass companies' record charge would be about 40,000 lb., and he felt that the small furnaces then in vogue were much more easily controlled than the huge furnaces now in operation. F. R. Pyne took sharp issue with this idea, saying that since in the old days plates and staybolts were the principal outlet for pure copper products, toughness and strength were the prime considerations. Now, however, copper is made with an eye toward its electrical properties; as a result it is controlled so completely as to its arsenic, silver and oxygen contents that it actually is too pure to suit some manufacturing processes. Aluminum apparently is another whose best properties are had with somewhat impure metal.

Intercrystalline Brittleness

Two papers on intercrystalline brittleness of lead and of copper were presented by H. S. Rawdon in collaboration with S. C. Langdon. It appears that much lead sheathing used to protect aerial and subterranean feederlines on electric systems is subject to a crumbling deterioration, giving spots so weak and brittle that it could be easily crumbled into a gray powder. Each particle when pressed with a pestle appeared quite malleable and, when cut, gave the characteristic color and luster of lead. Microscopic examination of a portion in which the metal was only partly embrittled showed that the method of the corrosive attack is intercrystalline in its nature, and that the action begins on the exposed surface of the sheathing and proceeds inwardly was very evident. A chemical analysis of the material showed that there was no essential difference between the corroded and the uncorroded parts and that the lead contained a considerable amount of tin.

Since the melting point of the granules was within 0.2 deg. C. of the sound portion, it was concluded that allotropy was not present. In fact, specimens of very pure lead were treated in the manner described by previous investigators for the production of the allotropic form of lead. No evidence was obtained to justify the claim that lead may exist in an allotropic state analogous to the well-known gray tin. The forms of lead previously described in the scientific literature as allotropic states appear to be due to an intercrystalline attack by the electrolyte, immersion in which was necessary to bring about the allotropic change. The rate at which the so-called allotropic transformation occurs is largely a function of the purity of the lead and the acidity of the electrolyte in which the metal is immersed.

From these experiments, and others exhibiting the mechanism of etching agent attack, Dr. Rawdon concludes that the difference in solubility of the impurities (which are substantially all insoluble in the solid, and therefore form eutectiferous cementing films) and of the pure lead comprising the interior of the crystal accounts largely for the disintegration of the metal by intercrystalline embrittlement when immersed in a weak acid solution consisting of substances leached out of the surrounding concrete. The greater rate of disintegration of commercial lead, as compared with pure lead, is due to the larger amount of these intercrystalline impurities.

In the short paper on copper, Rawdon and Langdon determine the cause of embrittling when ductile bars are cleaned in molten salt. During this time they had been in contact with iron, thus forming a galvanic cell of which copper was the cathode. Metallic sodium was then deposited from the fused electrolyte, which immediately alloys with the copper. The most striking feature is the selective attack by which the metal at the grain boundaries is acted upon and the action progresses inwardly between the crystals instead of forming an alloy layer upon the outside of uniform thickness. The behavior of a specimen showing under the microscope but a thin penetration by the sodium, when subjected to the bend test illustrates the effect of a relatively thin brittle skin upon the properties of a much larger piece. The structure of the interior of the specimen showed no evidence of brittleness any more than did that of the rod used as an anode, or the rod in its initial state. It may be assumed, therefore, that only a relatively very thin skin has been rendered brittle by the electrolytic action, yet the properties of the entire rod have been very profoundly changed.

Discussion

T. D. Yensen called attention to this latest variety of copper brittleness in comparison to a similar effect of hydrogen, occluded at the cathode or elsewhere. As he has shown with N. B. Pilling, in this case hydrogen enters into the copper very readily, but reacting with the oxide in the eutectic areas, forms water which diffuses outward very slowly.

G. H. Clamer and F. A. Hall also pointed out the very annoying and expensive failures of bearing liners, which had not yet been adequately studied. These liners, which may be either pure lead or lead alloyed with antimony and tin, are turned and soldered to a backing. After more or less service they crack away

at the tinned joint, and if they fall out of a journal without the fact being noticed, hot boxes are sure to result. The same phenomenon gave some trouble with aircraft motors. The connecting rod bearings were bronze shells with babbitt linings. A preliminary study of this indicated intercrystalline fracture, but Mr. HALL was unable to pursue the study to a successful conclusion.

ZAY JEFFRIES pointed out that much brittleness in even purest metal was due to the entirely different physical properties of the crystalline grains and the amorphous cementing material, citing Rosenhain and Archbutt's recent results on season cracking of brass, wherein they show that such is an intercrystalline break due to the amorphous materials' entirely different rate of deformation under applied load than that of the grain metal. A similar effect has been shown by Merica to take place in the β-brass boundaries of α grains. Lead of great purity can be broken at the grain boundaries after long exposure to moderate loads; the amorphous phase apparently is viscous, deforming slowly like pitch, while the crystalline phase is non-viscous but elastic, deforming under load quickly to a definite point. Boiler tubes stressed and at 300 to 400 deg. C. acquire great brittleness for the same reasons: in fact Dr. Jeffries believes that much brittleness can only be explained by a difference of specific properties, amorphous to crystalline phase, usually accentuated at high temperatures and especially evident under slow loadings.

MILLING AND SMELTING

FREDERICK P. DEWEY presented an exhaustive paper on "Volatilization in Assaying" which we hope to publish in full in the near future. Starting from the common excuse of poor results that volatilization is to blame, he discusses the general effect of vaporization in cupellation, the loss through dusting, the relation of vapor pressure and volatility, the condensation of muffle fumes, and then passes on to a review of the literature on volatility of gold, silver and lead, both pure and alloyed and as affected by oxygen in solution, each section of which is amplified by observations from the author's unexcelled practice. In the end he is forced to the conclusion that there is no real evidence that in a properly conducted assay, the loss of either gold or silver by volatilization is sufficient to affect appreciably the result, even when arsenic or antimony may be present.

DISCUSSION

J. W. RICHARDS, in discussion, observed that theoretical deductions from vapor pressure curves were often unsubstantiated in practice simply because losses by "misting" were very important—that is, the true vapor carries with it a cloud of minute globules of liquid metal, whose quantity has no simple relation to the boiling point. The author, however, emphatically disputed the purely theoretical conclusion that all solid metals had a vapor pressure greater than zero.

COAL-PULVERIZING PLANT AT NEVADA CONSOLIDATED SMELTER

A detailed description of a dust-firing system was given by R. E. H. POMEROY in a paper entitled "Coal-Pulverizing Plant at Nevada Consolidated Smelter." The plant itself replaced an oil-storage system and contains many innovations suggested by the smelter staff, and has operated over a year with entire satisfaction and very little repair replacements.

The principal advantages of the system, which influenced this decision, were: (1) Equal safety; no pulverized coal is stored at the furnaces; (2) greater ease of operation, furnace fires being controlled by regulating valves in burner branches, as in gas firing; (3) better organization; all machinery, including pulverized coal feed, is under one roof, and the organization is separate from the furnace department; (4) greater cleanliness; all machinery is under vacuum and the building is automatically ventilated. (5) greater flexibility of application; the coal and air mixture can be piped where needed.

As is perhaps well known, this system works on a closed circuit and involves the transportation of pulverized coal as a suspension in air, the quantity of coal required at any furnace being withdrawn by appropriate connections, and any unconsumed coal, amounting to from 10 to 100 per cent of the supply, may be returned to the grinding plant by a separate main. The paper contains a well-made flow sheet showing each piece of apparatus in its proper location.

DISCUSSION

In discussion, B. F. TILLSON called attention to the fact that certain data, essential to the designer of such piping systems, appeared to be very hard to find. For instance, what is the friction of a stream of air carrying coal? What is the best proportion of air to coal? What is the minimum velocity which will carry, say, 200-mesh coal? Mr. TILLSON also was puzzled to know why flare-backs at the nozzles are not continually occurring. It appears that if all the 2-in. head often used were translated into velocity head, the speed of the combustible mixture would amount to about 8,000 ft. per min., yet the Bureau of Mines states that the minimum velocity of propagation of explosion in coal dust is 200 ft. per sec. and rapidly approaches a velocity ten times as high.

TREATING CONVERTER SLAG

A paper by FREDERICK LAIST and H. J. MAGUIRE on "Reverberatory Furnace for Treating Converter Slag at Anaconda" has already been abstracted in CHEMICAL & METALLURGICAL ENGINEERING, Feb. 4, 1920, p. 231. The chairman, E. P. MATHEWSON, said that this large furnace was constructed with no little trepidation. However, it was structurally excellent, and operated very nearly as predicted after the first few starting troubles had been overcome. The new furnace added far more than its allowable quota to the smoke in the converter building, while some adjustment was necessary before the correct location of the slag inlet was found.

C. G. MAIER emphasized his ideas already developed that in order to recover copper from slags the quantity of contained Fe_3O_4 must be reduced. Otherwise it will oxidize sulphur from the globules of trapped sulphides, forming bubbles of SO_2 gas, which act as a balloon, buoying up the particle.

W. C. SMITH observed that he had examined slags from the Tennessee Copper Co., which substantiated Maier and Van Arsdale's conclusions. Blast furnaces working on green ore showed no magnetite; slag from a matte-concentrating furnace contained but very little magnetite; converter slag, however, was loaded with Fe_3O_4 and overflow from a settler to which molten con-

[1] *Eng. & Mining J.*, May 10, 1919, vol. 107, p. 815; CHEM. & MET. ENG., July 1, 1919, vol. 21, p. 46.

verter slag had been added had nearly as much magnetite as the original converter slag. Mr. Smith had run several series of successive charges of converter slag plus 14 per cent coke into an ordinary blast furnace in regular operation, at the same time sampling the slag at frequent intervals, but no increase in the amount of cementite could be discovered.

E. E. THUM called attention to the diversity of practice in regard to the handling of converter slag at the large Western plants, and pleaded for an analysis of the smelterman's ideas in the light of Maier and Van Arsdale's researches. Many plants cast their converter slag in a more or less expensive manner, using machines of various degrees of excellency, for subsequent resmelting in a blast furnace. Other metallurgists were content to add the slag to a reverberatory furnace; some in the solid state, others insisting that it be poured in with a very considerable drop. It is, in fact, contended that a reverberatory will recover copper from concverter slag if its iron content be low enough, but unfortunately some ore supplies will not allow a close limitation of this element.

MILLING PLANT OF THE ALASKA-GASTINEAU MINING CO.

E. V. DAVELER's paper on the "Milling Plant of the Alaska-Gastineau Mining Co." appears in full on page 361 of this issue. The most noticeable innovation was the use of skip-hoists in place of belt-elevators, and this feature was commented upon in the discussion. W. L. RENICK, a member of the operating staff, stated that these skips were very discouraging at first, requiring two men on each to approach a semblance of operation. A flat cable was used, so that the speed of skip travel rapidly changed even when the driving motor was running uniformly, but unfortunately the blow at the bottom and top stop could not be regulated. This meant trouble with stopping at the correct place, and more trouble with bin gates opening and filling hoist pit with ore. However, as soon as the dash-pot described was hit upon, the problem was solved so satisfactorily that the staff would not think of replacing this automatic equipment with the old-style bucket elevators.

The discussions on Iron and Steel will be presented in this journal for March 3, 1920.

Elimination of Dust Hazard at Niagara Falls Plant

A survey of the chemical and metallurgical plants at Niagara Falls by the United States Public Health Service brought forth the fact that the health of the workers in many of the factories was endangered by the presence of innumerable fine particles of dust in the air. Once breathed into the lungs, such particles are never expelled. Photomicrographs show the tiny particles to be exceedingly sharp and jagged and chemical tests prove them to be practically insoluble.

In all of the factories the laborers were found to be exposed to dangers which would eventually incapacitate them for further work. Fortunately over 60 per cent of the labor in these plants seeks new employment monthly and the result of exposure to such dangers is not as evident as it would be if the workers remained at the same work for longer periods.

As a result of the survey industrial hygiene engineers devised means of removing the dust from the air and minimizing hazards from fumes and poisonous gases. In spite of the fact that the installation of such devices was expensive, factory managements immediately put them into use.

Imports and Exports

The Department of Commerce reports for December, 1919:

DOMESTIC EXPORTS FROM THE U. S. BY COUNTRIES

Countries	Caustic Soda — Lb.	Caustic Soda — Value	Soda Ash — Lb.	Soda Ash — Value
Denmark	784,299	$22,330	.....	.....
France	7,760	2,077	.....	.....
Greece	22,800	800	.....	.....
Italy	630,880	21,777	.....	.....
Spain	339,433	30,773	.....	.....
Canada	691,619	25,489	2,860,936	$81,132
Costa Rica	6,900	250	.....	.....
Honduras	3,480	135	8,823	227
Nicaragua	30,950	1,069	.....	.....
Salvador	7,600	360	.....	.....
Mexico	155,133	5,719	42,955	1,175
Jamaica	12,938	519	3,750	50
Cuba	624,672	16,172	141,900	2,834
Haiti	20,040	672	.....	.....
Dominican Republic	14,375	498	3,600	90
Argentina	34,378	1,519	.....	.....
Brazil	451,330	22,515	11,040	259
Chile	45,992	2,204	.....	.....
Colombia	58,011	2,190	26,500	835
Ecuador	20	1	.....	.....
British Guiana	1,000	60	.....	.....
Peru	4,240	195	.....	.....
Uruguay	2,208	85	.....	.....
Venezuela	23,443	803	12,591	397
China	115,504	3,469	300	6
Japanese China	89,654	3,586	.....	.....
British India	58,250	1,850	5,600	135
Dutch East Indies	64,792	2,592	3,000	61
Japan	6,358,922	229,273	1,050,208	20,531
Philippine Islands	2,800	77	.....	.....
British South Africa	4,467	195	.....	.....
Total	10,667,890	$399,254	4,171,203	$107,732

DOMESTIC EXPORTS FROM THE U. S. BY COUNTRIES—IMPORTS INTO THE U. S. BY TOTALS

Glycerine

Countries	Lb.	Value	Countries	Lb.	Value
Azores and Madeira Is.	100	$28	China	87	24
Greece	1,625	409	British India	2,570	704
Spain	2,845	627	Dutch East Indies	50	12
Canada	1,168	234	French East Indies	400	120
Costa Rica	576	131	Hong Kong	7,150	1,840
Nicaragua	160	55	Japan	71,100	15,792
Mexico	11,404	2,093	Philippine Islands	60	15
Trinidad and Tobago	50	13	British South Africa	500	115
Cuba	6,610	1,461	Egypt	2,000	436
Haiti	50	15			
Argentina	2,550	762	Total	129,597	$30,060
Brazil	1,227	314			
Chile	14,100	3,489	IMPORTS		
Colombia	1,245	862		Lb.	Value
Peru	1,395	370			
Venezuela	575	139	Total	607,408	$54,567

German Opinion of Chemical Foundation

In a recent bulletin issued by the Chemical Foundation to its stockholders and licensees, attention is called to an article on "The Chemical Foundation and Its Aims," which appeared in *Die Chemische Industrie*, vol. 42, p. 186, August, 1919. A literal translation of the article is included in the bulletin.

The German critic has been impressed with the idea that the stock of the Foundation is to be as widely distributed as possible, and that each stockholder is to be allowed only two shares of voting stock. He is further impressed with the fact that the patents of the Foundation are open only to those manufacturers who can prove their Americanism as well as to show adequate technical qualifications. He carefully calls attention by the use of italics to the fact that as many of the patents owned by the Foundation are *product* patents, the Foundation should be able to exclude importations *as a matter of course.* In conclusion it is stated that *"the further development of the Chemical Foundation must at any rate be watched very closely in Germany. In truth this company represents the shrewdest militant organization that thus far has been formed abroad against the German chemical industry. Neither legal nor moral scruples concerning the inconsiderate action previously taken against guaranteed private property appear to have occurred to the founders of this company, for whom the principle 'Right or Wrong, My Country' apparently has exclusive prevalence in peace times as well."*

The Engineer in National Affairs

Presidential Address at the Annual Meeting of the American Institute of Mining and Metallurgical Engineers—Outline of a National Policy With Regard to Railroads, Shipping, and Industrial Relations—Need of Engineering Thinking in Government Administration

BY HERBERT C. HOOVER

I HAVE been greatly honored as your unanimous choice for president of this Institute, with which I have been associated during my entire professional life. It is customary for your new president, on these occasions, to make some observation on matters of general interest from the engineer's standpoint.

The profession of engineering in the United States comprises not alone scientific advisers on industry, but is in great majority comprised of the men in administrative positions. In such positions they stand midway between capital and labor. The character of your training and experience leads you to exact and quantitative thought. This basis of training in a great group of Americans furnished a wonderful recruiting ground for service in these last years of tribulation. Many thousands of engineers were called into the Army, the Navy, and civilian service for the Government. Thousands of high offices were discharged by them with credit to the profession and the nation.

Engineers for Efficiency in Government

We have in this country probably one hundred thousand professional engineers. The events of the past few years have greatly stirred their interest in national problems. This has taken practical form in the maintenance of joint committees for discussion of these problems and support to a free advisory bureau in Washington. The engineers want nothing for themselves from Congress. They want efficiency in government, and you contribute to the maintenance of this bureau out of sheer idealism. This organization for consideration of national problems has had many subjects before it, and I propose to touch on some of them this evening.

Interdependence of World Affairs

Even more than ever before is there necessity for your continued interest in this vast complex of problems that must be met by our Government. We are faced with a new orientation of our country to world problems. We face a Europe still at war; still amid social revolutions; some of its peoples still slacking on production; millions starving; and therefore the safety of its civilization is still hanging by a slender thread. Every wind that blows carries to our shores an infection of social disease from this great ferment; every convulsion there has an economic reaction upon our own people. If we needed further proof of the interdependence of the world, we have it today in the practical blockade of our export market. The world is asking us to ratify long-delayed peace in the hope that such confidence will be restored as will enable her to reconstruct her economic life. We are today contemplating maintenance of an enlarged Army and Navy in preparedness for further upheavals in the world and failing to even provide some insurance against war by a league to promote peace.

Some of Today's Problems

Out of the strain of war, weaknesses have become even more evident in our administrative organization, in our legislative machinery. Our Federal Government is still overcentralized, for we have upon the hands of our Government enormous industrial activities which have yet to be demobilized. We are swamped with debt and burdened with taxation. Credit is woefully inflated; speculation and waste are rampant. Our own productivity is decreasing. Our industrial population is crying for remedies for the increasing cost of living and aspiring to better conditions of life and labor. But, beyond all this, great hopes and aspirations are abroad; great moral and social forces have been stimulated by the war and will not be quieted by the ratification of peace. These are but some part of the problems with which we must deal. I have no fear that our people shall not find solutions; but progress is sometimes like the old-fashioned rail fence—some rails are perhaps misshapen, and all look to point the wrong way; but in the end, the fence progresses.

Objections to Government Control

Your committees, jointly with those of other engineering societies, have had before them and expressed their views in many matters concerning the handling of the railways, shipping, the reorganization of the Government engineering work, the national budget, and other practical items.

The war nationalization of railways and shipping are our two greatest problems in Government control awaiting demobilization. There are many fundamental objections to continuation of these experiments in socialism necessitated by the war. They lie chiefly in their destruction of initiative in our people and the dangers of political domination that can grow from governmental operation. Beyond this, the engineers will hold that the successful conduct of great industries is to a transcendent degree dependent upon the personal abilities and character of their employees and staff.

Competition and Efficient Schooling

No scheme of political appointment has ever yet been devised that will replace competition in its selection of ability and character. Both shipping and railways have today the advantage of many skilled personnel, sifted out in the hard school of competition, and even then the Government operation of these enterprises is not proving satisfactory. Therefore, the ultimate inefficiency that would arise from the deadening paralysis of bureaucracy has not yet had full opportunity for development. Already, we can show that no government, under pressure of ever-present

political or sectional interests, can properly conduct the risks of extension and improvement or can be free from local pressure to conduct unwarranted service in industrial enterprise. On the other hand, our people have long since recognized that we cannot turn monopoly over to unrestrained operation for profit or that the human rights of employees can ever be dominated by dividends.

Need of Increased Transportation Facilities

Our business is handicapped on every side by the failure of our transportation facilities to grow with the country. It is useless to talk about increased production to meet an increased standard of living in an increasing population without a greatly increased transport equipment. Moreover, there are very great social problems underlying our transport system. Today their contraction is forcing a congestion of our population around the great cities, with all that these overswollen settlements import. Even such great disturbances as the coal strike have a minor root in our inadequate transportation facilities and their responsibility for intermittent operation of the mines.

We are all hoping that Congress will find a solution to this problem that will be an advanced step toward the combined stimulation of the initiative of the owners, the efficiency of operation, the enlistment of the good will of the employees, and the protection of the public. The problem is easy to state. Its solution is almost overwhelming in complexity. It must develop with experience, step by step—toward a real working partnership of its three elements.

The return of the railways to the owners places predominant private operation upon its final trial. If instant energy, courage, and large vision in the owners should prove lacking in meeting the immediate situation, we will be faced with a reaction that will drive the country to some other form of control. Energetic enlargement of equipment, better service, co-operation with employees, and the least possible advance in rates, together with freedom from political interest, will be the scales upon which the public will weigh these results.

Expansion of Shipping

Important phases of our shipping problem that have come before you should receive wider discussion by the country. As the result of war pressure, we will spend over $2,800,000,000 in the completion of a fleet of nineteen hundred ships, of a total of 11,000,000 tons—nearly one-quarter of the world's cargo shipping. We are proud of this great expansion of our marine, and we wish to retain it under the American flag. Our shipping problem has one large point of departure from the railway problem, for there is no element of natural monopoly. Anyone with a water-tight vehicle can enter upon the seas today, and our Government is now engaged upon the conduct of a nationalized industry in competition with our own people and all the world besides. While in the railways Government inefficiency could be passed on to the consumer, on the seas we will sooner or later find it translated to the national Treasury.

Private vs. Government Shipping Business

Until the present time, there has been a shortage in the world's shipping, but this is being rapidly overtaken, and we shall soon be met with fierce competition of private industry. If the Government continues in the shipping business, we shall be disappointed from the point of view of profits; for we shall be faced with the ability of private enterprise to make profits from the margins of higher cost of Government operation alone. Aside from those losses inherent in bureaucracy and political pressure, there are others special to this case. The largest successfully managed cargo fleet in the world comprises about one hundred and twenty ships, and yet we are attempting to manage nineteen hundred ships at the hands of a Government bureau. In normal times the question of profit or loss in a ship is measured by a few hundred tons of coal wasted, by a little extravagance in repairs, or by four or five days lost on a round trip. Beyond this, private shipping has a free hand to set up such give-and-take relationships with merchants all over the world as will provide sufficient cargo for all legs of a voyage, and these arrangements of co-operation cannot be created by Government employees without charge or danger of favoritism. Lest fault be found, our Government officials are unable to enter upon the detailed higgling in fixing rates required by every cargo and charter. Therefore, they must take refuge in rigid regulations and in fixed rates. In result, their competitors underbid by the smallest margins necessary to get the cargoes. The effect of our large fleet in the world's markets is thus to hold up rates, for so long as this great fleet on one hand holds a fixed rate others will only barely underbid. If we hold up rates, an increasing number of our ships will be idle as the private fleet grows. On the other hand, if we reduce rates we shall be underbid until the Government margin of larger operation cost causes us to lose money.

Problems of American Shipping Industry

We shall yet be faced with the question of demobilizing a considerable part of this fleet into private hands, or frankly acknowledging that we operate it for other reasons than interest on our investment. In this whole problem there are the most difficult considerations requiring the best business thought in the country. In the first instance, our national progress requires that we retain a large fleet under our flag to protect our national commercial expansion overseas. Secondly, we may find it desirable to hold a considerable Government fleet to build up trade routes in expansion of our trade, even at some loss in operation. Thirdly, in order to create this fleet, we have built up an enormous shipbuilding industry. Fifty per cent of the capacity of our shipyards will more than provide any necessary construction for American account. Therefore there is a need of obtaining foreign orders, or the reduction of capacity, or both. I believe, with most engineers, that, with our skill in repetition manufacture, we can compete with any shipbuilders in the world and maintain our American wage standards; but this repetition manufacture implies a constant flow of orders. It would seem highly desirable, in order to maintain the most efficient yards until they can establish themselves firmly in the world's industrial fabric, that the Government should continue to let some ship construction contracts to the lowest bidders, these contracts to supplement private building in such a way as to maintain the continuous operation of the most economical yards and the steady employment of our large number of skilled workers engaged therein.

When we consider giving orders for new ships, we must at the same time consider the sale of ships, as we cannot go on increasing this fleet. When we consider sale, we are confronted with the fact that our present

ships were built under expensive conditions of war, costing from three to four times per ton the pre-war amount, and that already any merchant, subject to the long time of delivery, can build a ship for 75 per cent of their cost. It would at least seem good national policy to sell ships today for the price we can contract for delivery a year or two hence, thus making the Government a reservoir for continuous construction. We could thus stabilize building industry to some degree and also bring the American-owned fleet into better balance, if, as the Government sold three or four emergency-constructed cargo vessels, it gave an order for one ship of a better and faster type. This would make reduction in our shipbuilding steadier and would give the country the type of ships we need.

Engineering Committees Recommend Remedies for Governmental Efficiency

Our joint engineering committees have examined with a great deal of care into organization of and our expenditure on public works and technical services. These committees have consistently and strongly urged the appalling inefficiency in the Government organization of these matters. They report to you that the annual expenditure on such works and services now amounts to over $250,000,000 per annum, and that they are carried out today in nine different governmental departments. They report that there is a great waste by lack of a national policy of co-ordination, in overlapping with different departments, in competition with each other in the purchase of supplies and materials and the support of many engineering staffs.

They recommend the solution that almost every other civilized government has long since adopted, that is, the co-ordination of these measures into one department under which all such undertakings should be conducted and controlled. As a measure practical to our Government, they have advocated that all such bureaus should be transferred to the Interior Department, and all the bureaus not relating to these matters should be transferred from the Interior to other departments. The committee concludes that no properly organized and directed saving in public works can be made until such a regrouping and consolidation is carried out, and that all of the cheese-paring that normally goes on in the honest effort of Congressional committees to control departmental expenditure is but a tithe of that which could be effected if there were some concentration of administration along the lines long since demonstrated as necessary to the success of private business.

National Budget Advocated

Another question of Government organization to which our engineers have given adhesion is in the matter of the national budget. To minds charged with the primary necessity of advance planning, co-ordination, provision of synchronizing parts in organization, the whole notion of our hit-or-miss system is repugnant. A budget system is not the remedy for all administrative ills; it provides a basis of organization that at least does not paralyze administrative efficiency as our system does today. Through it, the co-ordination of expenditure in Government departments, the prevention of waste and overlapping in Government bureaus, the exposure of the pork barrel, and the balancing of the relative importance of different national activities in the allocation of our national income can all be greatly promoted. Legislation would also be expedited. No budget that does not cover all Government expenditure is worth enactment. Furthermore, without such reorganization as the grouping of construction departments, the proper formulation of a budget would be hopeless. The budget system in some form is so universal in civilized governments and in competently conducted business enterprise, and has been adopted in so many of our States, that its absence in our Federal Government is most extraordinary. It is, however, but a further testimony that it is always a far cry of our citizens from the efficiency in their business to interest in the efficiency of their Government.

Problem of Relationship Between Employer and Employee

Another great national problem to which every engineer in the United States is giving earnest thought, and with which he comes in daily contact, is that of the relationship of employer and employee in industry. In this, as in many other national problems today, we are faced with a realization that the science of economics has altered from a science of wealth to a science of human relationships to wealth. We have gone on for many years throwing the greatest of our ingenuity and ability into the improvement of processes and tools of production. We have until recently greatly neglected the human factor that is so large an element in our very productivity. The development of vast repetition in the process of industry has deadened the sense of craftsmanship, and the great extension of industry has divorced the employer and his employee from that contact that carried responsibility for the human problem. This neglect of the human factor has accumulated much of the discontent and unrest throughout our great industrial population and has reacted in a decrease of production. Yet our very standards of living are dependent on a maximum productivity up to the necessities of our population.

Another economic result is, or will be yet, a repercussion upon the fundamental industry of the United States, that is, agriculture. For the farmer will be unable to maintain his production in the face of a constant increase in the cost of his supplies and labor through shrinkage in productivity in other industries. The penalty of this disparity of effort comes mainly out of the farmer's own earnings.

Collective Bargaining and Sanctity of Contracts the Remedy

I am daily impressed with the fact that there is but one way out, and that is to again re-establish, through organized representation, that personal co-operation between employer and employee in production that was a binding force when our industries were smaller of unit and of less specialization. Through this, the sense of craftsmanship and the interest in production can be re-created and the proper establishment of conditions of labor and its participation in a more skilled administration can be worked out. The attitude of refusal to participate in collective bargaining with representatives of the employees' own choosing is the negation of this bridge to better relationship. On the other hand, a complete sense of obligation to bargains entered upon is fundamental to the process itself.

Employee and Employer Have Common Ground

The interests of employee and employer are not necessarily antagonistic; they have a great common

ground of mutuality, and if we could secure emphasis upon these common interests we would greatly mitigate conflict. Our Government can stimulate these forces, but the new relationship of employer and employee must be a matter of deliberate organization within industry itself. I am convinced that the vast majority of American labor fundamentally wishes to co-operate in production and that basis of good will can be organized and the vitality of production re-created.

Intermittency of Employment Great Loss to the Community

Many of the questions of this industrial relationship involve large engineering problems, as an instance of which I know of no better example than the issue you plan for discussion tomorrow in connection with the soft-coal industry. Broadly, here is an industry functioning badly from an engineering and consequently from an economic and human standpoint. Owing to the intermittency of production, seasonal and local, this industry has been equipped to a peak load of 25 or 30 per cent over the average load. It has been provided with a 25 or 30 per cent larger labor complement than it would require if continuous operation could be brought about. I hope your discussion will throw some light on the possibilities of remedy. There lies in this intermittency not only a long train of human misery through intermittent employment, but the economic loss to the community of over a hundred thousand workers who could be applied to other production, and the cost of coal could be decreased to the consumer. This intermittency lies at the root of the last strike in the attempt of the employees to secure an equal division among themselves of this partial employment at a wage that could meet their view of a living return on full employment.

These are but few of the problems that confront us. But in the formulating of measures of solution, we need a constant adherence to a national ideal and our own social philosophy.

Radicalism and Reaction and Their Influence on the Solution of Economic Problems

In the discussion of these ideals and this social philosophy, we hear much of radicalism and of reaction. They are, in fact, not an academic state of mind but realize into real groups and real forces influencing the solution of economic problems in this community. In their present-day practical aspects, they represent on the one hand roughly various degrees of exponents of socialism, who would directly or indirectly undermine the principle of private property and personal initiative, and, on the other hand, those exponents who in various degrees desire to dominate the community for profit and privilege. They both represent attempts to introduce or preserve class privilege, either a moneyed or a bureaucratic aristocracy. We have, however, in American democracy, an ideal and a social philosophy that sympathize neither with radicalism nor reaction as they are manifested today.

American Democracy Has Stood the Test

For generations the American people have been steadily developing a social philosophy as part of their own democracy—and in these ideals it differs from all other democracies. This philosophy has stood this period of test in the fire of common sense; it is, in substance, that there should be an equality of opportunity—an equal chance—to every citizen. This view that every individual should, within his lifetime, not be handicapped in securing that particular niche in the community to which his abilities and character entitle him, is itself the negation of class. Human beings are not equal in these qualities. But a society that is based upon a constant flux of individuals in the community, upon the basis of ability and character, is a moving, virile mass; it is not a stratification of classes. Its inspiration is individual initiative. Its stimulus is competition. Its safeguard is education. Its greatest mentor is free speech and voluntary organization for public good. Its expression in legislation is the common sense and common will of the majority. It is the essence of this democracy that progress of the mass must arise from progress of the individual. It does not permit the presence in the community of those who would not give full meed of service.

American Conception

Its conception of the State is one that, representative of all the citizens, will in the region of economic activities apply itself mainly to the stimulation of knowledge, the undertaking only of works beyond the initiative of the individual or group, the prevention of economic domination of the few over the many, and the least entrance into commerce that Government functions necessitate.

The method and measures by which we solve this accumulation of great problems will depend upon which of these three conceptions will reach the ascendancy among our people.

Unlawful Radicalism Less Dangerous Than Reaction

If we cling to our national ideals it will mean the final isolation and the political abandonment of the minor groups who hope for domination of the Government, either by "interests" or by radical social theories through the control of our political machinery. I sometimes feel that lawful radicalism in politics is less dangerous than reaction, for radicalism is blatant and displays itself in the open. Unlawful radicalism can be handled by the police. Reaction too often fools the people through subtle channels of obstruction and progressive platitudes. There is little danger of radicalism ever controlling a country with so large a farmer population, except in one contingency. That contingency is from a reflex of continued attempt to control this country by the "interests" and other forms of our domestic reactionaries.

U. S. Must First Solve Its Own Problems if It Is to Contribute to Civilization's Advance

The mighty upheaval following the World War has created turmoil and confusion in our own country no less than in all other lands. If America is to contribute to the advance of civilization, it must first solve its own problems, must first secure and maintain its own strength. The kind of problems that present themselves are more predominantly economic—national as well as international—than at any period in our history. They require quantitative and prospective thinking and a sense of organization.

These are the sort of problems that your profession deals with as its daily toil. You have an obligation to continue the fine service you have initiated and to give it your united skill.

Theoretical Study of Nitrogen Fixation by the Electric Arc—II

Chemical Dynamics of the Nitrogen-Oxygen Reactions at the Temperature of the Arc and During Cooling—Effect of the Rate of Cooling Upon the Dissociation of NO—Cooling Curves*

By CHARLES P. STEINMETZ

If THE gas mixture of N_2, O_2, and NO, of concentration a_0 produced by a temperature T_0, is very slowly cooled, during falling temperature the NO concentration will fall so as to have at every temperature T the corresponding equilibrium concentration a, and as a greatly decreases with decreasing temperature, very little NO will be left in the cold gas mixture. If, however, the gas mixture is cooled very rapidly, from the temperature T_0 to the temperature T_1, at which the reaction velocity has become so slow that NO is practically stable, a greater or lesser part of the high concentration a_0, corresponding to the high temperature T_0, will be saved. The quicker the cooling the more will be saved.

The first problem then is to determine that cooling curve, that is, that rate of cooling at which with decreasing temperature the NO concentration still reaches the temperature equilibrium at each temperature; a materially more rapid cooling would be required to save a great part of the NO produced at high temperature.

Mathematically, however, the problem cannot be put in this form, as the reaction curves are exponentials, and the equilibrium concentration at each temperature is reached theoretically only after infinite time.

The problem thus must be put in the form to determine the cooling curve, that is, the rate of temperature decrease, by which the NO concentration a at each temperature exceeds the equilibrium concentration by a small constant value x. That is, to determine the cooling rate $\frac{dT}{dt}$, by which the NO concentration at each temperature T is $a + x$, where a is the equilibrium concentration corresponding to the temperature T, and x a small constant quantity.

Concentration of NO in Air

The equilibrium concentration of NO is given by equation (13):

$$C = \frac{a^2}{\left(n - \frac{a}{2}\right)\left(o - \frac{a}{2}\right)} \qquad (43)$$

where: a = concentration of NO,
n = total or initial N_2 concentration, = 0.777 in air,
o = total or initial O_2 concentration, = 0.210 in air,

and C is the equilibrium constant, which is given as function of the temperature T by van't Hoff's equation:

$$\frac{d \log_e C}{dT} = -\frac{Q}{RT} \qquad (15)$$

Substituting (43) into (15) gives:

$$\frac{d}{dT}\left[\log_e a^2 - \log_e\left(n - \frac{a}{2}\right) - \log_e\left(o - \frac{a}{2}\right)\right] = -\frac{Q}{RT}$$

and expanded:

$$\frac{da}{dT}\left(\frac{2}{a} - \frac{1}{2n - a} - \frac{1}{2o - a}\right) = -\frac{Q}{RT}$$

thus:

$$\frac{da}{dT} = \frac{-Q}{RT^2\left(\frac{2}{a} - \frac{1}{2n - a} - \frac{1}{2o - a}\right)}$$

$$= \frac{21{,}600}{T^2\left(\frac{2}{a} + \frac{1}{1.554 - a} + \frac{1}{0.42 - a}\right)} \qquad (44)$$

Values of the rate of change of the NO concentration a, with the temperature T: $\frac{da}{dT}$ are given in Table IV, from 800 to 4200 deg. abs., and plotted in Fig. 2, together with the values of a.

Lag in Dissociation

If at constant temperature T, the NO concentration exceeds the equilibrium value a by a small amount x,

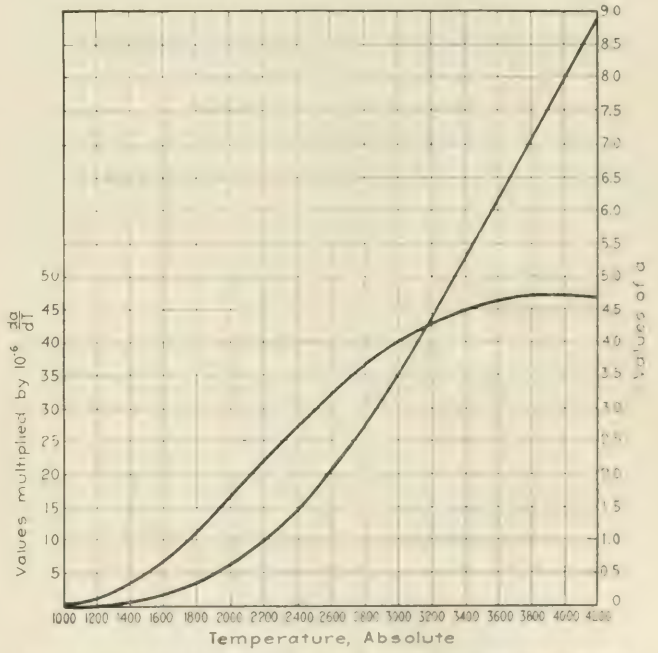


FIG. 2. THERMAL EQUILIBRIUM—NO CONCENTRATION IN AIR

that is, $a + x$, the rate of dissociation is given by equation (26) as:

$$r = \frac{dx}{dt} = c_1(a - x)^2 - c\left(n - \frac{a}{2} - \frac{x}{2}\right)\left(o - \frac{a}{2} - \frac{x}{2}\right) \qquad (45)$$

*For Part I see CHEM. & MET. ENG., vol. 22, No. 7, Feb. 18, 1920, pp. 299-304.

where c_1 and c_2 are the velocity constants given in Table I, as functions of the temperature T.

Expanding (45) and substituting the equilibrium conditions:

$$c_2 a^2 - c_1\left(n - \frac{a}{2}\right)\left(o - \frac{a}{2}\right) = 0$$

gives:

$$v = \frac{dx}{dt} = x\left[2a\left(c_2 - \frac{c_1}{4}\right) + \frac{c_1}{2}(n + o)\right] \qquad (46)$$

or, as c_1 is small compared with c_2:

$$v = \frac{dx}{dt} = x[2ac_2 + \frac{c_1}{2}(n + o)]$$
$$= x(2ac_2 + 0.493c_1) \qquad (47)$$

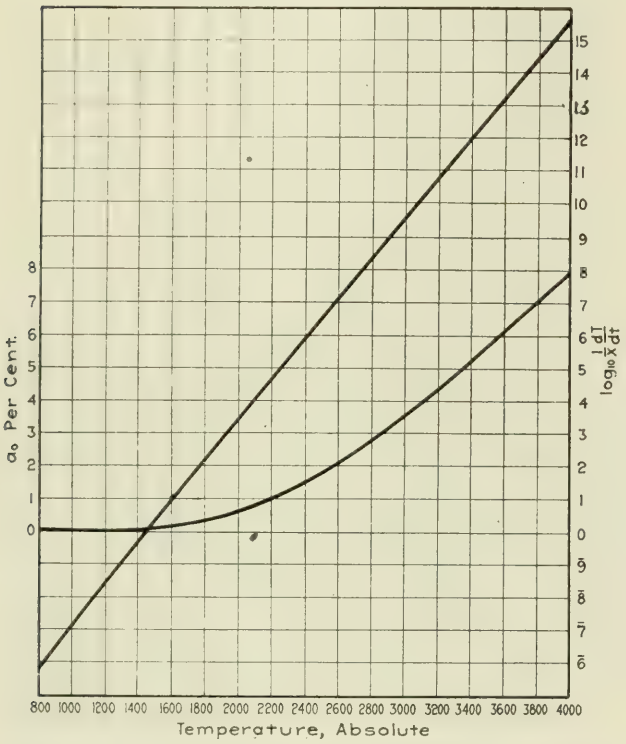


FIG. 3. COOLING CURVES

As the second term in equation (47) is small compared with the first term, this equation can be approximated by:

$$v = \frac{dx}{dt} = 2xac_2 \qquad (48)$$

Values of

$$\frac{1}{x}\frac{dx}{dt} = 2ac_2 - 0.493c_1 \qquad (49)$$

for air, are given in Table IV, and values of:

$$\log_{10} -\frac{1}{x}\frac{dx}{dt}$$

are plotted in Fig. 3 with T as abscissæ, in Fig. 4 with $\log_{10}T$ as abscissæ.

From (44) follows, by integration:

$$x = x_o e^{-(2ac_2 - 0.493c_1)t} \qquad (50)$$

Cooling Curves

If the temperature T of the gas mixture falls with the time t at such a rate

$$\frac{dT}{dt} = f_o(T) \qquad (51)$$

that the change in concentration by dissociation, $\frac{dx}{dt}$, by equation (51), equals the change of equilibrium concentration with the temperature, $\frac{da}{dT}$, then at the decrease of temperature with the time, the decreasing concentration of NO remains by a constant value x above the equilibrium concentration a corresponding to the respective time. That is, on such cooling curve, the NO concentration lags by the constant value x above the falling equilibrium concentration.

The condition herefor obviously is:

$$\frac{dx}{dt} = \frac{da}{dT} \times \frac{dT}{dt} \qquad (52)$$

Thus:

$$\frac{dT}{dt} = f_o(T) = \frac{dx}{dt} \div \frac{da}{dT} \qquad (53)$$

is the equation of the cooling curve giving a constant excess x above the temperature equilibrium values a.

Substituting (46) and (44) into (53), and expanding, gives:

$$\frac{dT}{dt} = -\frac{xRT^2}{Q}[2a\left(c_2 + \frac{c_1}{4}\right) + \frac{c_1}{2}(n + o)]\left(\frac{2}{a} + \frac{1}{2n - a} + \frac{1}{2o - a}\right) = \frac{xT^2}{21{,}600}(2ac_2 + 0.493\,c_1)\left(\frac{2}{a} + \frac{1}{1.554 - a} + \frac{1}{0.42 - a}\right) \qquad (54)$$

Values of $\frac{1}{x}\frac{dT}{dt}$, that is, the cooling curves giving constant excess concentration x, are calculated in Table IV.

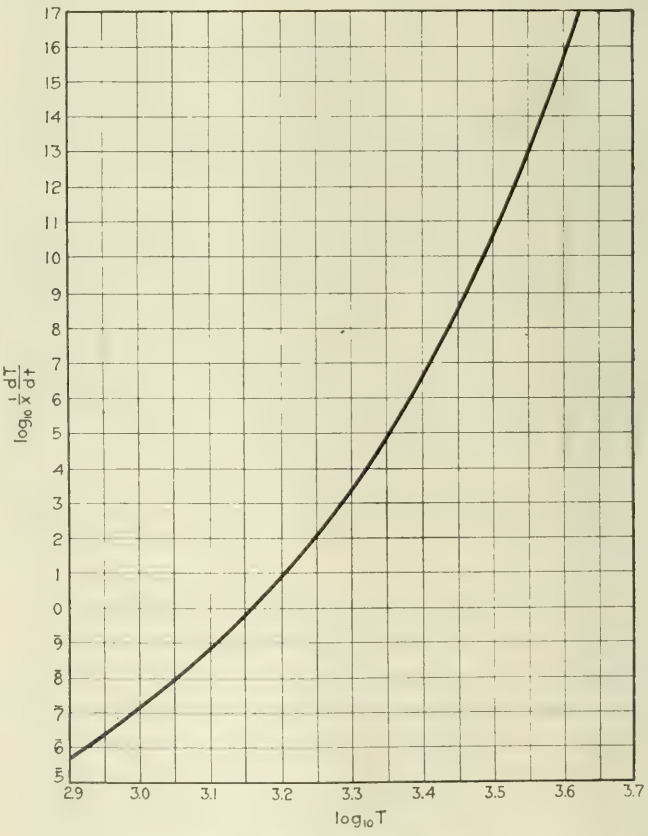


FIG. 4. COOLING CURVES

Inversely now, if a cooling function is given, as for instance, cooling by the radiation law

$$\frac{dT}{dt} = f(T) = bT^4 \qquad (55)$$

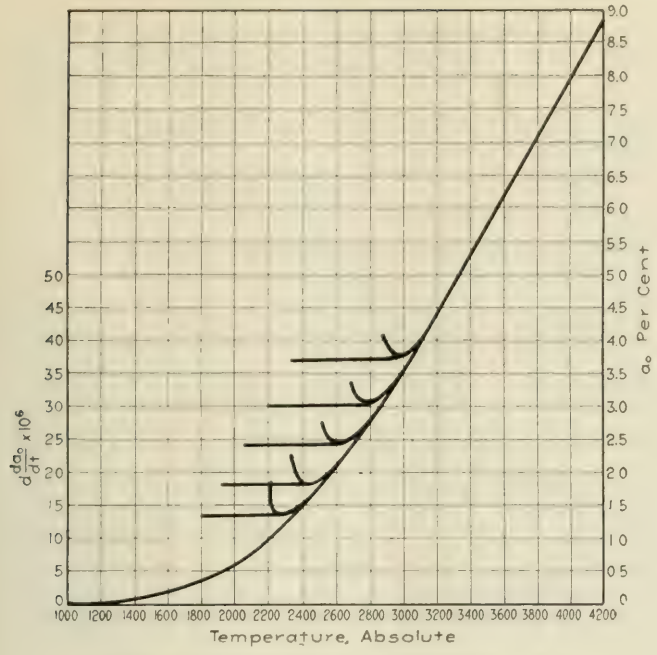


FIG. 5. COOLING BY RADIATION LAW

or cooling by heat conduction, at a rate proportional to the temperature:

$$\frac{dT}{dt} = f(T) = bT \qquad (56)$$

or cooling at a constant rate, as for instance, by an air blast mixing cold air with the gases:

$$\frac{dT}{dt} = f(T) - b \qquad (57)$$

then, by substituting the values of the cooling rate, (55) to (57), etc., into equation (54), the value x is found, that is, for each temperature T, the value x of the NO concentration, by which it exceeds the equilibrium concentration a of this temperature. Provided, however, that x is small compared with a.

This can conveniently be done by plotting the equation (54) in the form:

$$\frac{1}{x}\frac{dT}{dt} = \frac{T^2}{21{,}600}(2ac_2 - 0.493c_1)\left(\frac{2}{a} - \frac{1}{1.554\ a} - \frac{1}{0.42\ a}\right) \qquad (58)$$

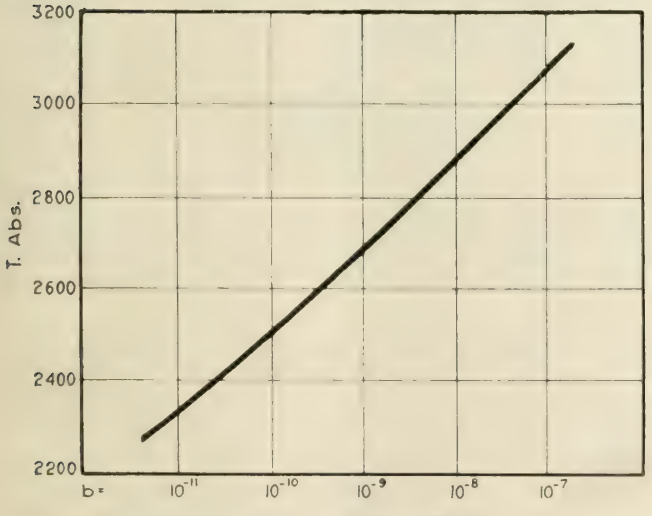


FIG. 6a. COOLING BY RADIATION LAW

TABLE IV. COOLING CURVES

T Degs. Abs.	$\frac{da}{dT}$ Air $\times 10^{-6}$	$\frac{1}{x}\frac{dx}{dt}$ Air	$\frac{1}{x}\frac{dT}{dt}$ Air	$\text{Log}_{10}\frac{1}{x}\frac{dT}{dt}$ Air	$\text{Log}_{10} T$
800	0.034	2.0×10^{-12}	5.9×10^{-5}	$\bar{5}.771$	2.903
900	0.106	3.0×10^{-11}	2.8×10^{-4}	$\bar{6}.447$	2.954
1000	0.323	4.2×10^{-10}	1.3×10^{-3}	$\bar{7}.114$	3.0
1100	0.63	3.62×10^{-9}	5.75×10^{-3}	$\bar{7}.760$	3.041
1200	1.28	3.32×10^{-8}	2.6×10^{-2}	$\bar{8}.415$	3.079
1300	2.1	2.42×10^{-7}	1.16×10^{-1}	$\bar{9}.064$	3.11
1400	3.3	1.64×10^{-6}	5.0×10^{-1}	$\bar{9}.699$	3.046
1500	4.8	1.02×10^{-5}	2.12	0.326	3.176
1600	6.7	6.13×10^{-5}	9.2	0.964	3.204
1700	8.7	3.31×10^{-4}	3.8×10	1.580	3.230
1800	11.2	1.78×10^{-3}	1.59×10^{2}	2.201	3.255
1900	13.8	9.3×10^{-3}	6.73×10^{2}	2.828	3.279
2000	16.4	4.62×10^{-2}	2.82×10^{3}	3.450	3.301
2100	19.0	2.23×10^{-1}	1.18×10^{4}	4.072	3.322
2200	21.7	1.05	4.85×10^{4}	4.686	3.342
2300	24.3	4.86	2.00×10^{5}	5.301	3.362
2400	26.9	2.22×10	8.25×10^{5}	5.916	3.380
2500	29.4	9.9×10	3.37×10^{6}	6.528	3.398
2600	31.9	4.36×10^{2}	1.36×10^{7}	7.133	3.415
2700	34.4	1.94×10^{3}	5.63×10^{7}	7.750	3.431
2800	36.7	8.41×10^{3}	2.29×10^{8}	8.360	3.447
2900	38.5	3.57×10^{4}	9.3×10^{8}	8.968	3.462
3000	40.1	1.52×10^{5}	3.8×10^{9}	9.580	3.477
3100	41.5	6.34×10^{5}	1.53×10^{10}	10.185	3.491
3200	42.8	2.64×10^{6}	6.17×10^{10}	10.790	3.505
3300	44.0	1.10×10^{7}	2.5×10^{11}	11.398	3.518
3400	45.0	4.53×10^{7}	1.01×10^{12}	12.004	3.531
3500	45.7	1.86×10^{8}	4.08×10^{12}	12.611	3.544
3600	46.2	7.60×10^{8}	1.65×10^{13}	13.217	3.556
3700	46.6	3.06×10^{9}	6.56×10^{13}	13.817	3.568
3800	46.9	1.25×10^{10}	2.67×10^{14}	14.426	3.580
3900	47.0	4.98×10^{10}	1.06×10^{15}	15.025	3.591
4000	47.0	2.00×10^{11}	4.26×10^{15}	15.629	3.602
4100	46.9	8.00×10^{11}	1.71×10^{16}	16.233	3.613
4200	46.8	3.12×10^{12}	6.66×10^{16}	16.823	3.623
∞	∞	∞	∞	∞	∞

with T as abscissæ, this curve being independent of x, and then plotting, of the actual cooling curve $f(T)$, the values $\frac{1}{x}\ f\ (T)$ for various values of x. The points of

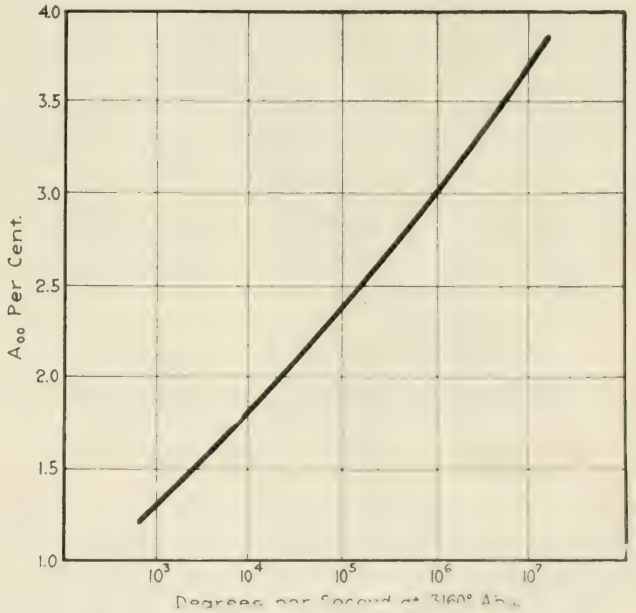


FIG. 6b. COOLING BY RADIATION LAW

intersection with (58) give the temperatures T, at which the excess concentration x exists, and herefrom then a new concentration curve can be plotted, with $a + x$ as ordinates, giving the change of concentration with the temperature, when the temperature decreases by the chosen cooling law $\frac{dT}{dt} = f(T)$.

Cooling by Radiation

The radiation law

$$\frac{dT}{dt} = bT^4 \qquad (59)$$

gives: $$\log_{10} \frac{dT}{dt} = 4 \log_{10} T + \log_{10} b \qquad (60)$$

At: $T = 3160$ deg. abs., $b = 10^{-7}\ 10^{-8}\ 10^{-9}\ 10^{-10}\ 10^{-11}$ gives a cooling rate, per millisecond of:

10,000 1000 100 10 1 deg. C.

If then x is constant, it follows, from (42):

$$\log_{10} \frac{1}{x}\frac{dT}{dt} = 4 \log_{10} T + \log_{10} b - \log_{10} x \qquad (61)$$

a linear equation in $\log_{10} \frac{1}{x}\frac{dT}{dt}$ and $\log_{10} T$.

Plotting then from Table IV, $\log_{10} \frac{1}{x}\frac{dT}{dx}$ as function of $\log_{10} T$, in Fig. 4, as the dissociation function of NO, and taking the points of intersection of this curve with the straight lines (61) corresponding to various values of x, gives $\log_{10} T_0$ and T_0, the critical temperatures, at which in cooling by the law (59) the concentration exceeds the equilibrium value a_0 of temperature T_0, by the value x.

Herefrom then follows the concentration $a_0 + x$ of the cooling curve (59).

Table V gives, for various values of b and of x, the values of T_0, a_0 and $a_0 + x$.

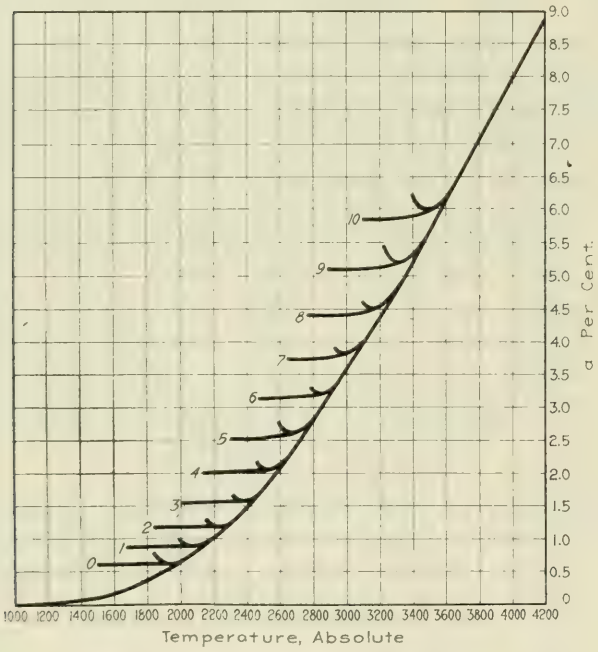


FIG. 7. CONSTANT RATE OF COOLING

a_0 is taken from the plot of a_0 against T, in Fig. 5, and $a_0 + x$ plotted on the same curve sheet, giving an estimate of the final values of concentrations of NO in air.

These are plotted, with b as abscissæ, in Fig. 6, and recorded in Table VI, together with the temperature T_3', at which the minimum of the $a_0 + x$ curve is reached, and the temperature T_{00}, at which the final value of NO concentration, a_{00}, would be the equilibrium values, and the temperature T, at which $x = 0.1$.

Cooling at Constant Rate

Cooling by mixing the arc gases with cold air, as is usually done in arc furnaces, may probably be best approximated by cooling at constant rate, at least within the initial range.

A temperature gradient at the arc surface of 1000 deg. C. per cm. appears reasonable, and even several times as high gradients may be expected in quickly moving arcs. Assuming an air velocity of 100 m. per sec., which is moderate, would give a cooling rate of 10^7 deg. per sec.

Thus, in cooling at uniform rate, by the cooling law

$$\frac{dT}{dt} = -b \qquad (62)$$

TABLE V. COOLING CURVES $\frac{dT}{dt} = bT^4$

	$x =$	0.05	0.1	0.2	0.4	0.7	1.0	% Final
$b = 10^{-7}$								
10^7 degrees	$T_0 =$	3125	3070	3015	2960	2910	2885	
per second	$a_0 =$	4.04	3.82	3.60	3.38	3.20	3.10	
at 3160 deg. abs.	$a_0 + x =$	4.09	3.92	3.80	3.78	3.90	4.10	3.70
$b = 10^{-8}$								
10^6 degrees	$T_0 =$	2940	2880	2820	2765	2715	2685	
per second	$a_0 =$	3.30	3.09	2.86	2.68	2.50	2.39	
	$a_0 + x =$	3.35	3.19	3.06	3.08	3.20	3.39	3.00
$b = 10^{-9}$								
10^5 degrees	$T_0 =$	2755	2700	2640	2585	2540	2510	
per second	$a_0 =$	2.64	2.44	2.24	2.03	1.89	1.80	
	$a_0 + x =$	2.69	2.54	2.44	2.43	2.59	2.80	2.39
$b = 10^{-10}$								
10^4 degrees	$T_0 =$	2506	2505	2450	2400	2355	2325	
per second	$a_0 =$	1.96	1.79	1.62	1.48	1.36	1.29	
	$a_0 + x =$	2.01	1.89	1.82	1.88	2.06	2.29	1.79
$b = 10^{-11}$								
10^3 degrees	$T_0 =$	2375	2325	2270	2220	2175	2150	
per second	$a_0 =$	1.42	1.29	1.15	1.03	0.94	0.08	
	$a_0 + x =$	1.47	1.39	1.35	1.43	1.64	1.88	1.33

TABLE VI. RADIATION COOLING

Cooling constant ..... $b =$ Or	10^{-7} 10^7	10^{-8} 10^6	10^{-9} 10^5	10^{-10} 10^4	10^{-11} 10^3 deg. per sec. at 3160 deg. abs.
Final NO concentration.... $a_{00} =$	3.70	3.00	2.39	1.79	1.33%
Corresp. equilibrium temp.. $T_{00} =$	3035	2885	2685	2505	2340 deg. abs.
Temp. of $a_0 + x$ minimum... $T^1 =$	2980	2800	2610	2430	2270 deg. abs.
Temp. of $x = 0.1$ ..... $T =$	3070	2880	2700	2505	approx. 2325

TABLE VII. COOLING CURVES $\frac{dT}{dt} = b$

	$x =$	0.05	0.1	0.2	0.4	0.6	0.8	1.0	Per Cent Fina
$b = 10^{10}$	$T_0 =$	3615	3565	3515	3470	3435	3415	3400	
Degrees per	$a_0 =$	6.25	6.00	5.79	5.58	5.42	5.33	5.22	
second	$a_0 + x =$	6.30	6.10	5.99	5.98	6.02	6.13	6.25	5.86
$b = 10^9$	$T_0 =$	3450	3400	3345	3300	3270	3250	3235	
Degrees per	$a_0 =$	5.50	5.25	5.02	4.80	4.64	4.55	4.47	
second	$a_0 + x =$	5.55	5.35	5.22	5.20	5.24	5.35	5.47	5.10
$b = 10^8$	$T_0 =$	3285	3230	3185	3135	3105	3085	3070	
10^8 degrees	$a_0 =$	4.74	4.47	4.30	4.10	3.97	3.89	3.84	
per second	$a_0 + x =$	4.79	4.57	4.50	4.50	4.57	4.69	4.84	4.42
$b = 10^7$	$T_0 =$	3120	3070	3025	2970	2935	2915	2900	
10^7 degrees	$a_0 =$	4.04	3.84	3.65	3.42	3.29	3.21	3.15	
per second	$a_0 + x =$	4.09	3.94	3.85	3.82	3.89	4.01	4.15	3.76
$b = 10^6$	$T_0 =$	2950	2895	2850	2805	2775	2755	2735	
10^6 degrees	$a_0 =$	3.36	3.13	3.00	2.82	2.71	2.63	2.55	
per second	$a_0 + x =$	3.41	3.23	3.20	3.22	3.31	3.43	3.55	3.14
$b = 10^5$	$T_0 =$	2790	2735	2685	2635	2610	2590	2570	
10^5 degrees	$a_0 =$	2.77	2.55	2.37	2.20	2.10	2.03	1.98	
per second	$a_0 + x =$	2.82	2.65	2.57	2.60	2.70	2.83	2.98	2.52
$b = 10^4$	$T_0 =$	2625	2570	2525	2475	2450	2430	2410	
10^4 degrees	$a_0 =$	2.16	1.98	1.84	1.67	1.60	1.55	1.50	
per second	$a_0 + x =$	2.21	2.08	2.04	2.07	2.20	2.35	2.50	2.00
$b = 10^3$	$T_0 =$	2455	2410	2360	2310	2285	2265	2250	
1000 degrees	$a_0 =$	1.60	1.50	1.37	1.25	1.18	1.13	1.10	
per second	$a_0 + x =$	1.65	1.60	1.57	1.65	1.78	1.93	2.10	1.54
$b = 10^2$	$T_0 =$	2300	2250	2200	2150	2125	2105	2085	
100 degrees	$a_0 =$	1.21	1.10	0.98	0.89	0.83	0.79	0.76	
per second	$a_0 + x =$	1.25	1.20	1.18	1.29	1.43	1.59	1.76	1.14
$b = 10$	$T_0 =$	2135	2085	2040	1990	1960	1940	1925	
10 degrees	$a_0 =$	0.85	0.76	0.68	0.60	0.55	0.52	0.50	
per second	$a_0 + x =$	0.90	0.86	0.88	1.00	1.15	1.32	1.50	0.85
$b = 1$	$T_0 =$	1970	1925	1875	1830	1805	1785	1765	
1 degree	$a_0 =$	0.58	0.50	0.43	0.38	0.34	0.32	0.30	
per second	$a_0 + x =$	0.63	0.60	0.63	0.78	0.94	1.12	1.30	0.60

TABLE VIII. CONSTANT RATE COOLING

b = cooling constant, degrees per second.
a_{00} = final NO concentration, per cent
T_{00} = corresponding equilibrium temperature
T^1 = temperature of $d_0 + x$ minimum
T = temperature where $x = 0.1$ per cent

$b =$	10^{10}	10^9	10^8	10^7	10^6	10^5	10^4	10^3	10^2	10	1
$a_{00} =$	5.86	5.10	4.42	3.76	3.14	2.52	2.00	1.54	1.14	0.85	0.60
$T_{00} =$	3530	3360	3210	3045	2890	2725	2580	2415	2270	2130	2010
$T^1 =$	3470	3300	3170	3000	2850	2670	2530	2380	2210	2070	1950
$T =$	3565	3400	3215	3070	2895	2735	2570	2410	2250	2085	1925

the range of b from 10^{10} to 1 would give the entire range from the lowest cooling rate, up to and beyond the highest feasible rate.

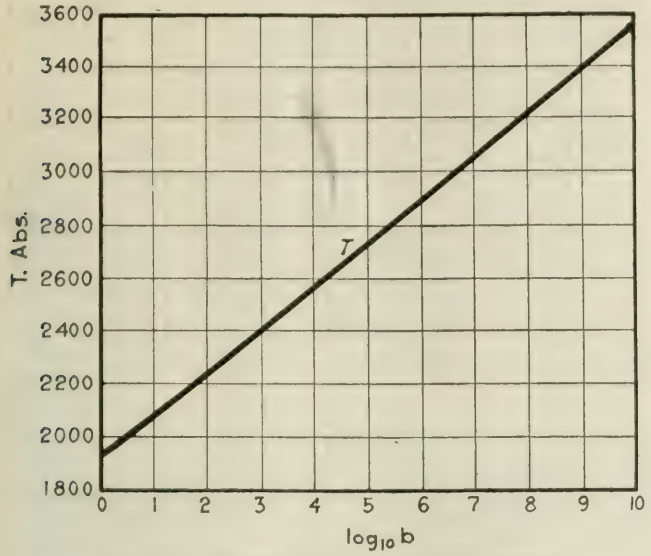


FIG. 8a. CONSTANT RATE OF COOLING

From (62) follows:

$$\log_{10} -\frac{1}{x}\frac{dT}{dt} = \log_{10} b - \log_{10} x \qquad (63)$$

For each value of the cooling constant b, and for the various values of x, the values of $\log_{10} -\frac{1}{x}\frac{dT}{dt}$ thus are found by equation (63), and for these values from Fig. 3 the corresponding values of time T_o are taken and recorded in Table VII, together with the values of a_o, corresponding to T_o, and the values of $a_o + x$. These are plotted in Fig. 7.

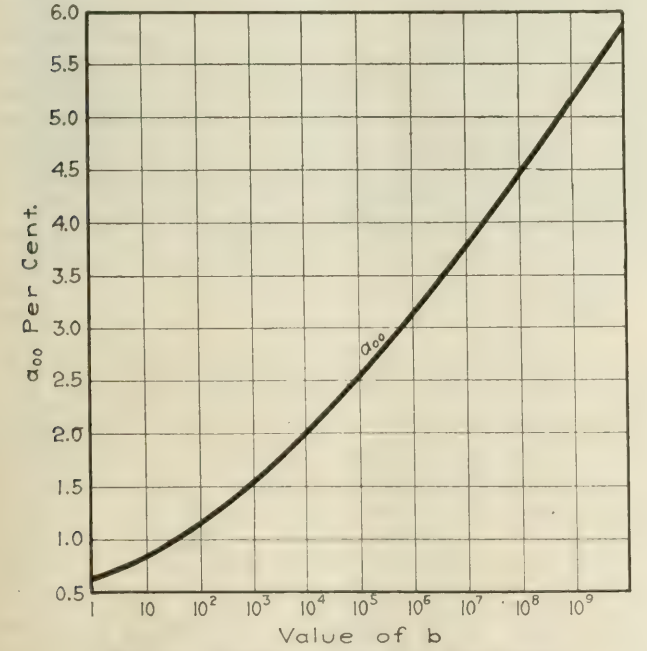


FIG. 8b. CONSTANT RATE OF COOLING

Here again, as in Fig. 5, the curves of $a_o + x$ become an approximation only at the minimum values, and inaccurate at temperatures below the minimum values, due to the assumption that x is small compared to a_o ceasing to apply. The actual curve and the final limiting value a_{oo} of $a_o + x$ thus are estimated and recorded in the last column of Table VII. These are plotted, with b as abscissa, in Fig. 8, and Table VIII gives, for various values of b, the final concentration a_{oo}, the temperature T_{oo}, at which a_{oo} would be the equilibrium concentration, and the temperature T' of the minimum value of the $a_o + x$ curve.

It is interesting to note from Tables V to VIII, and the corresponding Figs. 5 to 8, the similarity of the curves, though the two cooling laws considered: cooling at constant rate and cooling at a rate proportional to the fourth power of the temperature, are nearly the two extremes.

Roughly, a tenfold increase of the cooling rate increases the final NO concentration a_{oo} by about ½ per cent (somewhat more at the higher, less at the lower cooling rates).

With decreasing temperature, on these two cooling laws and thus also any intermediary cooling law, the NO concentration $a_o + x$ follows the equilibrium concentration a_o without appreciable deviation, down to a certain critical temperature. Then the calculated NO concentration $a_o + x$ rapidly rises above the equilibrium concentration, reaches a minimum and then increases again, all within a narrow range of temperature. As stated before, the minimum and the rise at temperatures below that of the minimum are only apparent, due to the approximate equation of $a_o + x$ ceasing to apply, and the actual curve of NO concentration $a_o + x$ reaches a constant value, very little lower than the minimum value of the plotted curve, so that the latter is a fair approximation of the final concentrations.

It is interesting to note that the entire range, from the temperature where the NO concentration still practically follows the equilibrium curve, down to the temperature where the NO concentration has practically become constant, is within a temperature interval of about 100 degrees.

The final NO concentration a_{oo} corresponds to equilibrium concentration a_o, which is very close to the final concentration a_{oo}.

Thus, substituting in equation (58) the cooling function

$$\frac{dT}{dt} = f(T)$$

and substituting $x = 0.001$, gives, for air:

$$f(T) = \frac{T^2 10^{-6}}{21.6}(2ac_2 - 0.493c_1)\left(\frac{2}{a} - \frac{1}{1.554 - a} - \frac{1}{0.42 - a}\right) \qquad (64)$$

This gives the final concentration $a_{oo} = a$, which is derived by the cooling law $f(T)$, provided, however, that the arc temperature is higher than the temperature T corresponding to a.

(Part III will be published in our next issue.)

Government Kelp Plant to Continue Operations

The Government's kelp plant at Summerland, Cal., can be maintained from the returns from its potash output alone. In addition, nearly as much return is made from the four principal byproducts, which are iodine, salt, ammonia and bleaching carbon. The bleaching carbon is being prepared and sold at the Summerland plant at 15c. a lb. In recovering the ammonia enough combustible gas is released to take care of the fuel requirements of the plant.

Testing Natural Gas for Carbon Black

By Roy O. Neal*

BEFORE work is begun on a plant for the production of carbon black from natural gas, the gas should be tested. The actual amounts of carbon black obtained by the same process when using different gas may vary decidedly, as is shown in Table I. The quantity recovered closely follows the percentage of ethane[1], heating value and amount of elementary carbon calculated from the hydrocarbons determined by analysis. The gas from Louisiana has the lowest percentage of nitrogen and the highest percentage of hydrocarbons, namely, 97.56, yet when burned at a factory it gives the smallest yield of carbon black. This is due to the large proportion of methane, which contains 33.5 lb. of carbon per thousand cu.ft., whereas ethane contains 67 lb. of carbon. The two gases from West Virginia have very similar compositions and give approximately the same yield of carbon black. The gas supplied to the plant in Wyoming has the largest calorific value, carbon content and considerably more ethane than any of the other gases and produces the greatest yield. With the richer gases not only the actual quantity of carbon obtained is larger, but also the per cent recovery increases. An examination of the chemical analysis of a gas is probably as trustworthy an indication of the available carbon black as that obtained with a small portable apparatus where gas is burned and the deposited carbon black is collected and weighed.

TABLE I. CARBON CONTENT AND QUANTITY OF CARBON BLACK RECOVERED BY CHANNEL PROCESS

	Louisiana (a) Per Cent	West Virginia (b) Per Cent	West Virginia (c) Per Cent	Wyoming (d) Per Cent
Methane [1]	94.12	70.75	65.23	45.45
Ethane	3.44	24.14	30.07	43.10
Carbon Dioxide	0.50	0.28	1.56	0.96
Nitrogen	1.94	4.83	3.14	9.49
Heating value [2]	962	1,086	1,134	1,176
Lb. carbon per 1,000 cu.ft. of gas [3]	33.8	39.9	42.3	44.3
Reported obtained as carbon black, lb. per 1,000 cu. ft.	0.80	1.00	1.10	1.40
Per cent recovery	2.4	2.5	2.6	3.1

[1] Chemical analyses of gases were made by Donald B. Dow, junior chemist of Bartlesville Station, U. S. Bureau of Mines.
[2] Net heating value in B.t.u. per cu.ft. at 32 deg. F. and 760 mm. pressure.
[3] Calculated from carbon content of methane and ethane.

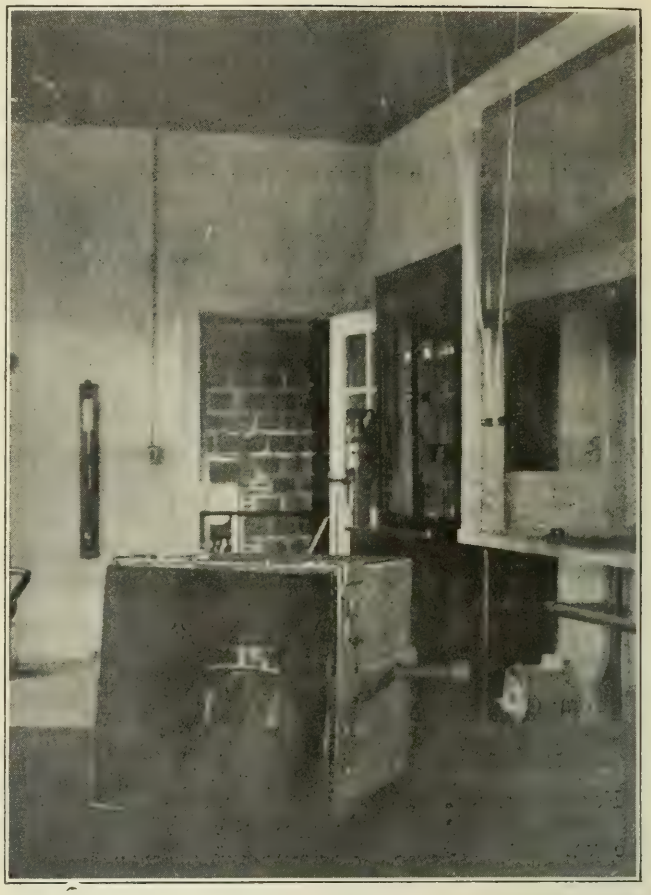


FIG. 2. APPARATUS DETACHED FOR TRANSPORTATION

The writer has designed an apparatus for determining the quantity of carbon black which one might expect to obtain from an unknown gas. Details of the apparatus are shown in Fig. 1. The apparatus is made of 16-gage sheet iron held together with $\frac{1}{8}$-in. rivets. The carbon black is deposited upon a plate 8 x $10\frac{3}{4}$ x $\frac{1}{4}$ in. and is removed by a scraper 1 x 8 x $\frac{1}{16}$ in. that is operated by hand. The draft is controlled by eight 1-in. ventilating holes provided with covers, which are pivoted above the holes, and by a revolving damper located at the top of the hood. The pipe carrying the lava tips can be lowered below the depositing plate and held at any distance by attaching a plug in stopper holes below the supports. The hopper carries a sliding door for removing the carbon black. Lava tips capable of burning about 4 cu.ft. of gas per hr. are used. The hood, hopper and legs are detachable and fit into the central portion of the device to facilitate transporting in the field. The apparatus

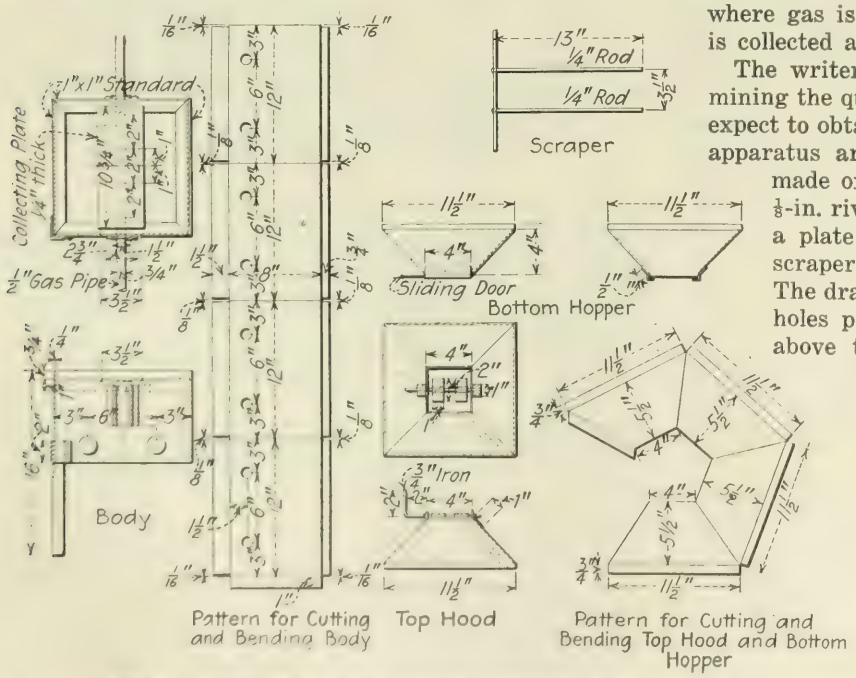


FIG. 1. DETAILS OF PORTABLE TESTING APPARATUS

*Formerly chemical engineer, Petroleum Division, Bureau of Mines.

[1]For the chemical analysis of natural gas the reader is referred to "The Sampling and Examination of Mine Gases and Natural Gas," George A. Burrell and F. M. Seibert; Bulletin 42, Bureau of Mines, 1913. "Gas Analysis," L. M. Dennis, The MacMillan Co., New York, 1913.

ready for transporting in the field is shown in Fig. 2. The apparatus can be used in the field by connecting directly to the supply of gas and using suitable wind breaks if assembled in the field, or can be used in the laboratory by obtaining a sample of gas under pressure in a steel cylinder.

The source of supply of gas is connected with a meter registering at least as small a quantity as one-tenth of a cu.ft. and on this line should be a quarter-inch needle valve in order to limit the flow of gas through the apparatus. Between the meter and the apparatus, where the gas is burned, is attached a "U" tube for determining the pressure of the gas. The top of the lava tips should be about 2½ in. below the depositing plate and a gas pressure of from ½ to 1 in. of water should be maintained. These factors will of necessity be changed when examining different gases and in the preliminary tests changes should be made until the

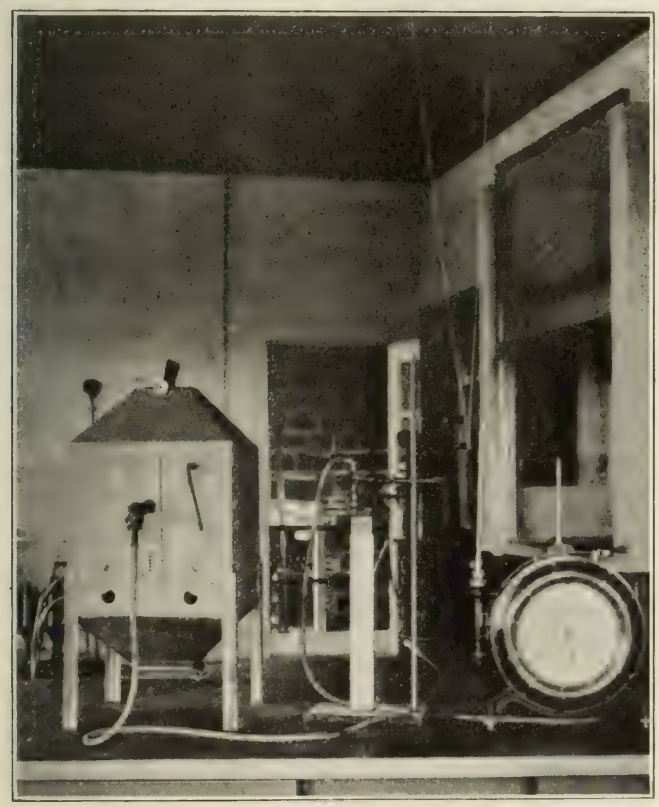


FIG. 3. APPARATUS FOR DETERMINING THE QUANTITY OF CARBON BLACK IN GASES

largest recovery is obtained. A test should last at least an hour, during which time 15 or 20 cu.ft. of gas should be burned. It is possible to make a test without using the meter in the field by previously calibrating the apparatus against a meter in which different pressures on the manometer tube are observed and the time recorded. This will give fairly accurate data on volumes, provided, of course, that the lava tips are not broken, plugged, or partly restricted by foreign matter after the apparatus has been standardized. During the test the carbon black should be removed from the collecting plate by the scraper every 10 min., and at the end of test the carbon which is deposited on the sides of apparatus and plate is removed by use of a small brush. This accumulated carbon black is then weighed. From the data on the volume of gas burned, quantity of carbon black collected and pressure on the gas, the quantity of carbon black which one might expect to obtain in plant operation from a given gas can be calculated. The apparatus assembled is shown in Fig. 3.

In both methods only comparative results are obtained. The portable apparatus will give results approximately paralleling those procured in commercial plants using the channel system, but if some other process is used, it is necessary to standardize the apparatus against a plant where conditions will be similar to those where gas in question is examined.

White Oil Corp.,
Tulsa, Okla.

Relation Between Viscosity and Penetrance of Creosote Into Wood

By Ernest Bateman

IT HAS been generally presumed in the wood preservation industry that the viscosity of a creosote oil is an important factor of the amount of penetration which can be obtained in creosoted woods. The nature of the influence of viscosity, however, has not been worked out. In fact, Bond makes a statement (A. W. P. A., 1913), "that there was no apparent relation between the viscosity of mixtures of creosote with three carbon-free tars and three normal tars and the corresponding absorptions and penetrations into the longleaf pine." Later Teesdale and MacLean in a more comprehensive work (U. S. Department of Agriculture Bulletin 607) state that "the relative viscosities of mixtures of coal-tar creosote and coal tar from different sources are not necessarily a true index of their ability to penetrate wood. In these tests the viscosities of mixtures containing different tars did not appear to have any definite relation to the ease or difficulty of penetration." These statements were based on viscosities as measured by the Engler viscosimeter, which gives a purely empirical measure of the viscosity. Since the publication of Bond's work, Weidner of the United States Bureau of Standards has published (A. S. T. M., 1915) tables for converting Engler numbers to absolute viscosities. The data collected by Bond and by Teesdale and MacLean and also some additional unpublished data have been recalculated to absolute viscosities, with the result that very definite relationships are found to exist between the viscosity and the penetration of creosote in the longleaf pine and noble fir, and it seems likely that the same or nearly the same sort of relation would hold for other species.

Calculated Results

In general the equation $xy = k$, where x is longitudinal penetration, y the absolute viscosity at the temperature of treatment, and k a constant for the wood, appears to answer all the data available on the longitudinal penetration of longleaf pine and noble fir when the treatments were made with 75-lb. pressure for 2 hr. The results of a large number of penetration experiments with different oils in both longleaf pine sapwood and noble fir are given in Fig. 1. The maximum equation of the curve is $xy = 0.6$; the equation of the minimum values is $xy = 0.09$; while the equation of the average values is $xy = 0.3$. The effect of the addition of carbon-free tar and tar containing various amounts of free carbon to the same coal-tar creosote is shown in Fig. 2. The effect is merely that which might be expected from increasing the absolute viscosity of the oil; similarly it can be shown that the effect of raising the temperature of the oil at the time of treatment is

that which would be expected from the change of viscosity which results, provided the other variables are constant. The data available on radial and tangential penetration are not so complete as those for longitudinal penetration; nevertheless such as are available seem to

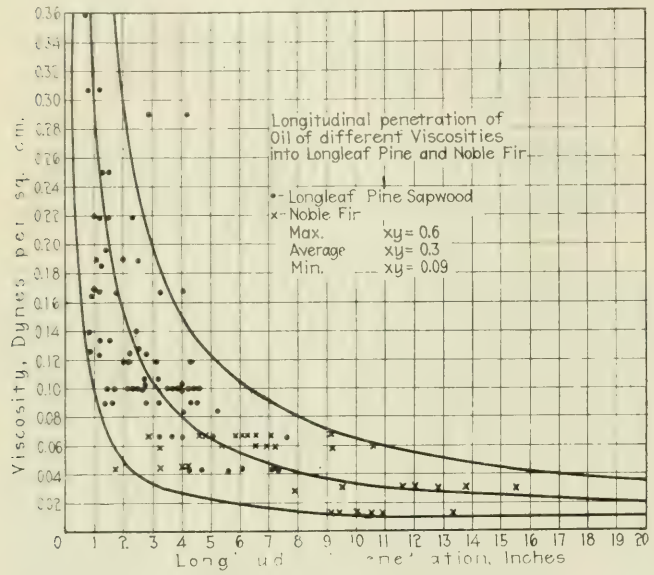


FIG. 1

indicate that for noble fir and probably for longleaf pine sapwood the equations are $yx^2 = k$ and $y\sqrt{x^3} = k$ for radial and tangential penetration respectively when the treatments are made at 75-lb. pressure for 2 hr.

There are four variables which will most certainly

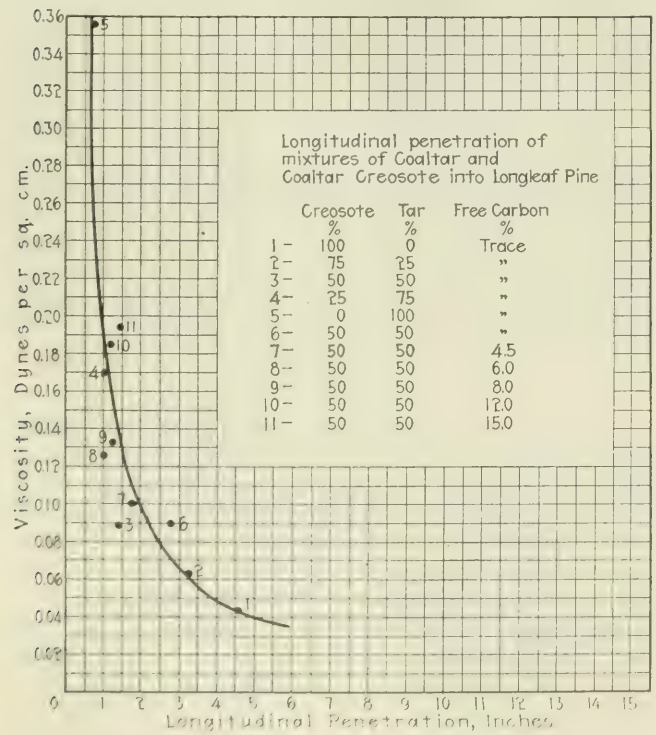

Longitudinal penetration of
mixtures of Coaltar and
Coaltar Creosote into Longleaf Pine
Creosote % Tar % Free Carbon %
1- 100 0 Trace
2- 75 25 "
3- 50 50 "
4- 25 75 "
5- 0 100 "
6- 50 50 "
7- 50 50 4.5
8- 50 50 6.0
9- 50 50 8.0
10- 50 50 12.0
11- 50 50 15.0
Viscosity, Dynes per sq. cm.
Longitudinal Penetration, Inches

FIG. 2

affect the penetration of oils in the wood. These are viscosity of the oil, the time during which the treatment is carried on, the pressure at which the oil is applied, and variations in the wood itself. This paper shows the relationship between the viscosity of the oil and the depth of penetration only when all three of the other variables are kept at the values used in the experiment: namely, 2-hr. treatment at a pressure of 75 lb. per sq.in. upon Southern yellow pine sapwood or noble fir. The effect of the other variables and their relationship to penetration is not known except in a general way. We know that in general an increase in the time of treatment increases the penetration of oil, but a penetration is finally obtained beyond which increased time has little or no effect, and the same is true of the relationship between pressure and penetrance; that is, we might expect the curve showing the relationship between penetrance and both time and pressure to take the form of a parabola. The effect of changing all three variables (viscosity, pressure, and time of treatment) at the same time is probably the product of these three equations. It is expected that further work will be done along these lines to prove out the relationship which is here shown.

Conclusions

The following conclusions can be drawn from the work:

1. That a very definite relation exists between the viscosity of the oil and the depth of penetration, and that this relation is amenable to mathematical treatment.

2. That a change in temperature of the oil has no other effect than that of changing the viscosity.

3. That the presence of free carbon in tar-creosote solutions has apparently no other effect than would be expected from the increased viscosity.

4. The following equations hold for longleaf pine and noble fir when the time of treatment is 2 hr. and the pressure 75 lb. per sq.in.

Longitudinal penetration $yx = k$
Tangential penetration $y\sqrt{x^3} = k_2$
Radial penetration $yx^2 = k_3$

where x is the penetration, y the absolute viscosity, k, k_2 and k_3 constants.

5. When the pressure and time of treatment are changed, the power of x and the value of k are changed. Sufficient data are not available to work out the effect of changes in time and pressure.

6. That the measurement of the viscosity of oils intended for treatment is perhaps the most important measurement as far as penetrance is concerned.

Inferiority of Shellac as a Glue

The highest strength value obtained in a recent series of tests where varnished surfaces were glued with casein glue was 1712 lb. per sq.in. and the lowest 1000 lb. Where shellac was used as a binder the maximum shear strength obtained was 1425 lb. per sq.in., the minimum 450, and the average 758 lb. These values indicate that shellac used as a glue is not comparable with casein or animal glues.

Melted shellac or shellac varnish should never be used for binding wood. It has been found during tests of varnished pieces that before a number could be brought to the testing machine they had fallen apart, and where they reached the machine for shearing tests the joint always broke at the joint and not in the wood. This makes it very necessary to clean wood parts which are to be glued, from all varnish or shellac before applying the animal glues.

Milling Plant of the Alaska-Gastineau Mining Co.*

Description of a Gold-Milling Plant Built in the Arctic Regions to Handle Very Low-Grade Ore—A Practicable Process Depended Upon the Low Cost of Roll-Crushing and Low Values in Slimes—Automatic Skip Hoisting in Place of Bucket Elevators Is Another Unique Feature

BY E. V. DAVELER†

THE milling plant of the Alaska-Gastineau Mining Co. is located at the town of Thane, Alaska, on Gastineau Channel, four miles south of Juneau and directly across the channel from the Ready Bullion mine of the Treadwell mines on Douglas Island. Previous to the organization of the Alaska-Gastineau Mining Co., in 1912, the milling was done at the stamp mill of the Alaska Perseverance Co., located at the mine in Silver Bow Basin. But the contemplated increase in production made it necessary to locate the mill on Gastineau Channel, as not enough water was available at the mine during the winter months, nor was there room for taking care of the large tonnage of tailings that would ultimately be discarded from the mill.

CHARACTER OF ORE

The gold and silver values occur in quartz lenses associated with pyrrhotite, galena, arsenical pyrites, and zinc blende. These lenses occur in large bodies of slate, schist and metagabbro, which also carry some valuable metallic contents. With the essential low cost of mining, it was necessary to mine large bodies of low-grade material containing the high-grade streaks. Of the minerals, pyrrhotite, the magnetic sulphide of iron, is predominant, and galena is the next sulphide present in quantity. The gold occurs free and coarse and associated with the iron sulphide in its finer state. The silver occurs with the lead or is alloyed with the gold. A chemical analysis of the ore shows

Silver, oz.	0.10	Magnesia, per cent	0.4
Silica, per cent	59.7	Sulphur, per cent	1.2
Iron, per cent	5.2	Lead, per cent	0.1
Alumina, per cent	21.4	Zinc, per cent	0.2
Lime, per cent	5.0		

EXPERIMENTAL WORK

Investigations at the old Perseverance stamp mill had developed the following points:

Roughing concentration following stamping gives a fair recovery. Practically all gold values are liberated at 50-mesh. Amalgamation of the ore ground through 30-mesh yields 63 per cent of the gold as bullion. An iron concentrate could be made carrying gold and silver values. Slimes were very low in value.

While the experimental plant was being built, laboratory work developed the fact that slimes were consistently low in value, which was of great importance in the later developments of the milling operations.

In Fig. 1 is shown a flow sheet of the experimental mill. This plant had a daily capacity of 75 tons, so all tests were run on this basis in order that results might be comparable with actual milling practice. The roll capacity, of course, was greater, but the concentration department was run at normal tonnage. Machines were so placed that almost any variation desired in the flow could be made. All launders had ample grade and there was very little chance for concentration of values at any place in the mill. Headings and tailings were sampled automatically every 2 min. and hand samples were taken on the products of all machines coincident with the tonnage tests. These were then calculated back against the automatic samples for check.

As proper sampling of the ore was known to be very difficult, due to the coarse particles of gold free in the ore, the greatest precautions were taken. From laboratory tests before starting the experimental mill, it was known that grinding a large sample to 10-mesh was necessary to check results.

The heading sample was taken automatically after roll grinding with maximum size particles of 10-mesh, and on a mill run of 20 tons the heads sample amounted to 400 lb. This sample was rolled very carefully and then riffled through a Jones type sampler with a 1-in. opening. A cut of 50 lb. was obtained and the reject of 350 lb. was saved for other work. The 50-lb. sample was re-rolled and riffled to 12.5 lb., which was ground to 100-mesh and after rolling was cut to about 4 lb., for an assay sample. The 37-lb. cut was saved for screen analysis work. The 350-lb. reject from the first cut was sacked and sent to the Arthur plant of the Utah Copper Co., where check runs were made in the laboratory unit. On the average the variation of all

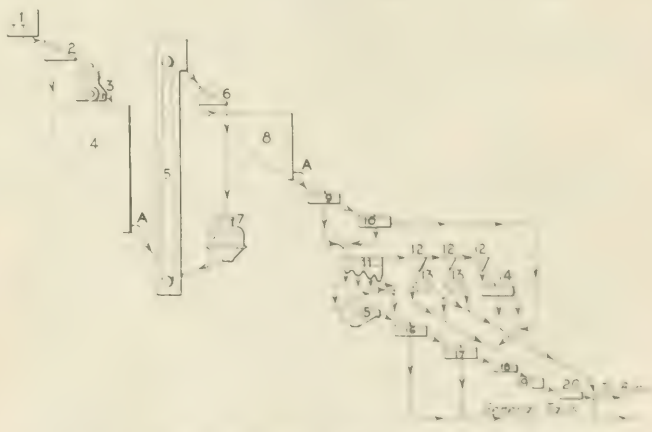


FIG. 1. FLOW SHEET, EXPERIMENTAL MILL.

1. Fairbanks-Morse track scales. 2. 1¼-in. grizzly. 3. No. 1 style "D" Gates crusher; capacity 5 to 9 tons per hr. 4. Coarse ore bin; capacity 100 tons. 5. 16-in. bucket elevator. 6. Two Colorado inpact screens 3 x 4 ft., 660 shakes per min.; 12-mesh 0.020-wire screen. 7. 42 x 16 in. Garfield rolls; r.p.m. pulley 160. 8. Fine ore bin; capacity 150 tons. 9. 4-ft. Garfield roughing table; 260 r.p.m.; ⅝-in. stroke. 10. No. 6 Wilfley table; 2[illegible] r.p.m.; ⅝-in. stroke. 11. Four-compartment Richards-Lavely classifier; revolution shaft 80. 12. Three cone tanks; capacity, 180 cu.ft. 13. Two 6-ft. vanners; 190 shakes; 1½-in. throw. 14. No. 3 Deister slime table. 15. Hardinge mill, 30 in. x 8 ft. [illegible] r.p.m. 16. 4-ft Garfield table; 260 r.p.m. ⅝-in. stroke. 18. 4 x 8 ft. shaking plate; 1½-in. fall; 150 r.p.m. 19. Cobbe-Middletown grinding pan; 5-ft. diameter; 50-mesh screen. 20. Stationary plate, 4 x 6 ft. A. Feeders, plunger type.

*A paper presented at the meeting of the American Institute of Mining and Metallurgical Engineers, Feb. 17, 1920.

†Mill superintendent, Butte & Superior Mining Co., Butte, Mont., formerly in charge of experimental work and milling operations, Alaska-Gastineau Mining Co.

runs in the heading assay between the Utah and Alaska results was under 5 cents on the gold assay. In assaying the nail method was used and four three assay-ton charges made on each sample, combining the resultant button for parting and weighing. In the hand-sampling work, six men were used, two sampling each day, and all six men were alternating in the work to eliminate the personal equation as much as possible.

The experimental crushing plant was started with waste to observe the effect of roll-crushing. The ore was low in moisture, running consistently under 2.5 per cent; the ore screened very readily and under ¼-in. size the slate lost its long splintery character and became cubical. The worst problem that developed in the crushing tests was the dust, which was eradicated by sprays; they were also used in the large milling plant. In the concentrating tests, the simplest methods were used first, then these were elaborated as was found necessary.

The first tests were with grinding with the rolls to varying mesh, from 6 to 16; this was followed by primary roughing on Garfield tables and cleaning the rough concentrate on Wilfley tables. Both tables were making final tailing. This method gave a recovery of 75 per cent, a tailing of $0.44, and a concentrate of $13 gold, showing a very satisfactory initial recovery, and work was followed upon tailings from this operation. Screen analysis showed that practically all the gold was liberated from the gangue with 50-mesh grinding. The tailings from the tables were then classified in the

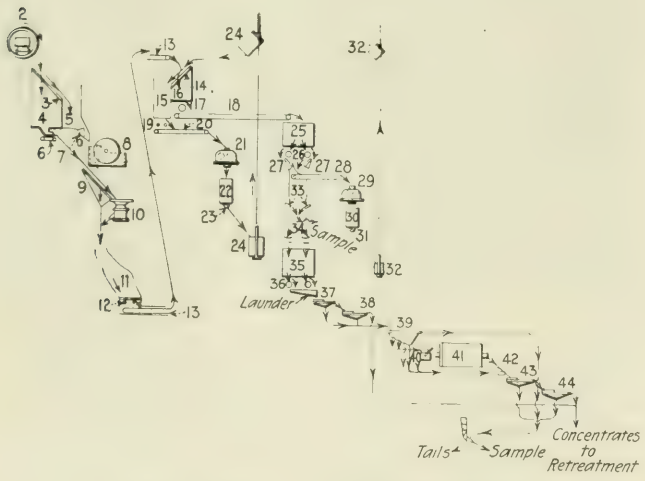


FIG. 2. FLOW SHEET FOR COARSE CRUSHING PLANT, ROLL PLANT AND ONE 2,500-TON SECTION OF CONCENTRATING PLANT

Janney classifier, the material on 50-mesh being reground in the Hardinge mill, and the fine sands sent direct to the secondary roughing tables.

The product from the Hardinge mill was treated separately on both the roughing and the finishing machines, but with the development of the practice it was found that it could be combined with the fine sands from the classifier and treated on the roughing table, the rough concentrate being cleaned on finishing tables. Tailing made on the roughing table on the final test was $0.176; and on the finishing machine $0.32; as the tonnage of the finishing tailings was small, both roughing- and finishing-machine tailings were sent to waste.

The slime overflow from the Janney classifier, comprising about 17 to 20 per cent of the original tonnage, was very low in values, an average assay on all tests being $0.178 gold. Tests were run on this to see if an economical recovery could be made, but nothing satisfactory was worked out. It was then turned to the tail race as waste. This, of course, was one of the most satisfactory developments of the test work.

The above data show that a very economical treatment had been worked out giving high recovery at a low cost. Several check runs made with the flow sheet as adopted showed a tailing of $0.176 gold and an extraction of 89.30 per cent of the gold values. The tonnage of concentrates produced in the final check runs showed that 89.30 per cent of the gold values was concentrated into a product in the ratio of 60 to 1.

Retreatment of Concentrates

Following this, work was started on the retreatment of the concentrates. An average analysis of the concentrates was as follows:

Gold	$80.00	Magnesia, per cent	0.8
Silver, oz	6.30	Copper, per cent	0.1
Lead, per cent	5.2	Zinc, per cent	2.7
Iron, per cent	37.3	Arsenic, per cent	0.2
Silica, per cent	12.9	Tin, per cent	0.1
Alumina, per cent	10.7	Sulphur, per cent	27.0
Lime, per cent	2.2		

The first step in the treatment was to separate the lead concentrate from the iron concentrate, which was easily done on Wilfley tables, using a finger to regulate the cut. This lead concentrate carried all the free coarse gold, a material very hard to sample. Tests showed that this lead concentrate would be separated in a ratio of 857 to 1 as to the original ore milled. The further separation of the free gold from this was left to work out later and attention was paid to the iron concentrate remaining. This iron concentrate carried from $12 to $25 gold values, some silver, and some lead.

The first work was to grind to suitable mesh and amalgamate and reconcentrate. Grinding to 100-mesh liberated the values sufficiently for amalgamation. The iron concentrate, after plating, could then be reconcentrated and a small quantity of iron-lead concentrate of high enough grade to warrant shipping could be made. The final tests showed a tailing of $1.93 gold and $0.26 silver, which with the lead concentrate would mean a shipping concentrate in the ratio of 400 to 1 of the ore milled. At the laboratory in Utah, a tailing of $0.93 gold was made with fresh concentrates; as the concentrates used at Alaska had oxidized somewhat, it was felt that the same results could be obtained in mill practice.

During the winter of 1913, laboratory tests were run at Alaska on cyaniding the iron concentrates to determine whether higher recovery could not be made. The presence of pyrrhotite made this rather difficult, but the method was finally worked out on an economic basis, giving an average recovery of 98.50 per cent of the gold values, with a 4-lb. cyanide consumption. However, the higher cost of the process was a disadvantage, so it was decided to use concentration and amalgamation on the iron concentrates.

Mill Construction

During the experimental work, which lasted until March, 1914, active construction work had been started in the large mill. By February, 1915, with the exception of the retreatment plant, enough of the mill was completed to insure starting operations. Three operating shifts were organized and on duty at the plant

for ten days before the plant started, running machinery available, so that when ore was started through there was practically no delay and the usual troubles of starting a new plant were missing. Actual mill operations were started on March 1, 1915.

Flow Sheet of the Mill

The ore from the different levels is dumped into one of the two ore-ways by 4-ton cars of the Granby type. These two ore-ways are equipped with four underswung arc gates for loading into the 10-ton cars that carry the ore to the mill. At the coarse crusher bins, the cars are spotted in groups of four and dumped by a revolving tipple (2, Fig. 2).

The ore dumped from the cars rolls down a 45 degree slope to a line of 8-in. steel I-beams spaced 10 in. apart and equipped with manganese shoes to take the wear. After over 6,000,000 tons had been dumped on these grizzlies (3), a number of the I-beams had to be replaced, because of bending, but the manganese shoes are still in service. To facilitate the sliding of the wet ore, boiler plate was used; later this was replaced by worn-out roll shells 1 in. thick, which were straightened under the steam hammer at a red heat. This makes a very cheap liner and has a very long life. The oversize from the grizzlies falls into steel bins (5) ahead of the jaw crusher, while the undersize falls into another bin (4).

The undersize from the grizzlies is fed by four 42-in. (106-cm.) wide apron feeders (6) to a stationary crimped-wire screen (9) 3 ft. (0.9 m.) wide and 14 ft. (4 m.) long set at an angle of 45 degrees with 2½ in. (6.35 cm.) openings. The undersize from this screen drops through raises (11) cut in the rock to an underground storage bin, which has a capacity of 8,000 tons. This bin was cut out of the rock during the construction period, the broken rock being crushed in a temporary plant for use as rock and sand in all the concrete used in the mill. It has thus served two useful purposes. At the bottom of the bin there is a reinforced-concrete arch over the tunnel leading to the fine-crushing department.

The oversize from the grizzlies is fed by air-operated arc gates (7) to two 36 x 42-in. (91 x 106-cm.) Buchanan jaw crushers (8) grinding to 5 in. (12.7 cm.) and discharging on 2½-in. (6.35-cm.) stationary double-crimped screens (9); the undersize of these screens drops into the underground storage bin (11). The oversize from all of the 2½-in. screens drops into four No. 8 K Gates gyratory crushers (10), which reduce the feed to pass through a 2½-in. opening. The crushers are of the gun-lock type, the mantles and concaves being of manganese steel. The lower concaves last about eight months on a 16-hr. daily operating basis. Changing the concaves and rezinking an entire set in one crusher takes 8 hr. under normal conditions.

All the crushers are belt driven from a central line shaft, which is divided into two sections so that each side of the plant is independent. The line shaft is of 5 15/16-in. cold-rolled shafting, each unit being driven by a 200-hp. General Electric motor. Mechanically controlled clutch pulleys transmit the power to the crushers through a belt drive. Electric switches are provided so that the operator can cut off power from either the gyratory or the jaw-crusher floor. This plant has a capacity of 3,500 tons in 8 hr. crushing to pass through a 2½-in. ring. The operating crew consists of a crusher man, feeder man, and oiler, per shift; one man and a helper on the day shift do all the routine repair work. Changing of concaves or mantles is done by the rigger crew when needed.

The product from the coarse crushing plant is fed from the bottom of the underground storage pocket by eight rotary feeders (12) to a tunnel conveyer belt (13), which carries it to the fine-crushing section. The rotary feeders are pulleys, 36 in. (91 cm.) in diameter with a 36-in. face, which slowly revolve and pull the ore from chutes attached to the bin bottom. The rotary feeder has a capacity of about 3,000 tons daily with the standard gate opening; different feeders are operated during each 24-hr. period to maintain an even character of ore, as there is some segregation in size in the ore pocket. These feeders are very economical to install and to maintain. After about 4 yr. service some are still in place and the cost of repairs to them has been practically negligible, and wherever possible, they are used throughout the plant. The conveyor (13) discharges ore on four all-steel impact screens (14) of the Colorado type, a modification of the standard impact screen commonly used on finer ore, but strengthened for heavy work. Four screens handle the mill feed of 10,000 tons daily, screening to a 1-in. opening. Double crimped wire screens are used and are made in the shops at the plant.

The oversize from these screens drops into a 2,500-ton bin (15) which acts as storage for the feed to the 72 x 20-in. (182 x 50-cm.) rolls (21). The undersize from the screens drops onto a 42-in. eight-ply conveyor belt (18) and is distributed by a tripper over bins (25) feeding fine impact screens (27). The oversize is fed by a rotary feeder (19) to a 36-in. rubber-covered conveyor belt (20) discharging to 72 x 20-in. rolls (21). The belt and feeders are driven from the roll shaft, insuring stopping of the feed in case rolls are stopped suddenly for any reason. These rolls crush to through 1-in. and the two sets are capable of handling oversize from a 12,000-ton mill feed daily. The product falls into the skip storage bin (22) of small capacity and is elevated by automatic skips (24) to the level of the 42-in. tunnel conveyor discharging over six impact screens. The oversize from these screens then returns to a bin ahead of the 72 x 20-in. rolls.

Elevating by Skip

The ore is hoisted by a 5-ton skip operated automatically by a 75 to 135-hp. Westinghouse hoist motor. The loading mechanism consists of an air cylinder connected to a rod, which opens the gate (23). The air is run into the cylinder through a three-way valve operated by a shaft which is rotated by the descending skip. High-pressure water is available and can be used in place of air. The time of loading is determined by an oil dashpot, which at the same time throws the master switch operating the motor. The time of loading a 5-ton skip is 11 sec., and the complete cycle of operation with two skips operated from the same motor is 1 min. 50 sec. Flat plow-steel cable ⅜ in. x 5 in. (0.95 x 12.7 cm.) is used for hoisting two skips running from the same drum, one loading while the other is dumping. The hoisting distance is 100 ft. (30 m.). This is a new feature in milling practice and replaces dry elevators very effectively. The operating and maintenance cost is quite low, the cost of maintenance being $0.009 per ton milled.

Ore from bin (25) is screened by sixty impact screens (27) of the Colorado type, making 600 vibrations per min. and equipped with 8-mesh 0.032-in. (8.3-mm.) wire-screen cloth and 9-mesh 0.028-in. (7.1-mm.) wire-screen cloth. The screens are equipped with manganese cams and tappets. The undersize from these screens falls to a 36-in. traveling conveyor (34) distributing over the fine bins (35) ahead of the concentrating department. At this point a sample of the mill heads is taken.

The oversize from the screens is conveyed by ten 24-in. (60.9-cm.) belt conveyors (23) to ten 54 x 20-in. (137 x 50-cm.) Garfield rolls (29) set to grind to 10-mesh. The feed to the rolls is sprayed to lay the dust. After grinding, the ore is hoisted by automatic 5-ton skips (32) to the 54-in. roll feed bin and screened as before. Each two sets of rolls are driven by a 300-hp. motor direct connected. The 300-hp. motor is interchangeable with the 300-hp. motor on the 72-in. rolls and the skip-hoist motors are identical with hoists (24). Conveyor and screens are driven from the 54-in. roll shafts.

A 30-ton capacity electric traveling crane operates over the floor of the fine-crushing department and over a large repair room at the end of the floor. The crane facilitates repairs, as any part of a machine can be assembled in the repair shed and then carried to its place. By having a supply of spare parts time lost can be kept at a minimum.

The ten sets of 54-in. fine-crushing rolls have a capacity of 11,000 tons daily, or 1,100 tons per roll to 10-mesh. The 54-in. roll shells give approximately 80 days' actual service and crush 96,000 tons of ore, or 17.6 tons of ore per lb. of steel in maximum operation.

Concentrator

The concentrating department is divided into four independent sections, each of which is equipped with twenty rotary feeders (36), ten primary Garfield tables (37), ten primary Wilfley tables (38), and ten four-compartment Janney classifiers (39), five tube mills (41), ten secondary Garfield tables (43), and ten secondary Wilfley tables (44). Each section then is composed of five parts, each of which can be shut down independently of the others.

The crushed product from the rolls is fed from the fine bins by rotary feeders (36) discharging into a 14-in. (35.56-cm.) launder to the Garfield tables (37). Water is here added for the first time, enough water being added to give proper consistency of feed to the tables. The launders all have sufficient slope so that water added is governed by table conditions.

Garfield tables making the first roughing concentration are double-decked tables 4 ft. (1.2 m.) wide x 12 ft. (3.6 m.) long, with riffles extending the length of the table. The head motion is of special design, very heavy and strong, as experience had shown that exceptionally heavy duty would be required. They produce a rougher concentrate, which is cleaned on Wilfley tables (38) and a tailing, which is laundered to the Janney classifiers (39).

The principle of roughing concentration, which has here been applied to gold milling for the first time, is based on the fact that the roughing table will handle a large tonnage of material per area of deck, giving a low-grade concentrate with high extraction. The low-grade concentrate can then be cleaned on a finishing table. It can easily be seen that the tonnage handled per table will materially cut down the floor space required for mill operation on a large tonnage, thus reducing construction cost and simplifying the subsequent milling operation. In fact, the success of the milling operations at this plant are due to the low cost of roll grinding and to the low cost and high efficiency of the roughing concentration.

The Wilfley tables clean the rough concentrate of the minerals present, rejecting a tailing that joins with the Garfield table tailings and is laundered to Janney classifiers. No. 5 Wilfley tables are used, but the head motion has been strengthened by increasing the size of the shaft and making the thrust bar and pitman of steel instead of iron. The concentrate from the Wilfley table is laundered to the retreatment plant. This concentrate comprises galena, pyrrhotite, sphalerite, and arsenical pyrites, all of which act as carriers for the gold.

Tailings from the primary Garfield and Wilfley tables run to four-compartment Janney classifiers (39). There are ten classifiers in a section, each classifier taking its feed from one Garfield and one Wilfley table. Each classifier, on the standard feed of 2,500 tons daily, is handling 250 tons daily. The maintenance of these classifiers is very small and one operator can look after forty classifiers and twenty tube mills. The classifier makes five products and has two main functions: one to deslime the material so that this slime, which is very low in value, can be rejected, and the other to separate the material coarser than 48-mesh for regrinding, as to liberate the values grinding to 48-mesh is necessary. In the first two spigots all material coarser than 48-mesh is dropped, the third and fourth spigots carry the sands finer than 50-mesh. The classifier overflow, which is all slimes, runs directly to the tail race. The first and second spigots discharge into a shovel or sand wheel box (40), which dewaters the feed and also discards any fine material that might be left in the feed. This combination of classifier with shovel wheel gives an excellent feed to the tube mills, as 90 to 93 per cent of the feed will remain on 48-mesh screen and about 4 per cent of over 48-mesh material passes through the third compartment of the classifier. The moisture to the tube mill is maintained at about 33 per cent.

Grinding Practice

The tube mill used (41) is a cylindrical mill 7 ft. (2.1 m.) in diameter, 10 ft. (3 m.) long, made by the Power & Mining Machinery Co. It is driven by a 75-hp. motor direct connected with a double reduction; the first reduction is through herringbone gear and pinion running in an oil bath, and the second reduction to the mill is by a heavy spur gear and pinion. Komata-type liner is used, the plates being made out of worn-out steel straightened and formed in the blacksmith shop. Lifting bars and screen are made of manganese. Each mill grinds the over-size from 491 tons daily, the product carrying about 30 per cent on 48-mesh. No return of oversize is made. Danish flint pebbles and adamant silica blocks are used for the grinding medium and, in case increase in capacity of the entire mill is made so that more than 10,000 tons is handled daily, additional tonnage can be ground in the mill by using steel balls and increasing the size of motor used. Consumption of pebbles from the beginning of operations has been 1 lb. per ton milled.

The product from the tube mills and the discharge

from the third and fourth spigots of the classifier run to secondary Garfield tables (43), each mill feeding two tables through distributor (42). These tables make a final tailing, which runs to waste. The rough concentrate from each table feeds one No. 5 Wilfley table (44), which makes a tailing to waste and a concentrate which joins the primary Wilfley concentrate and is laundered to the retreatment plant.

Retreatment Plant

From the concentrating department, the concentrates are laundered to elevator pits and carried to the top floor of the retreatment plant by a 12-in. bucket elevator (45, Fig. 3) in each half of the plant. From the elevator the concentrate is distributed to twelve standard No. 5 Wilfley tables (47), which remove a rough lead concentrate carrying all the free coarse gold. This lead concentrate is then retabled on one No. 5 Wilfley table (48) to separate the free gold from the shipping concentrate. This separates some of the coarse lead with

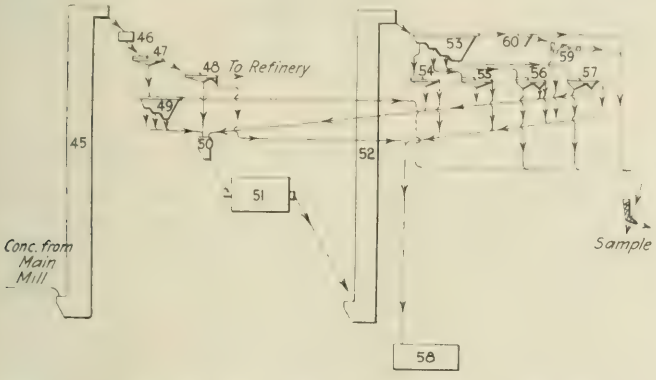


FIG. 3. FLOW SHEET, ONE-HALF RETREATMENT PLANT

practically all of the free gold, the weight of this product being about 1,000 lb. daily. It was treated at first in crucible furnaces, but is now treated in an open-hearth furnace, designed at the plant. Iron shavings are added to take up the sulphur present and the resultant products are a high-grade lead bullion and a matte. This lead bullion can be very accurately sampled and is shipped direct to the smelter.

The reject from the single table in each section handling the lead is a shipping concentrate carrying about $800 gold per ton and about 50 per cent lead. This is stored in bins (58) and shipped as often as boat sailings permit. The tailings from the twelve primary tables are dewatered into a three-spigot Janney classifier (48). The spigot discharge is then ground in a 7 x 10-ft. mill (51) to 100-mesh. After grinding the pulp is elevated (52) to a standard four-compartment Janney classifier (53). The first spigot feeds three Wilfley tables (54) and the second spigot three tables (55). These tables make a concentrate for the shipping bin (58) and a middling which returns to the tube mill (57) for further grinding. The third and fourth spigots each discharge to two tables (56 and 57), which make a concentrate to the shipping bin, a middling which returns for further grinding to the tube mill, and a tailing that goes to waste. The classifier overflow is settled in cone tanks (60) and then fed to six vanners (59), which make a shipping concentrate.

The final shipping concentrate then assays about $400 gold and 40 per cent lead, and 50 oz. of silver per ton; it is in a ratio of 1 to 1,000 of the original ore milled and contains about 44 per cent of the gold recovered, with about 56 per cent in the lead bullion. The tailings from the retreatment plant join the tailings from the concentrating mill, are sampled, and then run to the bay as waste.

Results Obtained

Following is average of series of samples throughout the plant, showing the results of the various concentrations of gold values:

General heads	$1.250	Tube-mill feed	.490
Primary Garfield tailings	.347	Tube-mill discharge	.490
Primary Garfield concentrates	13.150	Secondary Garfield tailings	.170
Primary Wilfley tailings	.844	Secondary Garfield concentrates	5.450
Classifier feed	.523	Secondary Wilfley tailings	.460
First spigot classifier	.600	Secondary Wilfley concentrates	5.360
Second spigot classifier	.320	General concentrating tails	.177
Third spigot classifier	.260	Retreatment tails	1.000
Fourth spigot classifier	.260	General tails	.200
Classifier overflow	.160		

The average value of the concentrate going into the retreatment plant is about $70 gold per ton; and after the initial lead concentrate is made, iron concentrate which is reground and treated is left, assaying $19 per ton. After treating a tailing of $1 is made.

TABLE I. GENERAL HEADS

	Mesh	Per Cent Material	Cumulative per Cent Material	Assay	Per Cent Value	Cumulative per Cent Value
Plus	10	2.5	2.5	$0.83	1.5	1.5
Plus	20	27.7	30.2	1.24	24.6	26.1
Plus	28	21.0	51.2	1.45	21.8	47.9
Plus	48	5.7	56.9	3.10	12.7	40.6
Plus	65	5.6	62.5	3.72	15.0	75.6
Plus	80	3.2	65.7	1.24	2.8	78.4
Plus	100	3.7	69.4	1.86	4.9	83.3
Plus	150	5.9	75.3	0.83	3.5	86.8
Plus	200	1.7	77.0	1.03	1.3	88.1
Minus	200	23.0	100.0	0.72	11.9	100.0
		100.0		$1.39	100.0	
			General Tails			
Plus	20	1.48	1.48	$0.15	1.18	1.18
Plus	28	9.08	10.56	.15	7.22	8.40
Plus	48	10.43	20.99	.21	11.60	20.00
Plus	65	12.59	33.58	.26	17.34	37.34
Plus	80	8.08	41.66	.26	11.13	48.47
Plus	100	8.88	50.54	.26	12.23	60.70
Plus	150	7.95	58.49	.26	6.32	67.02
Plus	200	7.17	65.66	.15	5.70	72.72
Minus	200	34.34	100.00	.15	27.28	100.00
		100.00		$0.19	100.00	
			Retreatment Tails			
Plus	65	2.70	2.70	$0.41	1.29	1.29
Plus	80	1.45	4.15	.52	0.88	2.17
Plus	100	9.55	13.70	.62	6.88	9.05
Plus	150	32.95	46.65	.72	27.58	36.63
Plus	200	4.35	51.00	.93	4.70	41.33
Minus	200	49.00	100.00	1.03	58.67	100.00
		100.00		$0.86	100.00	

Characteristic screen analyses of the mill heads, mill tailings and retreatment tailings are as shown in Table I, Tyler standard screen sieves being used.

Results

The work has shown that economic grinding of the ores for final concentration is through 48-mesh; that the slimes carry very low values; and that regrinding and concentration of the iron concentrate will liberate the gold values, permitting the iron to be thrown away. This, of course, reduces the smelting costs and losses to a minimum. Also, the lead concentrate produced carries 40 per cent lead, which is a good smelting product.

Concentrates are sacked and shipped to the Selby Smelting Co. for treatment. At the beginning of operations we were using amalgamation as an additional process in the retreatment of our concentrates but found this unnecessary.

Great pains are taken at the mill to insure accurate sampling of all vital products. For the headings to the concentrating departments, the undersize from each screen is sampled automatically and cutters ½ in. (12.7 mm.) wide are operated by a Scobey timing device throwing the four-way air valve connected to the air cylinder. A cut is taken every 12 min. and samples are collected every 24 hr. On a basis of 6,000 tons of ore milled, the combined sample averages about 3,000 lb., or ½ lb. per ton milled. This is carefully coned and ringed several times and then quartered, opposite quarters being saved together and about a 50-lb. sample cut from each of the two cuts by additional ringing and coning. These then are ground to 700-mesh in the laboratory and riffled to assay pulp size, weighing about 4 lb. each.

The assayer runs four charges of two assay-tons each on each sample, combines the resultant silver-gold buttons, and then parts and weighs them together. The average of the original and the duplicate is then taken as the average for the day.

The stream of tailings from each half of the mill is cut by an automatic sampler every 10 min. operated as for the head sample. These samples, amounting to 150 lb. each, are collected at the end of every shift. They are rolled and riffled, a 10-lb. sample from each shift sample being put through the pulverizer and ground to 100-mesh. From each of these shift tailing samples, the assayer runs four samples, each of three assay-tons, making a total of twelve crucibles for the three tailing samples.

Concentrate production is sampled automatically and at the time of shipment an auger sample is taken from each sack. Special sampling of different products throughout the plant is kept under way at all times.

Costs of Operation

While the plant has not treated its full tonnage, the results of operating in the year 1917, when for a period the tonnage was maintained at 7,023 tons, gives an idea of what costs will be under full operating basis. These costs are as follows:

Coarse crushing	$0.02804	Labor cost	$0.09746
Fine crushing	.09432	Supplies	.05454
Concentrating	.05136	Shop expense	.03787
General mill	.02778	Sundries	.04970
Power and light	.01467		
General overhead	.02340	Total	$0.23957
Total	$0.23957		

Potash Statistics

The following statistics, from German official sources, quoted by the *Fortnightly Information Review* of the American Chamber of Commerce in France, show the foreign and domestic sales of German potash salts, K_2O.

Year	Domestic Sales, Tons	Foreign Sales, Tons	Total, Tons	Value in Marks Calculated on Legal Prices	Value in Dollars at Par	Percentage Used in Agriculture	Percentage Used in Industry
1910....	460,618	346,473	807,091	133,800,000	$31,800,000	88.3	11.7
1911....	527,822	441,941	969,763	160,100,000	38,100,000	90.5	9.5
1912....	581,422	524,514	1,105,936	186,400,000	44,400,000	89.5	10.5
1913....	664,711	556,695	1,221,406	202,500,000	48,200,000	90.4	9.6
1914....	591,590	402,797	994,387	164,500,000	39,200,000	91.2	8.8
1915....	623,807	123,947	747,754	111,700,000	26,600,000	92.0	8.0
1916....	797,548	174,825	972,373	163,900,000	39,000,000	94.1	5.9
1917....	958,625	146,084	1,104,709	230,500,000	54,900,000	95.7	4.3

The statistics in Table I of the consumption of actual potash—K_2O (German)—in agriculture, not including industry, in the most important consuming countries, are also taken from German official sources. The quantity is given in short tons.

Durability of Cement Drain Tile in Alkali Soil

After an interruption of two years, due to the pressure of war work, the field inspection and testing in connection with the drain tile in alkali soils has again been taken up by the Bureau of Standards, Department of Commerce. In Minnesota, pieces of tile which have been in the ground since the last inspection have been removed for test and the concrete was found to be uninjured either by alkali or acids, but a number of both the best and poorest tile was found to be cracked. It is thought that some time during the cold weather water had backed up and stood in the pipe, freezing and bursting it. A complete survey of all the most important reclamation projects in the West is to be made in the near future, and based on this work the committee in charge of the investigation will endeavor to make definite recommendations relative to the manufacture and use of cement tile in alkali soils. The results of the work already accomplished are embodied in the Bureau's Technologic Paper T95, "Durability of Cement Drain Tile in Alkali Soil."

TABLE I. CONSUMPTION OF POTASH (K_2O) IN AGRICULTURE

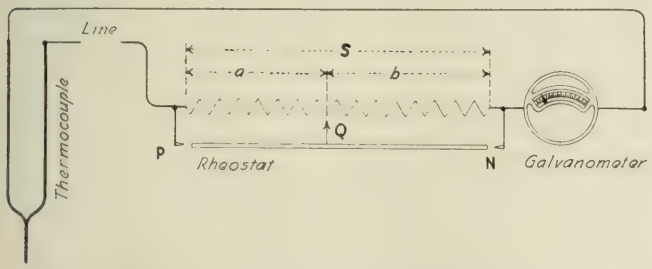
Country	1910 Tons	1911 Tons	1912 Tons	1913 Tons	1914 Tons	1915 Tons	1916 Tons	1917 Tons
Germany	395,269	464,575	509,722	589,713	531,990	572,232	748,617	917,820
Belgium	9,886	10,011	12,040	14,501	11,408	11,742	11,670	15,878
Holland	32,338	37,812	43,421	47,826	46,188	31,972	62,535	48,225
France	25,134	29,115	34,860	36,426	21,327	65	1	1
United Kingdom	20,084	22,992	25,756	25,572	12,792	.....	.....	.....
Luxemburg	118	193	312	442	511	1,632	1,800	2,384
Austria	12,996	16,572	20,767	23,072	23,404	18,611	27,820	32,724
Hungary	1,477	3,019	4,116	4,508	3,210	2,835	3,514	3,018
Switzerland	3,055	2,945	3,851	3,639	4,438	2,785	7,556	5,206
Italy	6,161	6,667	8,025	6,990	4,880	521	.....	.....
Russia	16,003	18,787	25,762	24,920	16,883	1,424	3,972	1,097
Spain	8,083	10,830	9,910	9,122	3,502	252	.....	.....
Portugal	870	1,244	1,248	1,365	455	60	.....	.....
Sweden	18,290	19,197	22,737	21,465	26,671	24,909	24,968	30,536
Norway	1,937	2,511	3,774	3,953	5,271	3,967	4,379	30,536
Denmark	4,804	6,195	6,607	8,222	8,212	8,553	18,260	30,536
Finland	1,080	1,459	1,565	1,766	684	.....	.....	.....
Balkan States	152	414	408	218	806	200	53	.....
Asia	3,531	5,137	6,406	6,281	4,633	707	38	40
Africa	1,808	2,523	3,455	4,807	2,126	121	.....	.....
United States	139,063	206,141	233,446	254,859	167,749	5,551	.....	.....
Canada			307	1,513	337	.....	.....	.....
Remainder of North and South America	8,345	7,467	8,614	10,140	7,271	.....	.....	.....
Australia	1,996	1,970	2,883	2,739	1,187	.....	.....	.....

Simple Pyrometer Adjustment

IN THE practice of pyrometry it is often difficult to bring about in the student's or user's mind an adequate appreciation of the several variables and electrical quantities to be considered. It is decidedly easier to teach the operator to read a galvanometer type instrument than to train him to employ a potentiometer or balancing type of meter. Quite often he is more impressed with the simplicity of the direct reading instrument than he is with its errors, with the result that the potentiometer, or adjusting type of instrument, suffers by comparison in his judgment.

As has been shown by many writers, resistance is the most uncontrollable source of error. It is therefore highly desirable, if this source of error is to be eliminated with the user's full appreciation, to teach him to measure it or compensate for it. A circuit described by Dr. E. F. Northrup in the current *Pyrolectric Bi-Monthly Bulletin* may be simply explained as follows:

In the accompanying figure an ordinary rheostat is placed in series in circuit. The resistance of the galvanometer is ordinarily known, being stamped on the instrument, and may be represented by the letter G.



Similarly the total resistance of the rheostat is designated by S, while the unknown resistance of thermocouple and line is called x. The problem is first to discover the value of the resistance of the entire circuit when in operating order.

Proceed as follows: Place the thermocouple in a hot furnace at equilibrium, close switch N and open P; then move the sliding contact Q on the rheostat to the left until the resistance a is zero and the deflection D of the meter is at its maximum. This gives the same meter reading for the temperature in question as though the line were connected directly to the galvanometer in the usual way, without rheostat in circuit and the total resistance, which may be called R_1, is $G + x$.

$$R_1 = G + x \qquad (1)$$

This deflection D is noted, and without changing the switches, move slides Q to the right until sufficient additional resistance a has been thrown in circuit to reduce the deflection by one-half. Galvanometer now reads $\frac{D}{2}$, the total resistance through which the current is passing is $G + x + a$ and may be called R_2, or

$$R_2 = G + x + a \qquad (2)$$

Now, without disturbing the slides Q, reverse the switches, opening N and closing P. The resistance, R_3, of the entire circuit, including galvanometer, line, rheostat and thermocouple, after this adjustment exactly equals S, the total resistance of the rheostat.

This is easily proved as follows:

Since adding resistance a to the circuit cut the deflection of the galvanometer in half, by that evidence it cut the current flowing in half. Now, since the applied electromotive force generated by the thermocouple is constant, it being held at uniform temperature, if the current is cut in two it was because the resistance of the circuit was doubled. Hence $R_2 = 2R_1$

Substituting from equations (1) and (2)

$$G + x + a = 2(G + x)$$

Simplifying $$a = G + x \qquad (3)$$

But the final course of the current is from thermocouple through line and switch P to slides Q and thence through resistance b to the galvanometer. Neglecting as before the resistance of the rheostat bar between P and N, the total resistance of the adjusted circuit equals the sum of the resistance of thermocouple, line, galvanometer, and coil b. In symbols

$$R_3 = x + G + b$$

but from equation (3) $G + x = a$. Hence, substituting

$$R_3 = a + b$$

By definition of a and b, they are the component parts of the rheostat, so that $a + b = S$. Or,

$$R_3 = a + b = S$$

In other words, the resistance of the adjusted circuit is equal to that of the total rheostat, which was what we set out to prove.

As remarked at the outset, variable resistance in thermocouple and line are responsible for the chief uncertainty in direct reading instruments. Here, then, is a simple method, where merely by a rheostat and a double throw switch, it is possible to correct a galvanometer for all errors due to line drop or extraction of current from high resistance shunt. When it is desirable to confirm any stationary needle reading, it can be done very quickly as follows: Reverse switches, run slide to zero, note deflection, draw deflection down one-half by sliding back contact Q, reverse switches, and check dial against former reading. The thermocouple resistance and the galvanometer resistance are measured in terms of the current sensitivity of the galvanometer, a factor that is practically constant, having a very slight change with temperature. It is believed to be a new method whereby the measurement of resistance is accomplished and expressed in terms of the galvanometer "current constant."

The relative error of setting is small in direct proportion as $b + x$ is small in comparison with g. Also the error of setting for $\frac{D}{2}$ is inversely increased with the reduction in the value of D.

Much has been written relative to the errors involved in the use of a galvanometer for measuring thermocouple electromotive forces. In general, it may be said that accuracy with a galvanometer is secured only at the sacrifice of durability, unless manual adjustment is made in the operation of the instrument to overcome the errors of resistance and resistance changes. The pyrovolter and the potentiometer both require manual adjustment for every reading, readings being taken on a "null" method.

It is believed that the circuit described will assist in impressing on operators the various sources of trouble in a thermocouple circuit and their relative importance and will suggest a method for overcoming them.

The following characteristics of this circuit may be of interest. Maximum allowable resistance in thermocouple circuit external to instrument is $M = s - g$. The emf. range of the instrument is given by $E = SI$, where I is the current required to deflect the galvanometer to full scale.

Legal Notes

By Wellington Gustin

Manufacturer and Seller of Tool Steel Warrants His Product—"High-Speed" Steel Not a Trade Name

THE uniform sales act has been adopted in most of the states. All sales contracts made therein must be construed according to decisions interpreting its provisions. The Supreme Court of Pennsylvania recently had occasion to pass upon a New York sales contract, the goods having been sold f.o.b. the point of shipment in New York to a manufacturer in Pittsburgh, Pa.

The Reliance Steel & Tool Co. of New York sold to the Metal Product Co., manufacturer in Pittsburgh, certain high-speed steel for the making of tools. When the steel arrived it appeared to be in good condition, but after expenses had been incurred by the manufacturer in its attempt to make the tools, it was found unfit for the purpose, or any other manufacturing purpose, and only valuable as scrap iron. Thereupon the buyer refused to pay. The seller brought suit for goods sold and delivered. (107 A., 713.)

Matters Involved in the Dispute

Upon trial of the cause there was no question raised as to the quantity of steel received, nor as to prices and credits allowed. There were three matters involved in the dispute, as follows: Was the steel of a quality reasonably fit for the making of tools? Was there an express warranty it should be so fit? And was there an implied warranty it should be reasonably fit for the purpose, because of seller's knowledge of the purpose for which it was purchased? Now, the seller admitted he knew the purpose for which the steel was purchased. The trial court gave judgment for the seller, and the buyer appealed to the Supreme Court, which reversed the judgment in the case.

Provisions of the Sales Act

On the appeal the last of the three questions was the important one to be determined. Its proper answer lay in the following provisions of the sales act, which provides:

"Where a buyer, expressly or by implication, makes known to the seller the particular purpose for which the goods are required, and it appears that the buyer relies on the seller's skill or judgment (whether he be the grower or manufacturer or not), there is an implied warranty that the goods shall be reasonably fit for such purpose. . . .

"In the case of a contract to sell or a sale of a specified article under its patent or other trade name, there is no implied warranty as to its fitness for any particular purpose.

"Where there is a breach of warranty by the seller, the buyer may, at his election, (*a*) accept or keep the goods, and set up against the seller the breach of warranty by way of recoupment in diminution or extinction of the price.

Measure of Damages for Breach of Warranty

"The measure of damages for breach of warranty is the loss directly and naturally resulting, in the ordinary course of events, from the breach of warranty.

"In the case of a breach of warranty of quality, such loss, in the absence of special circumstances showing proximate damage of a greater amount, is the difference between the value of the goods at the time of the delivery to the buyer and the value they would have had if they had answered to the warranty."

Supreme Court Holds That "High-Speed Steel" Is Not a Trade Name

The trial court held that "high-speed steel" is a trade name under the section above, and hence there was no implied warranty as to its fitness for any particular purpose. The Supreme Court said this was erroneous. There was evidence as to what constituted high-speed steel, and that each manufacturer thereof had a separate and distinct trade name for the particular high-speed steel manufactured by him. The generic name of an article made by several is not a trade name.

The seller was permitted to produce evidence of an alleged general custom in trade—contradicting the provision of the sales act quoted above—to the effect that, if a buyer discovers defects in high-speed steel, his only right is to return it and receive credit for the contract price. This was error, the court held.

Further, it held to be error to refuse to permit the buyer to show the expense incurred in the endeavor to make tools from the steel, before it discovered the impossibility of so doing. This objection was based on the provision above which says a buyer is entitled to set off only "the loss directly and naturally resulting in the ordinary course of events," which, "in the absence of special circumstances showing proximate damage of a greater amount, is the difference" between the value of the steel as it was and as it would have been had it "answered to the warranty." The court said it is difficult to understand what loss could more directly and naturally result, in the ordinary course of events, than the initial expenses incurred in using the steel, when the defects in it were not discoverable otherwise. That such expenses are allowable, if not too remote, has often been decided, both before and since the passage of the sales act.

It was contended by the seller that there was no implied warranty in the sale that the goods were fit for the purposes sold. Before the uniform sales act was passed the courts had held repeatedly that there was such an implied warranty so far as relates to the grower or manufacturer of the goods sold, and the only change made in the rule by this act was to extend it to include every seller, "whether he be the grower or manufacturer or not."

Law Implies Seller's Warranty of the Product

In an earlier case (28 L. Ed., 86) the Supreme Court of the United States said on this point:

"When, therefore, the buyer has no opportunity to inspect the article, or when, from the situation, inspection is impracticable or useless, it is unreasonable to suppose that he bought on his own judgment, or that he did not rely on the judgment of the seller as to latent defects of which the latter, if he used due care, must have been informed during the process of manufacture. If the buyer relied, and under the circumstances had reason to rely, on the judgment of the seller, who was the manufacturer or maker of the article, the law implies a warranty that it is reasonably fit for the use for which it was designed; the seller at the time being informed of the purpose to devote it to that use."

The Demand and Supply of Fixed Inorganic Nitrogen in the United States

A Concise Review of Our Present and Future Needs of Nitrogen and of the Advantage Resulting in the Continuous Operation of the Government Nitrate Plants to Help Supply Industrial and Agricultural Requirements

By ALFRED H. WHITE

THE United States uses fixed nitrogen for three main purposes—food, fertilizer, and chemical manufacture. The first two items are linked together, for the nitrogen fixed in foods is drawn from the soil, and provision must be made for the soil's replenishment. Provision for the increased food supply which this country needed during the war was hampered by lack of nitrogenous fertilizer. The increased cost of farm labor, and the increased value of crops, as well as the constant impoverishment of the soil, all point to the use of fertilizers in areas where they have not previously been used and their more liberal use on fields where they have formerly been used. It is safe to assume that nitrogenous fertilizers will be used in progressively increasing measure during the next decade at least.

One branch of the chemical industry of the country—that of explosives—was enormously stimulated during the war and has dropped down to approximately pre-war levels. The use of commercial explosives may be expected to grow with the development of the various industries in which they are used. Certain industries, notably the dye industry and those connected with the manufacture of artificial leather, photographic films, celluloid and other products of nitrated cotton, are requiring vastly increased amounts of nitric acid. These industries are still infants and may, if properly encouraged, be expected to grow materially faster than the average manufacturing industry of the country.

Organic and Inorganic Nitrogen

There are two fairly well recognized divisions of fixed nitrogenous products—organic and inorganic. The organic products are typified by tankage, dried blood and other products from the slaughter houses, and by the oil cake and hulls from the cotton plant. These products formerly went mainly to fertilizer, but in more recent years have been diverted more and more into food for cattle. Within a few years almost all of the oil cake and a considerable part of the high-grade tankage will be diverted away from fertilizer. The amount of organic nitrogen available for fertilizer is therefore decreasing and certainly no increase in it can be expected. The inorganic nitrogen compounds divide themselves into two broad classes—nitrates and ammonia compounds. These are not strictly interchangeable in either the fertilizer or the chemical world, but fortunately they are exchangeable to a considerable extent, and ammonia compounds are also convertible to nitrates, so that the world can increase its stock of either form in the full confidence that it will be used. The ammonia compounds of this country come almost entirely from the coke ovens and gas works. A relatively small amount comes from cyanamide obtained by fixation of atmospheric nitrogen at one plant at Niagara Falls. The nitrates come exclusively from Chile, on the west coast of South America.

Fixed Nitrogen as a Basis for Calculation

Since the United States can use both ammonia and nitrates, it is simpler, for purposes of study, to make all calculations in terms of fixed *nitrogen*, without reference to its source as ammonia or nitrate. Since the supply of organic nitrogen available for fertilizers is actually decreasing, it is clear that any increase in the amount of fixed nitrogen used by the chemical or fertilizer industries must come from inorganic sources.

The attached chart shows graphically the consumption of inorganic fixed nitrogen by the United States from 1902 to 1918, together with possible future developments. The development from 1902 to 1915 is fairly normal. The next four years reflect the war conditions and are so abnormal that they should not be considered in plotting future demand.

Future Demand for Fixed Inorganic Nitrogen

The graphs for the total consumption of inorganic nitrogen show an increase of nearly 200 per cent in the decade 1902-1912. The fluctuations are too great to permit any exact curve being traced, but the increase is very nearly linear and increases at the rate of 9,100 tons of nitrogen a year. If this line is projected to 1930, it shows a consumption of 300,000 tons of inorganic nitrogen for that year as indicated by line *E* of the chart. This is certainly low, for a flat increase of 9,100 tons means a decreasing rate which will have dropped to only 3 per cent annually at the end of this period. This could hold true only if the agricultural and chemical fields were becoming saturated. The contrary is the case, for the chemical industries of the country are growing rapidly, and the agricultural field, having not yet appreciated the economic advantage of nitrogenous fertilizers, will be only beginning to realize the full advantage of a more liberal use of fertilizer by that date.

It is therefore safe to assume a progressive increase in the total demand for nitrogen. Two graphs for this have been constructed, one portraying a 10 per cent cumulative annual increase, commencing with 1902 (line *G* of the chart), and the other a 7 per cent cumulative annual increase starting with a normal figure of 145,000 tons of inorganic nitrogen in 1913 (line *F* of the chart). The curve of 10 per cent increase lags throughout the pre-war period, and it is not certain that it indicates too rapid increases in the post-war period, although it does lead to rather startling figures. If the United States should continue to use fixed inorganic nitrogen at a cumulative 10 per cent annual increased rate, it would require, in 1930, 676,000 short tons of nitrogen, which,

translated to terms of nitrate, corresponds to 3,900,000 long tons of Chilean nitrate, more than twice as much as this country imported even under the stress of war and 25 per cent more than Chile can produce. If a 7 per cent cumulative increase is adopted as being more probable, it points to a total demand in 1930 of 458,000 tons of inorganic nitrogen, which, if supplied entirely from Chile, would require 2,600,000 tons of nitrate, which is nearly Chile's maximum output.

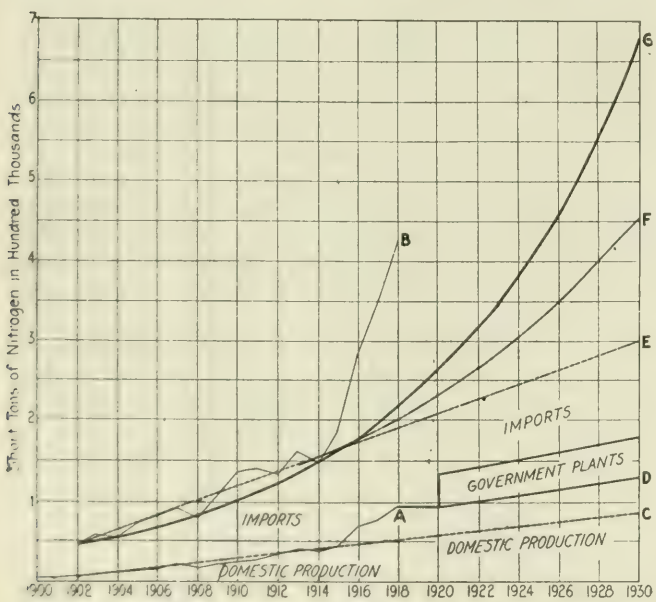
Of course it will not all be imported from Chile. Much of it will be produced at home, as ammonia compounds, and some may be imported as ammonia salts from European nations. The situation in 1913 is shown more fully in Table I.

The figures for nitrogen supply are all taken from the tables in the American Fertilizer Handbook, most of which are derived from official Government reports. The figures for utilization of sodium nitrates are taken from the report of the Federal Trade Commission (Senate Document 551, 64th Congress) on the Fertilizer Industry. The Commission received reports from six informants in close touch with the nitrate situation, whose averaged estimates for 1913 are as follows:

	Per Cent	Tons of Chilean Nitrate Based on 626,000 Tons Imports
Explosives	39.2	245,400
Fertilizers	45.5	284,800
Chemicals, etc.	15.3	95,800

The figures for utilization of ammonia are from an unpublished Government estimate.

The chart shows that the production of fixed inorganic nitrogen in the United States rose steadily in the period 1902 to 1915, but not so fast as the demand of the country, so that in the latter years of the period the importations were twice as great as in 1902. Even the great growth of the coke ovens during the war has failed to bring the American production of inorganic nitrogen up to within 100,000 tons of the normal demand. The curves show that if all the imports were from Chile, there would, on a normal basis, have to be at least 600,000 tons of nitrate imported in 1920.



INORGANIC FIXED NITROGEN TOTAL CONSUMPTION OF UNITED STATES

A and *B*. Total domestic production and imports for 1918.

C. Total estimated domestic production up to 1930 on the assumption of an annual increase of 2,800 tons, beginning 1902 (approximately normal previous to war).

D. Total estimated domestic production up to 1930 on the assumption of an annual increase of 3,700 tons after 1920.

E. Total estimated demand up to 1930 on the assumption of an annual increase of 9,100 tons (approximately normal during the decade 1902-1912).

F. Total estimated demand up to 1930 on the assumption of an annual cumulative 7 per cent increase over normal 1913 consumption.

G. Total estimated demand up to 1930 on the assumption of an annual cumulative 10 per cent increase over 1902 consumption.

TABLE I. STATISTICS FOR FIXED INORGANIC NITROGEN FOR U. S. IN 1913

1913 Supply of Fixed Inorganic Nitrogen[1]	Nitrogen Short Tons
Chilean nitrate, 626,000 long tons	109,000
Imported ammonium salts calculated as sulphate = 65,775 short tons sulphate	13,550
Domestic production of ammonia from coke ovens and gas works calculated as sulphate = 195,000 short tons sulphate	40,200
American Cyanamid Co. 15,000 tons cyanamide	3,000
	165,750

1913 Utilization of Fixed Inorganic Nitrogen		Nitrogen Short Tons
Imported Chilean Nitrate[2]		
Fertilizer	245,400 long tons[2]	
Explosives	284,800 long tons	
Chemicals, glass, etc.	95,800 long tons	
	626,000 long tons[1]	
	701,000 short tons	109,000
Ammonia:		
Sulphate for fertilizer	130,000 tons	26,800
Cyanamide	15,000 tons	3,000
Ammonia for essential industries		30,000
		168,800

[1]The American Fertilizer Handbook.
[2]Report on Fertilizer Industry by Federal Trade Commission, Senate Document 551, 64th Congress.

Future Domestic Production

The future domestic production depends largely on the byproduct coke ovens. Their rapid increase during the war has increased the production of byproduct coke so that in normal times approximately two-thirds of the coke will probably be produced in byproduct ovens.

The future increase in coke ovens will probably correspond somewhat closely to the growth of the pig iron industry, which takes by far the larger part of the coke made. The growth of pig iron production was almost exactly 50 per cent between 1905 and 1915. It will probably not increase so rapidly in the next decade. The assumption is therefore made that the production during the years 1919 and 1920 will be the same as in 1918, and that 1930 will show an increase of 40 per cent over 1920 in pig iron, and byproduct coke-oven coke and its resultant fixed nitrogen. This is shown on the chart as line *D*. It will be seen that it falls far short of meeting the fixed nitrogen demands of the country.

Future Fixation of Atmospheric Nitrogen

The two lines of fixation of atmospheric nitrogen which were largely developed during the war were the cyanamide and the Haber processes. Neither of them affords any definite promise of profitable *commercial* operation in this country in the near future. The cyanamide process requires too much electrical energy and the Haber process needs further study and development before it can be considered a commercial success. Nevertheless this country cannot afford to fall behind in the development of nitrogen fixation. The Chilean nitrate supplies are waning and sooner or later reliance will have to be placed on fixation processes.

Utilization of Government Plants

Fortunately, the United States Government is well fitted to carry on the work of nitrogen fixation. It has

in its Nitrate Plants Nos. 1 and 2 exemplifications of the two main types of processes. The cyanamide plant is of superior design and can be operated as a Government plant to produce fertilizer at a cost which will pay running expenses at the lowest price which fixed nitrogen is likely to reach, due to the fact that it has very cheap electrical energy, which will be produced at its hydro-electric plant at Muscle Shoals. It should return some interest to the Government on the investment. These plants should certainly be operated. When working at full capacity they will fix 50,000 tons of nitrogen a year. As shown by the chart, this is still entirely inadequate to meet the prospective demand. The figures are given more fully in the Tables II, III and IV.

TABLE II. FORECAST OF DEMAND AND SUPPLY OF FIXED INORGANIC NITROGEN IN U. S. FOR 1920

	Nitrogen Short Tons
Demand:	
Based on a normalized figure of 145,000 tons (as shown by the chart) in 1913 with an assumed normal increase of 7 per cent compounded annually. Factor for 7 per cent for 7 years = 1.60.	
Total demand, 145,000 × 1.6	232,000
Sources of Supply:	
Coke ovens, gas ovens and plant of American Cyanamid Co., estimated as same as 1918	92,700
Balance to be made up	139,300
Possible production from U. S. Nitrate Plant No. 2	41,500
Balance to be imported	97,800

Importations to be made up by Chilean nitrate or foreign ammonium sulphate:

	Per Cent of Total Supply to be Imported	Chilean Nitrate Equivalent in Long Tons
If Government nitrate plants are operated	42.1	508,000
If Government nitrate plants are not operated	60.4	710,000

TABLE III. FORECAST OF DEMAND AND SUPPLY OF FIXED INORGANIC NITROGEN IN U. S. FOR 1925

	Nitrogen Short Tons
Demand:	
Demand based on 1913 normalized figures from chart with increase of 7 per cent compounded annually. Factor = 2.25.	
Total demand 1925 = 145,000 × 2.25	326,000
Sources of Supply:	
Domestic coke ovens, gas ovens and private cyanamide plants with assumed increase of 20 per cent over 1920	111,240
Balance to be made up	214,760
Possible production from U. S. N. P. Nos. 1 and 2 41,500 + 8,500	50,000
Balance to be imported	164,000

Importations to be made up by Chilean nitrate or foreign ammonium sulphate:

	Per Cent of Total Supply to be Imported	Chilean Nitrate Equivalent in Long Tons
If Government nitrate plants are operated	50.5	947,000
If Government nitrate plants are not operated	66.0	1,234,000

Effect of Government-Owned Plants

As shown by the chart and the accompanying tables, there need be no fear that the present Government nitrate plants can in any way flood the market. They will serve to decrease the reliance which must be placed on Chilean or foreign sources and they will serve as a focus from which knowledge of the fixation art may be spread abroad through the country. Improvements may be expected from their research laboratories, and inventors of new processes will be assured of sympathetic assistance. The plants certainly will maintain themselves without expense to the Government and will return a dividend to the Government on its investment. If the future price of inorganic nitrogen rises at all proportionately to the price of other commodities, the net earnings should be considerable. The effect of the Government plants in reducing importations on the basis of the 7 per cent cumulative increased demand already discussed is shown in the following table:

TABLE IV. FORECAST OF DEMAND AND SUPPLY OF FIXED INORGANIC NITROGEN IN U. S. FOR 1930

	Tons
Demand:	
Demand based on normalized 1913 figures from chart with increase of 7 per cent compounded annually. Factor = 3.16.	
Total demand 1930 = 145,000 × 3.16	458,200
Sources of Supply:	
Domestic coke ovens, gas ovens and private cyanamide plants with assumed increase of 40 per cent over 1920	130,000
Balance to be made up	328,200
Possible production of U. S. N. P. Nos. 1 and 2	50,000
Balance to be imported	278,200

Importations to be made up by Chilean nitrate or foreign ammonium sulphate:

	Per Cent of Total Supply to be Imported	Chilean Nitrate Equivalent in Long Tons
If Government nitrate plants are operated	60.7	1,600,000
If Government nitrate plants are not operated	71.6	1,900,000

ESTIMATED PERCENTAGE OF INORGANIC NITROGEN REQUIREMENTS WHICH MUST BE IMPORTED

	Government Nitrate Plants in Operation	Government Nitrate Plants Idle
1920	42.1	60.4
1925	50.5	66.0
1930	60.7	71.6

Surely, with the lessons of the war still fresh in mind, this country cannot afford to count on the importation of more than one-half of the inorganic nitrogen, vital both for munitions and fertilizers. Unless the Government plants are operated and fixation processes encouraged, two-thirds of our inorganic nitrogen must be imported in the near future.

University of Michigan,
Ann Arbor, Mich.

Sodium Fluoride as a Wood Preservative

Tests made years ago indicated that sodium fluoride might successfully be used as a wood preservative because it had high toxicity, was not injurious to metal and was convenient to handle. Laboratory tests alone, however, are never sufficient to establish the value of any material as a wood preservative; actual service tests, even though they require years to complete, are also needed.

In order to obtain comparative durability records, the laboratory in 1914 placed sap-pine ties treated with sodium fluoride, together with ties treated with zinc chloride and creosote, in one of the mines of the Tennessee Coal, Iron & Railway Co., at Birmingham, Ala. Similar service tests were also started at this time on red oak ties placed in the tracks of the Baltimore & Ohio R.R. Co.

After five years of service the mine ties which were treated with sodium fluoride have been found in as good condition as those treated with zinc chloride, both showing very little deterioration. The creosoted mine ties apparently were in still better condition, while the untreated ones were in various advanced stages of decay. The red-oak railway ties treated with sodium fluoride were practically all sound, as were those treated with zinc chloride, whereas a large percentage of the untreated oak ties had been removed.

Both of these tests, as well as others started later, must continue for a number of years yet before the relative value of the sodium-fluoride treatment for ties and timbers is definitely known.—*Abstract from Forest Products Laboratory "Technical Notes."*

Caustic Pot Settings

By F. G. Wheeler

THE process of making caustic soda and chlorine as a step in the manufacture of other compounds has become widespread in the last decade. In many of these the chlorine is used on the spot and the caustic soda is sold. The final operation before placing the caustic soda upon the market is its concentration from a sirupy solution to the fused condition which is accomplished by boiling it in a large open vessel or "caustic pot" until no more water remains in the liquid. In this condition the fused caustic soda is finished by heating red hot, and as it cools it is allowed to settle. When the freezing point is reached, it is conveyed to sheet-steel drums, in which it solidifies, and in this condition is shipped.

The "caustic pot" is a large semi-spherical vessel of cast iron. The common form is one in which the depth of the pot is about 70 per cent of the diameter. Various sizes are used, a common one weighing about thirteen tons and discharging from eighteen to twenty tons of caustic soda per batch. It is supported by a concrete column and is heated from a furnace using either coal, wood, gas or oil for fuel.

Furnace Requirements

The design of the furnace has never been standardized, each engineer using what seemed to him the best for the purpose. This practice has resulted in many different designs, for each one of which is claimed various advantages.

The chief objects in designing such a furnace, besides the obvious one of the ability to finish the caustic, are economy in operation, long life for both the furnace and the pot, an arrangement which will automatically enable an ordinary workman to finish the caustic, and finally, protection against severe damage to either furnace or setting in case of pot failure.

The first two requirements are readily obtained by following boiler-furnace practice. The art of building boiler furnaces has reached such a general high state of perfection, and the principles which govern it are so familiar to boiler operators, that a furnace adapted to caustic-pot operation can easily be designed.

Economical Conditions

Economy can best be obtained by securing high furnace temperatures. The simplest way of accomplishing this result is to build a furnace only large enough to finish the caustic when it is forced to work at a high rate of combustion per sq.ft. of grate surface. The fireman must then keep his grates covered and work a thin fire in order to make the pot boil and "finish" the caustic on time. The result is a high furnace temperature and consequent economy of operation. As with boiler furnaces, care must be exercised in not creating a furnace temperature so high that the ash, in the particular coal which is used, will form clinker and plug the grates, but as high a temperature as possible under local conditions should be maintained.

The second condition leading to economy is the arrangement of the ash pit. This should hold a small amount of water so that steam will be formed and will pass with the air through the grate, rotting the clinker and keeping the grates free. The use of shaking grates will assist materially in this work.

The third factor for economy is the use of a combustion chamber behind the grate, before the hot gases are chilled by the pot. This allows the soot to be burned and produces a minimum amount of smoke. It may be obtained by building a deep bridge wall behind the grates, which allows the necessary distance through which the flames may pass for combustion before reaching the pot. An extra convenience for the fireman, where coal is the fuel, is the arrangement of the bridge wall so that the fireman can place his fire upon it while cleaning the grates. The old fire can then be drawn forward to start the new fire without inconvenience.

The final consideration leading to economy is the arrangement of the flue around the pot. No hot gases should pass from the furnace to the stack without coming in contact with the pot. The flue should be narrow and arranged with baffles to direct and hold the gases close to the pot, and so prevent them from passing too quickly up the chimney.

The writer prefers a three-battery setting, using two fusing pots and a preheating pot. This arrangement causes gases to pass around the fusing pot and then into contact with a preheating or "back" pot which is set higher than the fusing pot. The liquor in the back pot is heated before flowing into the front pot. The flues around the back pot should also be baffled so that the gases from one fusing pot do not antagonize those from the other pot.

A few minor details make for economy, such as the use of a damper in the flue between the pots, the scraping of the fusing pot free from soot and ashes, and the cycle by which one pot of a battery is worked with the other one to keep the feed liquor from the back pot the hottest when needed.

Conditions for Low Furnace Depreciation

Long life of both the furnace and the pot is very essential in caustic finishing work. Long furnace life is obtained by using good brick and setting them properly. Only the best grade of firebrick should be used. These can be obtained in most shapes so that the furnace can be built for the hardest work and the highest temperatures. An arch made of wedge brick set on end gives the longest life. A semi-circular arch allows for expansion and contraction better than a sprung arch. Buckstays properly located permit the arch to expand and contract without injury to the side walls, and make the furnace a compact, well-built device for meeting the best operating conditions. In locating the furnace in front of the fusing pot, care shou'd be taken to prevent the working floor from resting on the arch or the side walls of the furnace. The weight and the vibration from anything passing over the floor should not be conveyed to the arch, which should be free to respond to furnace conditions only.

Conditions for Low Pot Depreciation

Long pot life is obtained by protecting it from any blow-torch effect of the flames as they leave the furnace. The thick cast-iron wall of the pot will not respond to the cooling from the liquor inside as a boiler tube does. By placing a firmly set guard wall at the back end of the bridge wall in front of the pot, the flames may be made to come in contact with the pot gradually so that they will do it no injury. The guard wall should be thin. A thick, heavy guard wall holds and reflects the heat back into the furnace and

does not adapt itself to expansion or contraction. The reflected heat warps the grates and the furnace door, as well as burns the fireman's hands. Such a wall will crack easily. It also occupies the space which should be used for combustion in the furnace. The guard wall should also be arranged to support the inner end of the arch which rests upon it.

The caustic pot should be arranged so that it can be turned easily from time to time and so present a fresh surface to the flames at the sides of the guard wall. A pot regularly turned about every thirty charges will have a long life without further attention.

Other Operating Hints

Only a few points remain for an engineer to bear in mind. Sufficient draft should always be available and the baffles should be arranged in such a way that the passage of the gases to the chimney are not excessively large. All that the fireman should have to do is to keep a good fire until the finishing heat is reached, when the damper can be closed and the pot allowed to cool slowly, permitting all of the impurities to settle out.

The bottom of the pot should be protected from the heat so that, as the settlings reach the bottom, no currents of molten caustic will carry the settlings back into the clear portions of the liquid. This can be done with the same material which protects the supporting column and which makes the flue floor by filling well up around the bottom of the pot.

If a failure occurs from a crack or a sand hole, it sometimes happens that the molten caustic will leak out, dissolve the cinder or the sand filling below the setting and work its way down and under the foundation. For this reason the writer prefers to place a slab of concrete under the entire battery rather than only the amount required for supporting the load. This concrete, if it be made of granite gravel, will present an effective barrier to the molten liquid, and will prevent it from destroying the support under the foundation.

Caustic furnaces and settings which have been built in the manner outlined above have eliminated many difficulties. The caustic soda can be finished regularly with less than 1,000 lb. of coal per ton of caustic. A furnace will last for fifty or more charges with no repairs, and many caustic pots now in service have poured more than two hundred batches of caustic soda.

Bleach Process Co.
Appleton, Wis.

The Caking of Sulphate of Ammonia*

By C. G. Atwater and J. F. W. Schulze

Sulphate of ammonia, as usually produced, has shown a tendency to cake when stored in bags or in a pile. This has been ordinarily attributed to the presence of 1 to 2 per cent moisture and to a small amount of residual sulphuric acid from the saturator. This caking tendency is of little importance when the material is used in mixed fertilizers, as the sulphate is easily broken up in the usual processes of handling and mixing. When sulphate of ammonia is to be used by itself, as a separate fertilizer or top dressing, as is the intention with the dried and screened article recently placed on the market, the mechanical condition is a critical point and any tendency to cake must, if possible, be eliminated.

The obvious method of preparation is to dry the salt in a current of hot air and to screen out small lumps and nodules. This method at first seemed to be effective and produced an article that was fine, dry and readily spread by hand or agricultural machines, providing the moisture was less than 0.25 per cent. As the manufacture extended to additional plants, however, it was found that the product of some of them when brought well below 0.25 per cent moisture, showed a lack of condition; would not run freely in a drill and was more liable to cake on storage. In order to determine the cause of this trouble and to eliminate it, the investigation which the present paper describes was made.

Laboratory Examinations

A number of representative samples of ammonium sulphate were collected and two selected for examination. No. 1 was chosen as typical of those that did not absorb moisture on standing and did not cake, and No. 2 as typical of those that remained moist to the touch and tended to cake.

*A paper read before the Fertilizer Section at the Philadelphia meeting, Sept. 2-6, 1919, and published by permission of the American Chemical Society.

In No. 2 some pyridine was present, this being noticeable by smelling of the hands after squeezing a handful. Pyridine was also detected in No. 1 in the same manner, but a markedly smaller amount was present.

Free Pyridine Bases

At first it was thought that free pyridine bases were the cause of the moisture in the samples, but this was disproved when pyridine dissolved in ether was mixed with some of the No. 1 material. After the evaporation of the ether, pyridine escaped from the sulphate till it was as dry as before the application.

Hot air was passed through a drying tower containing No. 2 sulphate and when this was exposed again to the air it still became moist and turned red.

Both No. 2 and No. 1 samples were now placed under pressure of 200 lb. per sq.in. for 24 hr., to see if caking were caused. In the case of the former a slight lumpy condition resulted, but the No. 1 sulphate was scarcely affected by the pressure.

The estimation of the pyridine present was undertaken by the following method: There was weighed out 25 g. of $(NH_4)_2SO_4$ into a liter round bottom flask, about

TABLE I. ANALYSES

	Total Bases Per Cent	Free Bases Per Cent
No. 2	0.281 0.275 0.276	0.162 0.192
No. 2 exposed to air	0.220 0.224	
No. 2 dried 9 hr. with hot air	0.148 0.150	0.098 0.112
No. 1	0.039 0.039	

250 c.c. of water added and when solution was complete 5 c.c. N NaOH was added. This was immediately connected to a flask containing NaBrO solution, thence leading through a splash bulb to a condenser. When the first flask was boiled, the NH_3 liberated was oxidized to nitrogen by the NaBrO, the pyridine passing through unchanged and being collected in N/10 H_2SO_4.

After considerable experimental work Congo red was

selected as the most suitable indicator for the titration with N/10 alkali. At the best the end point was very poor, and only by titrating back and forth several times could a fairly accurate end point be obtained.

The bases as they are liberated near the end point are partly insoluble in water and form a sort of emulsion which makes difficult an accurate determination.

The results in Table. I have been calculated on the basis of pure pyridine.

It is quite evident from the results on free bases that considerable hydrolysis of the pyridine sulphate takes place in solution. In each pair of analyses the second one was purposely boiled a little longer than the first and hence gave a higher result, as was to be expected.

Also even in the air pyridine is liberated from $(NH_4)_2SO_4$ samples, which are actually acid already. The method of testing the acidity of sulphate is simple titration with alkali. A large part, if not all, of this acidity is due to the presence of pyridine sulphate.

As an example of the degree of acidity that pyridine sulphate is capable of assuming, especially in heated solution, the following test stands out: To 25 c.c. N/10 H_2SO_4 was added an excess of light pyridine. This solution was allowed to evaporate on the steam bath until no distinct odor of pyridine was obtained. On diluting and adding Congo red it required about 15 c.c. N/10 NaOH to produce an alkaline reaction. The weakness of this base and the consequent hydrolysis of its salts in solution is also shown by adding an excess of it to a N/10 acid solution containing indicator. It will give a distinct acid reaction even in the presence of a large excess of pyridine over the theoretical amount required to react with the acid present. Only by the addition of an enormous excess can an alkaline reaction be shown with Congo red.

Miscellaneous Impurities

Qualitative tests were made on the two samples of sulphate, and besides the pyridine bases, iron and chlorine were found in small amounts. A small precipitate appeared with bromine water with the No. 2 sulphate. This was taken to indicate the presence of phenols, especially since a nitrophenol odor was produced on boiling with dilute HNO_3. $FeCl_3$, however, gave no color to the solution.

Since the No. 2 sulphate turned red in the air, contrary to the behavior of the No. 1, it was thought that phenols were the cause of this phenomenon. But when crude phenols in ether solution were mixed with No. 1 sulphate and the ether allowed to evaporate no red color appeared. The phenols slowly evaporated and left the sample as dry as before.

Some of the No. 2 sulphate was extracted with benzol and ether after removing the water present by boiling with benzol. A small amount of resinous material and some pyridine were found. After extracting at least twelve times and allowing to stand in the air, the sulphate again became moist and turned reddish brown. A sample of this was treated with dry NH_3 gas and remained dry on standing, with no color change.

It now occurred to us that pyridine sulphate might be the cause of the sample taking up moisture; so a small amount of H_2SO_4 was added to some No. 1 sulphate and a pyridine ether solution, stirred in until all the ether had evaporated. Then on standing in the air the material became moist and also assumed the reddish color of the exposed No. 2 sulphate.

Further, several samples of the No. 2 class of sulphate, including No. 2 itself, were treated with cold dry NH_3 gas and after a few minutes became quite dry to the touch, remaining so indefinitely in the air.

Pyridine[1] is likewise readily liberated from the $(NH_4)_2SO_4$ by washing the latter with saturated liquor containing a small amount of NH_3. When 250 g. of sulphate was washed with 150 c.c. solution containing about 0.3 g. NH_3, the pyridine content was reduced from 0.380 per cent in the original to 0.180 per cent in the final product. This is identical to the amount of pyridine in the ammonia gas-treated material.

From these results it is quite apparent that the cause of the moist feeling and consequently of the caking of $(NH_4)_2SO_4$ samples is pyridine sulphate, other impurities being negligible in effect.

Pyridine Sulphate the Cause of Caking

The impurity in $(NH_4)_2SO_4$ is therefore recognized as pyridine sulphate. This causes the sample to feel moist to the touch and due to its presence in the sulphate the latter will take up moisture on damp days, only to lose it later with the decreasing humidity of the atmosphere to produce a decided caking effect. The amount of water taken up, as well as the resultant caking, is in proportion to the amount of pyridine sulphate present.

By passing dry NH_3 gas through samples containing pyridine sulphate, pyridine is liberated and passes off. If the NH_3 is preheated, quicker and more thorough results are obtained. A treatment of the sulphate with very dilute ammonia liquor produces practically the same effect, and in some cases would be more practical commercially. Ammonium sulphate may be produced by either of these simple methods freed of a major part of its original pyridine content. In this state it will not absorb an appreciable amount of moisture from the air and its caking will be negligible.

The Barrett Co.,
New York, N. Y.

Truck With Regenerative Braking

After a number of years of research in the field of light-weight, low-cost electric vehicles, Dr. Charles P. Steinmetz has recently announced the development of a light-weight electric truck, one of the principal features of which is the method of motor control, which gives the motor compound characteristics by a storage cell floating on the field circuit.

The result of this method of control, Dr. Steinmetz pointed out, is speed maintenance, quick starting, power saving in the field at large currents and the feature of regeneration both on down grades and on stopping.

The field and armature of the motor revolve in opposite directions, each driving one of the car wheels. In this way motor weight is saved, the differential is eliminated and the truck is simpler and more compact.

By saving in motor weight and in battery weight, by the elimination of differential and in other ways a lower-weight truck is obtained. The ½-ton truck, without body, for instance, will have a weight, it is stated, of only 2,300 lb.

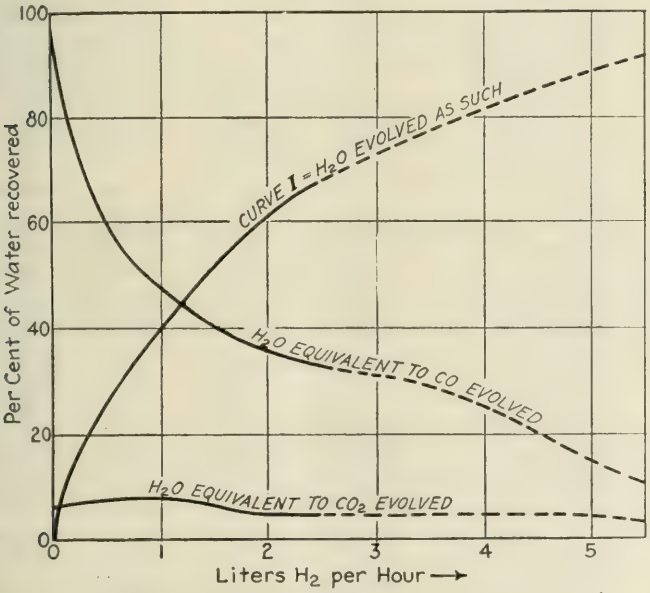
As a result of the above features and with the use of standard parts, it is claimed that lower operating cost and lower price will result.—*Electrical World*, vol. 75, p. 341, Feb. 7, 1920.

[1] See "Recovery of Pyridine From Byproduct Coke Ovens," Chem. & Met. Eng., vol. 22, No. 6, pp. 274-5.

Synopsis of Recent Chemical and Metallurgical Literature

Limitations of Ledebur Method for Oxygen in Steel.—In Bureau of Standards Scientific Paper No. 346, J. R. CAIN and EARL PETTIJOHN present a study of oxygen content of Boylston's ingots (*Carnegie Scholarship Memoirs*, vol. 7, p. 102) and ingots of a series of bessemer rail-steel heats made at the Bethlehem Steel Co.'s Sparrows Point plant. In both of these studies acid converter metal was deoxidized by various substances, such as spiegel, ferromanganese, ferrosilicon, ferrotitanium and aluminum, and the oxygen content determined by the Ledebur method as modified by the authors (see Bureau of Standards Technologic Paper No. 118).

There seems to be no relationship between the Ledebur oxygen and various methods of deoxidation in the ladle, the aluminum treatment in the molds or the effect of rolling, the analytic results for steels of approximately the same chemical composition varying in a vague manner up to 0.020, sometimes approaching even 0.030. Ledebur oxygen, therefore, probably



GENERATION OF H_2O, CO AND CO_2 AT 900 DEG. C.

has no relation to efficiency of deoxidation, probably because the slag oxides resulting from the additions trapped in the solid metal do not yield their oxygen in this method. Neither is annealing *in vacuo* for a given time and temperature, nor determining nitride nitrogen adequate for a study of deoxidation.

In order to study the reasons for this failure on the part of the reputable Ledebur method, CAIN and L. ADLER (Bureau of Standards Scientific Paper No. 350) studied the various reactions which may proceed during the determination, i.e., when heating a steel (iron, carbon and iron oxide) to 900 deg. C. in a stream of hydrogen of various speeds. Using a mixture of iron oxide and graphite, all the oxygen in the ore could be recovered as water.

That is, the reaction

$$FeO + H_2 = Fe_2 + H_2O$$

proceeds practically to completion without interference by $FeO + C \longrightarrow Fe + CO$ which Falcke says starts at about 600 deg. C.

However, when a mixture of iron oxide and cemented iron or cast iron was heated under a given gas stream, the amount of oxygen recovered as water fell off as the amount of iron-carbon alloy increased; that is, iron carbide has now partially reduced iron oxide. On studying a mixture which contained a ratio of ferrous oxide to combined carbon as 1 is to 5 (which was thought to approach extreme conditions occasionally found in steels) and varying the rate of hydrogen current, results plotted in the accompanying figure were found.

Since curve I showed such a large deficit in oxygen as water, additional studies were made in order to determine whether the other gases were CO, CO_2, and saturated hydrocarbons. The last proved to be very small, while the carbon oxides are plotted in the figure.

Reactions $FeO + C \leftrightarrows Fe + CO$

and $FeO + CO \leftrightarrows Fe + CO_2$

should tend to produce larger amounts of CO with increasing hydrogen rate, but since this condition was not found experimentally, it is thought that these reactions are not much affected at 900 deg. C. Thermal dissociation of carbon monoxide

$$2CO \leftrightarrows CO_2 + C$$

should be shifted to the left with more rapid hydrogen passage. A result in conformity to that found

$$CO_2 + H_2 \leftrightarrows CO + H_2O$$

tends toward the right at 900 deg., so a rapid current by sweeping quickly into a cool spot will suppress production of CO. Reaction

$$C + H_2O \leftrightarrows CO + H_2$$

is the one most affected, being shifted to the left, according to expectations. The figure shows that under the experimental conditions holding for Ledebur's method no more than 75 per cent of the reduction of ferrous oxide can be affected by hydrogen (temperature, 900 deg. C., carbon : ferrous oxide = 5 : 1; and hydrogen rate 3 liters per hr.)

Switzerland Factory Statistics in 1918.—The report of the Swiss Department of Public Economy published in the November, 1919, issue of the *Swiss Exporter* gives the statistics for the number of factories and employees in Switzerland in 1918, arranged according to industries. There were 9,327 establishments and 381,170 employees working under the factory acts. The figures for the various industries are as follows:

Industry	No. of Establishments	Employees — Male	Employees — Female	Total
Cotton	313	8,585	17,458	26,043
Silk	211	6,788	23,478	30,266
Wool	66	2,585	4,111	6,696
Linen	31	411	945	1,356
Embroidery	828	7,932	14,923	22,855
Other textile industries	129	1,430	3,183	4,563
Clothing and outfitting	1,031	11,279	24,890	36,169
Foods and table luxuries	791	13,573	13,614	27,187
Chemical industries	270	14,230	3,534	17,764
Power stations	276	4,705	8	4,713
Paper	700	12,798	6,105	18,903
Woodworking	1,325	21,954	910	22,864
Metals	902	30,961	5,582	36,543
Machinery	842	61,986	3,817	65,803
Watches and jewelry	1,222	25,376	21,099	46,475
Mineral materials	390	11,817	1,153	12,970
Total	9,327	236,410	144,760	381,170

From 1913 to 1918 the number of factory employees has gone up from 341,295 to 381,170, an increase of about 40,000; the increase is most notable in the machine, metal, watch and chemical industries. There has been a decrease in the number of employees in the

textile, paper, wood, food and mineral industries. In 1918 39 per cent of all factory employees in Switzerland were employed in the machine, watch, jewelry and metal industries; of the total number 38 per cent were females.

Acid-Resisting Metals.—The December, 1919, issue of *Chemie et Industrie* contains an extensive description of acid-resisting metals by Prof. C. MATIGNON. With the exception of a short description of ferroborides, the article treats of ferrosilicons. He gives their historic beginning with the work of Jouve, enumerates the different alloys used for acid-resisting containers used in France, Germany, Great Britain and America, and describes their properties (fusibility, density, conductivity, magnetism and chemical resistance). The study of the chemical resistance of the industrial ferrosilicons was made in collaboration with Miss Momal. They studied the action of nitric acid and the mixture of acetic and butyric acid on Metillure, Elianite I, Elianite II, Ironac, Duriron and Tantiron, for different periods of boiling. The results are tabulated. The article contains also a review of the uses of some of the alloys in the manufacture of apparatus for the heavy chemical industry.

Influence of Chemical Composition and Thermal Treatment Upon the Properties of Iron Alloys.—E. GUMLICH and P. GOERENS publish in the *Elektrotechnische Zeitschrift* of June 26, July 3, 10, 17 and 24, 1919, their report upon the results of experimental investigations into the properties of pure iron alloys which have been carried out in Germany for ten years or so under the co-operation of several scientific institutions and metallurgical concerns. Most of the measurements were made at the Reichsanstalt, hand in hand with metallographical studies conducted by WÜST and GOERENS. Suitable samples with systematically varying percentages of C, Si, Al and Mn were carried through certain thermal and magnetical cycles, and extensive sets of data for each condition of the material were obtained. By extrapolation from the curves for the several series of alloys there were obtained, as probable averages, the following data for pure iron: Specific gravity, 7,876 g. per cu.cm.; specific resistivity, 0.0994 ohm per min., sq.mm. at 20 deg. C.; temperature coefficient, 0.00573 per 1 deg. C.; magnetic saturation, 21,620 max. per cu.cm. The effects of annealing upon the magnetic properties of commercial transformer plate were thoroughly investigated, the results leading to the conclusion that the annealing causes a decided deterioration, the effect being worse the higher the temperature. During the first few hours, however, a net improvement is obtained, due to mechanical softening of the material and expulsion of gases, and the effects preponderate over the deterioration due to the annealing. Maximum improvement was observed in from 4 to 24 hr., and 785 deg. C. (1,440 deg. F.) appeared to be the most favorable annealing temperature.

Japan's Foreign Trade.—The January, 1920, issue of the *Trans-Pacific* gives, in statistical form, the quantity and value of the principal commodities imported and exported during the first nine months of 1919. Figures for the corresponding period of 1918 are given for comparison. Tables I and II present a summary of the figures given for products of interest to the chemical and metallurgical industries.

TABLE I. EXPORTS OF CHEMICALS, ETC., FROM JAPAN

	Nine Months Ending Sept. 30			
	1919		1918	
Articles and Countries	Quantity Kin (1.33 Lb.)	Value Yen ($0.4985)	Quantity Kin	Value Yen
Camphor:				
Total	1,525,275	5,070,684	1,493,973	3,083,555
United States	1,176,028	3,608,214	496,829	901,189
Colza (rapeseed) oil:				
Total	6,983,095	2,869,407	15,459,439	5,275,606
United States	3,698,835	1,474,447	13,068,538	4,525,098
Great Britain	1,651,944	714,800	136,935	41,239
Copper, ingot and slab:				
Total	28,375,824	17,096,596	41,048,833	28,522,298
China	20,379,717	12,448,710	7,569,454	5,585,267
France	238,769	143,966	11,819,970	8,097,310
Fish oil and whale oil:				
Total	8,056,092	2,299,921	15,797,459	3,003,245
United States	798,233	262,188	6,321,725	1,271,144
Great Britain	4,214,903	1,243,814	6,111,346	1,010,494
Belgium	1,541,008	372,284	.....	.....
Glass and manufactures:				
Total	.....	12,874,305	.....	11,366,889
United States	.....	1,179,533	.....	898,327
Menthol crystals:				
Total	190,977	1,875,363	208,344	1,288,469
United States	129,958	1,256,715	66,802	416,635
Great Britain	45,707	425,956	109,630	664,123
Pottery:				
Total	.....	14,969,891	.....	14,660,875
United States	.....	3,697,295	.....	3,704,400
Sugar, refined:				
Total	93,280,359	16,867,570	132,522,082	16,109,609
China	81,608,081	14,539,166	114,561,959	13,882,586
Sulphur:				
Total	37,038,868	1,536,337	73,660,663	2,816,921
Australia	19,019,024	660,066	49,176,150	1,617,913
Zinc, ingot and slab:				
Total	8,885,499	2,757,786	26,728,369	8,477,153
Great Britain	6,439,942	2,103,156	5,953,398	1,988,131
France	.....	.....	11,852,182	3,516,281

TABLE II. IMPORTS OF CHEMICALS, ETC., INTO JAPAN

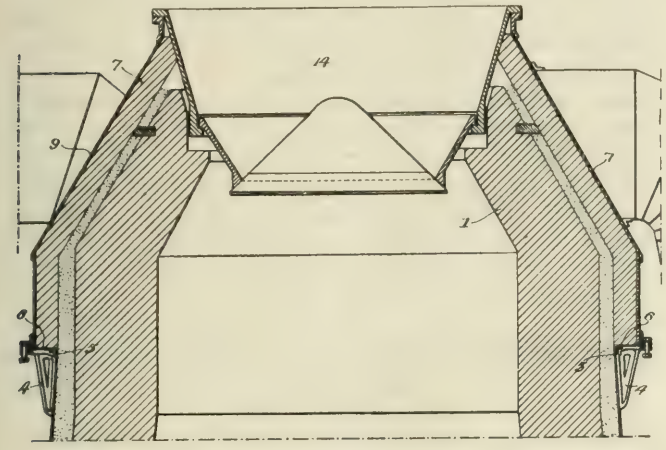
	Nine Months Ending Sept. 30			
	1919		1918	
Articles and Countries	Quantity Kin (1.33 Lb.)	Value Yen ($0.4985)	Quantity Kin	Value, Yen
Ammonium sulphate, crude:				
Total	460,363*	7,439,519	11,368*	189,669
Antimony:				
Total	3,094,639	522,569	9,159,900	2,124,394
China	3,094,639	522,569	9,159,886	2,124,390
Brass and bronze:				
Total	508,734	118,771	2,347,210	730,993
Caustic soda and soda ash:				
Total	99,311,647	9,748,059	68,994,199	9,493,916
United States	43,687,914	5,693 898	45,341,855	7,516,888
Great Britain	55,122,916	4,027,016	23,292,117	1,955,532
Dyes, coal-tar:				
Total	1,517,199	8,244,054	1,474,170	8,704,524
United States	1,059,200	6,076,910	981,363	4,962,748
Switzerland	326,803	1,443,207	105,822	450,662
Germany	28,770	151,193	345,893	3,007,789
Iron (lump, ingot, bloom, billet and slab):				
Total	349,488,804	42,653,692	261,956,631	39,697,972
United States	65,052,785	8,279,689	28,131,178	5,279,412
Iron (bar, rod plate, sheet, wire, etc.):				
Total	563,584,846	106,683,083	685,951,757	161,181,439
United States	484,450,202	91,170,563	662,762,640	154,347,096
Iron (pipe and tube):				
Total	39,627,163	10,125,025	46,466,075	10,926,390
United States	37,094,250	8,996,433	43,907,063	10,216,756
Kerosene oil:				
Total	24,971,677†	14,252,622	19,228,327†	6,625,200
United States	20,119,835†	11,842,377	17,065,227†	6,030,551
Lead (ingot and slab):				
Total	27,601,369	5,571,359	40,470,428	9,783,005
United States	8,026,195	1,329,201	15,831,293	3,723,802
Australia	17,454,274	3,870,828	22,419,954	5,512,726
Leather:				
Total	1,220,431	3,688,949	1,075,539	2,462,879
United States	817,565	2,293,150	632,540	1,644,745
Nickel (ingot and grain):				
Total	2,194,794	3,192,279	648,282	841,622
United States	1,880,666	2,783,039	478,093	665,890
Oil cake:				
Total	19,285,379*	98,994,640	15,660,575*	69,592,908
China	5,179,160*	28,267,094	2,956,129*	13,569,819
Kwantung Province	11,645,930*	57,972,566	9,948,934*	43,836,492
Paper:				
Total	.....	14,266,207	.....	5,774,344
United States	.....	12,517,457	.....	4,746,704
Paper pulp:				
Total	38,684,592	5,842,079	33,446,455	4,694,705
United States	20,196,973	3,002,999	9,631,481	1,462,503
Canada	16,784,795	2,481,557	21,558,153	2,883,281
Rubber and gutta-percha, crude:				
Total	14,878,156	13,775,042	7,346,028	8,599,703
Straits Settlements	14,237,937	12,768,442	6,734,545	7,722,170
Sodium nitrate, crude:				
Total	84,500,728	10,560,470	67,511,897	9,446,183
Chile	83,489,612	10,488,738	66,832,568	9,393,918
Tanning extracts:				
Total	4,692,224	869,193	5,307,805	1,172,188
United States	317,097	73,610	83,333	9,731
Argentina	1,200,990	188,237	1,241,670	301,862
Dutch India	1,415,023	221,584	1,926,831	426,200
Tin (ingot and slab):				
Total	4,036,363	5,598,543	3,868,421	6,475,553
Straits Settlements	2,909,088	3,948,065	2,603,452	4,252,576

* Picul (133⅓ lb.) † Gallons.

Recent Chemical and Metallurgical Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Blast-Furnace Top.—EDWIN G. RUST, of Philadelphia, Pa., has patented the blast-furnace top shown in the figure, so designed that the main furnace lining 1 is carried full height at maximum thickness, and the dome lining is supported entirely outside of the shell, being supported by brackets 4 and angle iron 5



BLAST-FURNACE TOP

riveted to the steel plate. Horizontal ring 6 is riveted to angle iron 5, but held down to the brackets only by loose bolts, so that thermal expansions and contractions may be reflected by a limited vertical movement of the outer part of the ring, the dome lining 7 and the hopper 14, all acting as a unit. (1,307,884; June 24, 1919.)

Rust Prevention.—JAMES H. GRAVELL, of New York City, notes that it is difficult to remove the last traces of the liquid, non-volatile phosphoric acid in which steel parts are immersed for rust proofing. Especially is it necessary to remove the last traces when the rust-proofed pieces are to be painted. He suggests that a saturated solution of oxalic acid in water be used instead. The pieces upon drying are then covered with finest crystals of solid acid, over which paint can be placed with no damage to its adherent qualities or permanency. In case oily metal is to be treated, 30 per cent by volume of an organic solvent such as alcohol is added to the bath. (1,315,017; Sept. 2, 1919.)

Sodium Ferrocyanide.—When a mixture of one part of coke with four parts of barium carbonate is heated in a suitable retort for about 6 hr. while a current of nitrogen is passed through the mass, the product obtained has approximately the following composition: $Ba(CN)_2$, 25 per cent; $BaCN_2$, 3; BaO, 23; $BaCO_3$, 35; C, 14. After grinding, the material is leached with hot water, yielding a solution of cyanide, cyanimide and hydroxide of barium. Treatment with sodium carbonate precipitates the barium as carbonate and forms the corresponding sodium salts. The cyanide is changed into ferrocyanide by heating the solution to 80 deg. C. with finely divided iron, and the hydroxide converted to carbonate by passing in carbon dioxide. In order to separate the sodium carbonate and sodium ferrocyanide by fractional crystallization, TEOFRON BOBERG, of London, England, takes advantage of the fact that the maximum solubility of sodium carbonate is coincident with the transition point at about 36 deg. C. Accordingly, the solution is evaporated to incipient crystallization at 80 deg. C., and then cooled to about 36 deg. C., when the ferrocyanide separates substantially free from carbonate. The mother liquor when cooled further gives crystals of sodium carbonate which are used again in the process. (1,318,258; assigned to Techno-Chemical Laboratories, Ltd., London, England; Oct. 7, 1919.)

Bismuth.—Concentrates containing 80 to 95 per cent of bismuth, with varying amounts of sulphur and tellurium, are heated to about 1,700 deg. F. A portion of the S and Te volatilizes, while a slag forms which may be stripped by cooling to about 1,200 deg. F. On reheating, the presence of S and Te is indicated by a purple tint on the surface of the molten metal. These impurities may be removed by treating with 5 to 10 per cent of $CaCl_2$ or $MgCl_2$. The chlorine volatilizes iron impurities, while the calcium or magnesium combines with the S or Te. (1,318,335; ELTON R. DARLING, assignor to Ellis-Foster Co.; Oct. 7, 1919.)

Sodium From Sodium Chloride and Calcium Carbide.—At temperatures between 1,200 and 1,300 deg. C. a mixture of calcium carbide and sodium chloride gives off vapors of metallic sodium which may be recovered in a suitable condenser. According to HORACE FREEMAN, of Niagara Falls, Ont., the reaction probably proceeds in two stages:

$$2NaCl + CaC_2 = CaCl_2 + Na_2C_2$$
$$Na_2C_2 + \text{heat} = 2Na + 2C$$

Obviously, other alkali metals may be made by the same process. (1,319,148; assigned to American Cyanamid Co.; Oct. 21, 1919.)

Oxidation of Methane to Formaldehyde.—Natural gas or other gas with high CH_4 content is mixed with two volumes of nitric oxide and a volume of air or oxygen sufficient to convert the nitric oxide into nitrogen peroxide. The gaseous mixture is then passed through a red hot porcelain tube. In order to prevent further decomposition or oxidation of the formaldehyde formed, REGINALD K. BAILEY, of Lawrence, Kan., suggests the following procedures: (*a*) The gases are quickly cooled by passing through water containing $CaCO_3$ in suspension. The $CaCO_3$ tends to unite with the oxides of nitrogen, except nitric oxide, thus preventing the formation of nitric acid; (*b*) the hot gases may be passed over a dehydrating agent such as CaO, whereby the water formed during the reaction is absorbed and the formation of nitric acid or nitrous acid prevented. Were these acids permitted to form, they would oxidize the formaldehyde to carbon dioxide and water. (1,319,748; Oct. 28, 1919.)

Use of Niter Cake in Diazotization.—Niter cake (sodium bisulphate) furnishes a cheap source of acid for the liberation of nitrous acid from sodium nitrite in the process of diazotization. In addition, the sodium sulphate formed acts as a precipitant for the compound formed after coupling. ELMER K. BOLTON, of Wilmington, Del., cites the following example of this use for niter cake: Aniline (60 g.) is converted into aniline sulphate by the addition of 51.3 g. of niter cake, showing, on analysis, 35 per cent acidity measured as sulphuric acid, and 22.3 g. of sodium nitrite is then added so as to diazotize the aniline sulphate,

which then becomes coupled with the excess of aniline to produce diazoamidobenzene, which separates out quantitatively and immediately from the water solution. (1,320,443; assigned to E. I. du Pont de Nemours & Co.; Nov. 4, 1919.)

Barium Nitrate From Barium Sulphide.—The conversion of alkaline earth sulphides into nitrates is conveniently accomplished by double decomposition with nitrates of metals whose sulphides are not stable in water solution, being hydrolyzed with the formation of H_2S and the hydroxide of the metal used. Nitrates of aluminum, magnesium and chromium are specifically mentioned by ROBERT W. DAVIS, JR., of Jenkintown, Pa. Using aluminum nitrate, the reaction which takes place at the boiling point of the solution may be written:

$$3BaS + 2Al(NO_3)_3 + 6H_2O = 3Ba(NO_3)_2 + 2Al(OH)_3 + 3H_2S$$

The aluminum hydroxide, being insoluble and in a flocculent form, is easily filtered off, so that a pure solution of barium nitrate is obtained. (1,321,013; Nov. 4, 1919.)

Precipitating Anthranilic Acid From Aqueous Solutions.—The sodium salt of anthranilic acid is ordinarily made by treating phthalimide with sodium hypochlorite and sodium hydroxide in accordance with the equation:

$$C_6H_4\begin{matrix}CO\\CO\end{matrix}NH + NaOCl + 3NaOH = C_6H_4\begin{matrix}COONa\\NH_2\end{matrix} + Na_2CO_3 + NaCl + H_2O$$

In attempting to precipitate anthranilic acid from the solution by means of HCl or H_2SO_4, difficulty is experienced in determining the correct amount of acid to use, since an insufficient amount will fail to precipitate all of the anthranilic acid, while an excess will result in the formation of the water-soluble hydro chloride (or sulphate) of anthranilic acid. During the process of acidification, the sodium carbonate is converted into chloride or sulphate. These sources of loss are remedied by RALPH S. POTTER, of Grantwood, N. J., in the following manner. The solution is first treated with CO_2, whereby at least 50 per cent of the sodium present as Na_2CO_3 is recovered as bicarbonate. The anthranilic acid is now precipitated by an acid which is too weak to form a salt with it, such as H_2SO_3, so then an excess has no harmful effect on the yield. (1,322,052; assigned to The Barrett Co.; Nov. 18, 1919.)

Treating Black Liquor From Sulphate Pulp.—The alkali losses incurred in the treatment of black liquor and in the preceding pulp-manufacturing process are usually compensated by the addition of salt cake to the black ash before calcination. The sulphate is reduced to sulphide during the latter operation. The carbonate which is also formed must be causticized by treatment with lime before it can be used in the digester. ELIS OLSSON, of East Angus, Que., proposes the substitution of niter cake for salt cake, thereby converting the carbonate into sulphate and avoiding the use of lime. The cooking liquor prepared from this product will contain sodium sulphide as the active agent. (1,322,043; Nov. 18, 1919.)

Purification of Iodine.—Certain impurities present in commercial iodine, such as iron iodide, iodine chloride and iodine bromide, cannot be removed by the process of sublimation. RAY M. CARTER, of Baltimore, Md., has patented the following method of purification: 200 lb. commercial iodine and a solution of 10 lb. KI in 100 lb. water are placed in a kettle, and steam is introduced through a perforated coil in the bottom. The steam decomposes the impurities referred to, liberating the iodine. The iodine vapors (mixed with steam) are condensed and the wet iodine dried at room temperature under a vacuum of 28 in. of mercury. (1,324,761; assigned to U. S. Industrial Alcohol Co.; Dec. 9, 1919.)

Anthraquinone and Phthalic Anhydride by Catalytic Oxidation.—CHESTER E. ANDREWS, of Pittsburgh, Pa., has found that aromatic hydrocarbons containing side chains or more than one ring may be oxidized by boiling with sulphuric acid in the presence of oxides of molybdenum or vanadium. Oxidizing agents such as sodium dichromate or manganese dioxide may be used, and the catalytic effect of the molybdenum or vanadium oxide is increased in many instances by the admixture of compounds or oxides of metals of the fifth or sixth group of the periodic system. Anthracene and ortho-xylene when treated in this manner, using 50 per cent H_2SO_4, yield anthraquinone and phthalic anhydride respectively. (1,324,715; assigned to the Selden Co.; Dec. 9, 1919.)

Personal

ROY N. BUELL will leave Battle Creek, Mich., the end of February to build a powdered lignite fuel plant in Melbourne, Australia.

G. M. BUTLER, director of the Arizona Bureau of Mines and dean of the College of Mines and Engineering, has been elected to head the Chamber of Commerce, Tucson, Ariz., for the coming year.

E. W. ENGELMANN has been appointed to the position of consulting research engineer for the Utah Copper, Chino Copper, Ray Consolidated Copper and Nevada Consolidated Copper companies, with headquarters in Salt Lake City.

ARTHUR G. HENRY, metallurgist for the Illinois Tool Works and secretary of the American Steel Treaters' Society, has resigned to become Chicago representative of the Vanadium Alloys Steel Co.

Dr. E. H. LESLIE has resigned from his position as assistant to the president and to the general manager of the U. S. Industrial Alcohol Co. of New York City and has accepted a position as associate professor of chemical engineering at the University of Michigan, Ann Arbor, Mich.

ALEXANDER MACKAY, president of the Dundee-Arizona Copper Co., with his son, Captain F. B. MACKAY, both of Dundee, Scotland, have made an inspection of the property of the company at Jerome, Ariz.

Dr. E. S. MERRIAM has resigned the professorship of chemistry of Marietta College to accept the position of chief chemist for the Safe-Cabinet Co., Marietta, Ohio.

R. B. MOORE, chief chemist, U. S. Bureau of Mines, was in Golden, Col., during the latter part of January in connection with the co-operative work on oil investigations undertaken by the State of Colorado and the Bureau of Mines.

R. A. ROSS, a member of the Administrative Commission of the City of Montreal, has been elected president of the Engineering Institute of Canada.

E. E. THUM, associate editor of CHEMICAL & METALLURGICAL ENGINEERING, spoke Wednesday evening, Feb. 18, on "The Effect of Phosphorus and Sulphur in Steel" under the auspices of the American Steel Treaters' Society at the Bush Terminal Bldg., New York.

HENRY E. WOOD, formerly of Denver, Col., who has been living in New York for the past year or two, has gone to Freeport, La., for a few months.

Obituary

Dr. David S. Pratt, formerly assistant director of the Mellon Institute of Industrial Research of the University of Pittsburgh, died in St. Louis, Mo., on Jan. 28, after a short illness from pneumonia. He was a member of the American Chemical Society and of the following fraternities: Phi Kappa Sigma, Sigma Xi, Alpha Chi Sigma, and Phi Lambda Upsilon.

David Shepard Pratt was born in Towanda, Pa., on Sept. 20, 1885, the son of Charles Manville and Louise Hale (Woodford) Pratt. Following the completion of the collegiate course at Cornell University (A.B., 1908), he was appointed a Fellow in Chemistry at that institution (1909-1911) and in 1911 he received the degree of Ph.D. Dr. Pratt then joined the staff of the Bureau of Chemistry, Washington, D. C., as assistant chemist, but shortly afterward was selected as chief of the Organic Division of the Bureau of Science in Manila, P. I., where he spent three productive years in chemical research and as a member of the Pure Food and Drug Board. In 1914 he decided to return to the States and accepted a professorship of chemistry at the University of Pittsburgh. Dr. Pratt occupied that chair and the headship of the organic department of the School of Chemistry at "Pitt" from 1914 to 1917, in which year he was made an assistant director of the Mellon Institute of Industrial Research. On Jan. 1, 1920, Dr. Pratt resigned at the Institute and was arranging to enter consulting chemical practice in St. Louis, Mo., at the time of his fatal illness.

Dr. Pratt was known principally for his published investigations on phthalic acid derivatives, but his reports of researches on various problems in the domain of tropical chemistry have also been of importance and he was a recognized authority on chemical Philippiniana. At the Mellon Institute Dr. Pratt enjoyed broad opportunities to apply, in the inquiries of the Industrial Fellowships under his supervision, his splendid equipment in chemistry and many results of technical importance were obtained through his suggestive aid. His profound knowledge of pure organic chemistry and his familiarity with research methods were respected by his associates and played a prominent part in establishing the high success of the system in operation at the Institute. His departure to enter professional practice was sincerely regretted by all of the members of the institution. Dr. Pratt resided in St. Louis at 38 Portland Pl. He is survived by his wife, Fredonia Elizabeth (Johnson) Pratt, and an infant son, David Shepard Pratt, Jr.

Current Market Reports

The Non-Ferrous Metal Market

New York, Feb. 20, 1920.—The copper market continues dull. Lead, zinc and tin have strengthened.

	Cents per Lb.
Copper, electrolytic	19.00
Aluminum, 98 to 99 per cent	33.00
Antimony, wholesale lots	11.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	60.00
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	8.37½
Zinc, spot, New York	9.50
Zinc, spot, E. St. Louis	9.22½
Silver (Dollars per oz.)	1.32¼

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	30.50

RARER METALS

Cadmium	lb.	$1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	85.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap	23½@24½
Aluminum, sheet scrap	22½@23½
Aluminum clippings	25½@27
Copper, heavy machinery comp	14½@14¾
Copper, heavy and wire	13½@14
Copper, light and bottoms	12½@12¾
Copper, heavy cut and crucible	15½@16
Brass, heavy	7¼@ 8¼
Brass, casting	10¼@10¾
Brass, light	5¼@ 6¼
No. 1 clean brass turnings	8¼@ 8¾
No. 1 comp. turnings	12 @12½
Lead, tea	5¼@ 5½
Lead, heavy	6½@ 7
Zinc, scrap	4½@ 4¾

Chemical and Allied Industrial Markets

New York, February 20, 1920.

Advancing prices among the heavy chemicals due to a low supply in some lines is the report of the week. Delivery on contracts has been held up by the recent storm, which, added to the car shortage, has caused considerable anxiety among the trade. Exporting has fallen off slightly owing to the abnormal rate of exchange and the great difficulty of obtaining shipments.

General Chemicals

Barium chloride has been active, with very little material to be found on the spot market. Quotations as high as $140@$150 per ton are reported, but the average price varied from $90@$110 per ton. A sudden stop in supplies has caused a jump in *bichromate of soda* to 33c. per lb. Producers ran short of coal, which, combined with the crippling of transportation, left the market empty. The price quoted on this item last week was from 21@23c. per lb. Exporting of *caustic soda* has been affected by the rate of exchange, and until this situation is relieved conditions will remain unsettled. Sales have been reported at $4.60 per cwt., while the prevailing price seems to be around $4.50 per cwt. *Soda ash* has also felt the drop in the money market, but producers are so completely sold out that this will hardly lessen the pressure. The average quotation on domestic light is about $2.25 per cwt., while $2.35 is the listing for foreign. *Formaldehyde* is practically unobtainable. The quotation of 52@55c. per lb. is the average for what small lots are changing hands. The increasing shortage on *bleaching powder* has advanced the price to $3.50 per cwt., while $4@$4.50 is being asked for small quantities on spot. The scarcity in the *ammonia* products has held this branch of the market firm, with very few shipments reported during the week.

Coal-Tar Products

This market remains practically unchanged. Large producers are withdrawing a number of items from their list of products due to the inability to meet the demand. Lack of raw materials and disadvantage of small plant facilities are accountable for this situation. Many firms are completely sold out and are having difficulty meeting contracts. The recent transportation tie-up has also affected this industry seriously. *Dimethylaniline* is the center of this group. Small quantities are to be had, but the report from producers is that they are all sold out. The average quotation is around $1 per lb., while $1.20 has been reported on some sales. *Phthalic anhydride* remains quiet at quotations varying from 50@80c. per lb. One large producer who has been out of the market for some time past is working on a process to produce a better grade than average market material at a cheaper price.

Naval Stores

Another drop in all grades of *rosin* has been caused by the falling off of export inquiry. The rate of exchange is directly accountable for this situation, and it is the opinion of many that the market will continue dull until more

favorable conditions arise. *Spirits of turpentine* is easier at $1.93@$1.95 per gal., with plenty of material on the domestic market.

Crude Rubber

The steady drop in this market has tempted buyers to invest for more than their present needs and as it seems they are waiting for more stable conditions. This field is probably feeling the drop in sterling more than any other market. *Para, up-river fine,* is quoted at 44c. per lb., while *caucho ball* is listed at 33½c. per lb. *First latex crepe* dropped to 48c. and *amber crepe* No. 1 is going at 45c. per lb.

The Iron and Steel Market

Pittsburgh, Pa., February 19, 1920.

Indications have increased that if the steel industry is able to operate at a fairly full rate and is able to ship its products there will be no acute scarcity of steel. There has been much opinion expressed in the past few weeks contrary to this view. Some of it has been expressed chiefly for the purpose of furnishing an argument for advancing selling prices of steel products. Buyers of steel have been equally responsible for views that there would not be enough steel to meet all requirements, since they have been free in the bidding of premium prices for early deliveries.

It is a very favorable circumstance that despite car shortages, affecting steel production in various ways, and despite predictions that there would be a short supply of labor for several months, with inefficiency, the production of steel has increased steadily, until it is now at a rate of nearly 90 per cent of capacity.

Coke Production Increasing

There has been no material change in the car supply in the Connellsville coke region for several weeks, the production having been practically uniform since the week ended Dec. 27, which was one of light production, on account of the holiday. Coke production at byproduct ovens, on the other hand, has increased rather steadily, as better coal supplies have been received, and this week further improvement is reported in this respect. Byproduct coke production is not yet up to normal at all points, but it is at a much better rate than one month or two months ago, and several individual plants are reported as being in full operation, with all ovens on and at normal coking time.

Shipping Finished Product

At nearly all steel mills car supplies for shipping finished product have proved more or less inadequate. Traffic managers have been very busy endeavoring to secure additional cars, and have had considerable success, though such success is never permanent, involving merely an additional supply of cars for a time, not a permanent increase in the trade. The quantity of finished steel lying at mills and awaiting shipment is very large, but has hardly increased in the aggregate in the past week or two. There has been little if any actual curtailment in steel production owing to finished material backing up against the rolls, a development that was feared and one that is not for a certainty forestalled even now. By as much as the supply of steel in the hands of jobbers and manufacturing consumers has been curtailed by the failure of steel produced to move to destination, by so much will there be extra supplies when the steel eventually is shipped.

Higher Steel Prices

The United States Steel Corporation continues to adhere to the March 21 or Industrial Board prices, and accordingly its entire product is taken up by regular customers so that there is no material left to offer to the customers of other mills, or to chance buyers. Among the independents, two large interests have committed themselves to the policy of taking care of regular customers at prices, except in the case of wire products, approximately equal to those ruling before the March 21 reductions, but one at least of these independents is quite ready to charge casual buyers, not regular customers, much higher prices when the buyer is willing to pay such prices, for early delivery. Among other mills various policies are pursued, the more common one being to stay almost entirely out of the market. Thus, while it is very hard to buy steel, there is also a condition of many of the mills not being sold far ahead by any means.

No Definite Price List

There is no definite list of prices now representing the steel market, as forward deliveries are unusual, and prompt deliveries vary in price according to time of delivery and tonnage. Prices on the whole are higher than a week or two ago, and the market in general seems to be in process of a runaway. Plates for anything like early delivery are now 3.75@4c. Bars are 3.50@4c. Dealers in oil well supplies have bid 3.50c. freely for "augur stems," representing a particularly economical form of steel bar to roll.

Sheets are selling at a very wide range of prices. While a chance buyer could not secure any black sheets at 4.50c., there has been some business done by mills with regular customers at this figure, $3 a ton above the March 21 price. More tonnage is moving at 4.65c. and still more at 5c., while small lots are bringing 6c., 6.50c. and 7c. In all cases the lower priced sales are to regular customers of the mills, while the highest priced transactions are with jobbers or speculators who have an opportunity to turn the material over at a profit. Blue annealed sheets have sold at 4.50c. in a moderate way, the March 21 price being 3.55c., while sales of some volume have been made at 5c. and even at 5.50c. Galvanized sheets are selling similarly at 6@8c., the March 21 price being 5.70c.

Wire nails for early delivery and regular mill lots are fairly well established at $4.25 per keg, base. The March 21 price, still adhered to by the American Steel & Wire Co., was $3.25, while the war control price was $3.50.

Pig Iron

The pig iron markets have continued to move upward, there being urgent buying pressure on the part of a few consumers, while producers have been very reserved about selling. In the past few weeks there has been practically nothing but second half iron to sell, and as furnaces regarded sales for that delivery as "backlog business" they have been indisposed to sell more than, say, one-third of their product at the opening prices. In the past two or three days there have been some signs of there being less buying pressure, and in some quarters, even among producers, predictions are now being made that present prices will be found to represent the top level on this movement. Seeing that they are far above the war-time prices and are more than two and one-half times the 10-yr. pre-war average of pig-iron prices, predictions that the advance has stopped cannot be regarded as wholly unreasonable. It is a fact well attested in history that all price advances have stopped at one time or another.

The valley market now stands at $42 for bessemer, $43 for basic and $42 for foundry. Basic had trailed far behind foundry, but took a sudden spurt last week. The Philadelphia market stands at $46.35, delivered, for No. 2X, Buffalo being $44.25 for No. 2X. Cleveland is about $42 for foundry iron, and Chicago $43. The Birmingham market remains at $40, with offerings rather light at the figure.

Ferro-Alloys

Domestic makers of ferromanganese seem to be well sold up for the half year, while for the second half they are selling only in a limited way at their recently advanced price of $160, delivered, for 76 to 80 per cent alloy. English is quoted at $150 c.i.f. Spiegeleisen is quoted at $56 to $57, furnace, for 19 to 21 per cent.

Electrolytic ferrosilicon is quiet at $80 for 50 per cent and $140 for 75 per cent, delivered Pittsburgh, valleys and Cleveland. Bessemer ferrosilicon is quoted at $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent f.o.b. Jackson, Ohio.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0 16 – $0 20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2 75 – 3 00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5 25 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	.....	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09½
Oxalic, crystals	lb.	.35 – .40	.40 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	.....
Sulphuric, 60 deg., drums	ton	.....	.....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	.....
Sulphuric, 66 deg., drums	ton	.....	.....
Sulphuric, 66 deg., carboys	ton	.....	.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P	lb.	.....	1.35 – 1.45
Tannic (tech.)	lb.	.....	.42 – .55
Tartaric, crystals	lb.	.....	.69 – .74
Tungstic, per lb. of WO	lb.	.....	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	.....	.65 – .78
*Alcohol, denatured, 190 proof	gal.	.....	.67 – .74
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¼ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.14 – .15	.16 – .17½
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	.....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	.....	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	.....
Barium chloride	ton	85.00 – 95.00	100.00 – 110.00
Barium dioxide (peroxide)	lb.	.26 – .27	.28 – .30
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.03½ – .04
Bleaching powder (see calcium hypochlorite)		.....	.....
Blue vitriol (see copper sulphate)		.....	.....
Borax (see sodium borate)		.....	.....
Brimstone (see sulphur, roll)		.....	.....
Bromine	lb.	.90 – .95	.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	.....	.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	..... – 3.50	4.00 – 4.50
Calcium peroxide	lb.	.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	.....	.75 – .80
Calcium sulphate, pure	lb.	.....	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	.....	.75 – 1.00
Caustic potash (see potassium hydroxide)		.....	.....
Caustic soda (see sodium hydroxide)		.....	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	.....	1.50 – 1.55
Copperas (see iron sulphate)		.....	.....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	.....	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		.....	.....
Epsom salt (see magnesium sulphate)		.....	3.00 – 3.25
Formaldehyde, 40 per cent	lb.	.....	.45 – .55
Glauber's salt (see sodium sulphate)		.....	.....
Glycerine	lb.	.....	.24½ – .26
Iodine, resublimed	lb.	.....	4.10 – 4.30
Iron oxide, red	lb.	.....	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	.....	.13 – .17
Lead nitrate, crystals	lb.	.....	.70 – .80
Litharge	lb.	.....	.09½ – .10½
Lithium carbonate	lb.	.....	1.50 – .....
Magnesium carbonate, technical	lb.	.....	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.00
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.12½ – .13	.17 – .....
Phosgene (see carbonyl chloride)		.....	.....
Phosphorus, red	lb.	.....	.60 – .65
Phosphorus, yellow	lb.	.....	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .37
Potassium bitartrate (cream of Tartar)	lb.	.....	.56 – .60
Potassium bromide, granular	lb.	.....	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .42
Potassium iodide	lb.	.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	.....	$0.65 – $0.95

*Nominal quotations.

		Carlots	Less Carlots
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1 20
Potassium prussiate, yellow	lb.	.....	.40 – .70
Potassium sulphate	ton	$225.00 –	.....
Rochelle salts (see sodium potas. tartrate)		.....	.....
Salammoniac (see ammonium chloride)		.....	.....
Sal soda (see sodium carbonate)		.....	.....
Salt cake (sodium sulphate)	ton	18.00 – 21.00	.....
Silver cyanide	oz.	.....	1.25 – .....
Silver nitrate	oz.	.....	.81½ – .82½
Soda ash, light	100 lb.	2.15 – 2.25	2 30
Soda ash, dense	100 lb.	2.25 – 2.50	2.50 – 2.75
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2 75 – 3.00
Sodium bichromate	lb.	.33 – .34	35 – .36
Sodium bisulphate (nitre cake)	cwt.	6.00 – 7 00	8 00 – 10.00
Sodium bisulphite	ton	7.00 – 8.00	8 50 – 9.00
Sodium borate (borax)	lb.	.08½ – .08¾	..... – .09
Sodium carbonate (sal soda)	100 lb.	1.40 – 1.55	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..... –	4.35 – 4.60
Sodium hyposulphite	lb.	..... –	.03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.11½ – .12½	.13 – .15
Zinc oxide, dry American	lb.	..... –	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.34 —	.42
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.05 —	1.25
Benzidine, sulphate	lb.	.90 —	1.00
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.55
Beta naphthol, sublimed	lb.	.65 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.85 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.80 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.70 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline	lb.	.95 —	1.20
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine	lb.	.55 —	.65
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.12 —	.18
Paranitrani'ine	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.15 —	3.00
Paratoluidine	lb.	1.75 —	2.50
Phthalic anhydride	lb.	.60 —	.80
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.43 —	.45
Salicylic acid, U. S. P.	lb.	.55 —	.60
Salol	lb.	.90 —	.95

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.22	—	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	—	$0.45
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1	lb.	.80	—	.88
Carnauba, No. 2, regular	lb.	.65	—	.78
Carnauba, No. 3, North Country	lb.	.46	—	.48
Japan	lb.	.18½	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.07½
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.10¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.09¼	—	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	.....	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.....	—	.14
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.45	—	$18.50
Rosin E-I	280 lb.	17.50	—	18.75
Rosin K-N	280 lb.	18.50	—	21.50
Rosin W. G.-W. W.	280 lb.	20 75	—	24.25
Wood rosin, bbl.	280 lb.	16.25	—	17.50
Spirits of turpentine	gal.	.....	—	1.94
Wood turpentine, steam dist.	gal.	.....	—	1.93
Wood turpentine, dest. dist.	gal.	.....	—	1.85
Pine tar pitch, bbl.	200 lb.	8.25	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.75
Retort tar, bbl.	500 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.93	—	.95
Rosin oil, second run	gal.	.95	—	.97
Rosin oil, third run	gal.	1.10	—	1.15
Rosin oil, fourth run	gal.	.....	—	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.44	—	$0.46
Upriver coarse	lb.	.33	—	.35
Upriver caucho ball	lb.	.33½	—	.34½
Plantation—First latex crepe	lb.	.48	—	.49
Ribbed smoked sheets	lb.	.47	—	.48
Brown crepe, thin, clean	lb.	.42	—	.43
Amber crepe No. 1	lb.	.45	—	....

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18	—	$0.19
Castor oil, AA, in bbls.	lb.	.21	—	.23
China wood oil, in bbls.	lb.	.24¾	—	.25¼
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½	—	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½	—	.23
Corn oil, crude, in bbls.	lb.	.19	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.19	—	.20
Cottonseed oil, summer yellow	lb.	.22	—	.27
Cottonseed oil, winter yellow	lb.	.24½	—	.25½
Linseed oil, raw, car lots	gal.	1.77	—	1.87
Linseed oil, raw, tank cars	gal.	1.70	—	1.80
Linseed oil, boiled, car lots	gal.	1.75	—	1.80
Olive oil, commercial	gal.	3.00	—	3.10
Palm, Lagos	lb.	.16½	—	.16½
Palm, bright red	lb.	.16½	—	.17½
Palm, Niger	lb.	.16	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.23½	—	.24
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal.	1.45	—	1.68
Rapeseed oil, blown, in bbls.	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19	—	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.17½	—	.20

FISH

Winter pressed Menhaden	gal.	$1.20	—	....
Yellow bleached Menhaden	gal.	1.23	—	....
White bleached Menhaden	gal.	1.25	—	....
Blown Menhaden	gal.	1.26	—	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.04	—	.05
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00	—	52.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	.07½
Graphite, crucible, 86% carbon content	lb.	.....	—	.07½
Graphite, crucible, 87% carbon content	lb.	.....	—	.07¾
Graphite, crucible, 88% carbon content	lb.	.....	—	.08
Graphite, crucible, 89% carbon content	lb.	.....	—	.08¼
Graphite, crucible, 90% carbon content	lb.	.....	—	.08½
Graphite, crucible, 91% carbon content	lb.	.....	—	.08¾
Graphite, crucible, 92% carbon content	lb.	.....	—	.09
Graphite, crucible, plus 92%	lb.	.....	—	.12
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, orange, fine	lb.	.....	—	....
Shellac, orange, superfine	lb.	1.70	—	1.75
Shellac, A. C. garnet	lb.	nominal		
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.50
Ferro-manganese, 70-80% Mn	gross ton	155.00	—	165.00
Spiegeleisen, 16-20% Mn	gross ton	50.00	—	60.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00	—	3.50
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	1.25	—	1.40
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60	—	$0.85
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	7.50
*Coke, furnace, .o.b. ovens	net ton	6.00	—	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	.....	—	25.00
Manganese ore, 45% Mn and over	unit	.50	—	.75
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	.....
Rutile, 95% TiO_2	lb.	.11	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

LOS ANGELES—The Los Angeles Soap Co., 633 East 1st St., has awarded the contract for the construction of a 1-story, 45x125-ft. factory at 1st and Banning Sts., to the Davidson Constr. Co., 1445 East 16th St., at $23,800.

Idaho

MALAD—The Town Council will soon award the contract for furnishing labor and material for the construction of 2,800 ft. 18-in. vitrified tile and 2,300 ft. open canal sewer in Dist. 1. A 30x50-ft. septic tank will be included in the project. J. H. Giles, engr.

Illinois

CHICAGO—The Acme Steel Goods Co., 2834 Archer Ave., has awarded the contract for the construction of a 1-story, 150x600-ft. building to house twenty 10-in. cold roll mills and corresponding ovens, etc., adjoining its present plant at Riverdale, to R. F. Wilson & Co., 1851 Elston Ave.

CHICAGO—The Concrete Steel Co., 53 West Jackson St., has awarded the contract for the construction of a 1-story, 80x100-ft. factory at Central Park Ave. and 31st St., to James Shedden & Co., 106 North La Salle St. Estimated cost, $25,000.

MOLINE—Williams, White & Co., 3rd Ave. and 8th St., plans to build a 1-story, 110x325-ft. foundry on 43rd St., between 3rd and 4th Aves. C. A. Hardy Co., Ry. Exch. Bldg., Chicago, engr.

Indiana

HAMMOND—The La Salle Steel Co., 2243 South Halsted St., has purchased a site on the North Side and plans to build a steel fabricating plant, consisting of 3 buildings, on same. Estimated cost, $1,000,000.

INDIANAPOLIS—The Acme Aluminum & Brass Wks., 420 South Harding St., is having plans prepared for the construction of factory. Estimated cost, $70,000.

INDIANAPOLIS — The Van Briggle Chemical Co., 16th St. and Capital Ave., will receive bids about March 1 for the construction of a chemical manufacturing plant. Estimated cost, $125,000. Charles E. Bacon, 1110 Odd Fellows' Bldg., archt.

Iowa

STANTON—The city will receive bids until March 4 for the construction of sewers and a disposal plant. Estimated cost, $60,000. Theodore S. DeLay, Creston, engr.

Louisiana

NEW ORLEANS—The Go-Ro Co., 826 Barrone St., plans to build a factory and is in the market for a Joet Ram squeeze molding machine, milling machines, screw milling and Fox monitor, cupola, tumbling mills, sand blast machine, core oven, etc. Estimated cost, $150,000.

Michigan

GRAND RAPIDS—The Toledo Plate & Window Glass Co., 19 Ottawa Ave., has awarded the contract for the construction of a 2-story, 123x130-ft. factory, including warehouse and office building, to C. Hoertz & Sons, 659 Bridge St. Estimated cost, $95,000.

NORTHVILLE—C. Freiburger, secy., Bd. of Health, 233 St. Antoine St., Detroit, will receive bids until March 1 for the construction of a 2-story, 28x36-ft. laboratory, in connection with the group of buildings to be constructed at the proposed Detroit Municipal Tuberculosis Sanitarium. Laboratory equipment will be installed in same. Stratton & Snyder, 1103 Union Trust Bldg., Detroit, archts.

Missouri

KANSAS CITY—The Cleveland Steel Barrel Co., 9612 Meech Ave., Cleveland, plans to build an 80x290-ft. factory at Southwest Blvd. and Hill St. This will be the first unit of a Western plant.

New Jersey

TRENTON—The Joseph Stokes Rubber Co., Taylor St., has awarded the contract for the construction of a 2-story, 70x100-ft. rubber factory, to N. A. K. Bugbee Co., 206 East Hanover St. Estimated cost, $35,000.

TRENTON—The Mercer Motor Co., Whitehead Rd., has awarded the contract for the construction of a 2-story, 40x73-ft. office building and a 1-story, 80x400-ft. paint shop, to the Standard Constr. Co., 1713 Sansom St., Philadelphia. Estimated cost, $200,000. Noted Jan. 28.

New York

BATAVIA—The city has revised plans prepared by A. Clark, city engr., for the installation of a gravity sewage disposal system to replace present pumping system. Estimated cost, $200,000.

ELMIRA—The General Electric Co., Hulett Bldg., has awarded the contract for the construction of a 1-story, 110x560-ft. foundry, to H. K. Ferguson Co., 6532 Euclid Ave., Cleveland. Estimated cost, $300,000.

NIAGARA FALLS—The Kimberly & Clark Co., Neenah, Wis., will receive bids for the construction of a paper mill on Royal Ave. Estimated cost between $175,000 and $200,000.

ROCHESTER—The New York Sewer Pipe Co., 545 Oak St., plans to rebuild the 5-story building which was recently destroyed by fire, entailing a loss from $40,000 to $50,000.

ROCHESTER—Sargent & Greenleaf Co., Court St., manufacturer of locks, plans to construct a 1-story, 185x214-ft. factory, 2-story, 40x214-ft. office building and a 1-story, 40x128-ft. brass foundry and power house on Norton St. The company is in the market for foundry equipment.

SYRACUSE—The Oberdorfer Brass Co., Water St., plans to build a 1-story, 280x440-ft. auto castings factory at Messina Springs. Estimated cost, $350,000. M. L. King, Snow Bldg., engr.

TUCKAHOE—The Hodsman Rubber Co. will soon award the contract for the construction of a 5-story, 60x150-ft. factory addition. Estimated cost, $200,000. W. L. Stoddart, 9 East 40th St., New York City, archt. and engr.

North Dakota

COOPERSTOWN—The city plans to construct a complete sewerage system, including a disposal plant, etc. Cost to exceed $25,000. Dakota Eng. & Constr. Co., Valley City, engr.

MAYVILLE—The city voted $10,000 bonds for the installation of a water-softening plant. T. R. Atkinson, Bismarck, engr.

Ohio

CLEVELAND—The Amer. Stove Co., 4700 Perkins Ave., has awarded the contract for the construction of a 2-story, 233x265-ft. enameling plant at 4100 Hough Ave., to the Boldt Constr. Co., 6110 Euclid Ave. Estimated cost, $150,000.

CLEVELAND—The Buckeye Brass Co., 6410 Hawthorne Ave., will receive bids until March 1 for the construction of a 1-story, 30x110-ft. foundry and a 75x75-ft. furnace room on Ashland Rd. Estimated cost, $60,000. N. W. Carl, secy. Allen Sogg, 319 Hippodrome Bldg., archt.

CLEVELAND—The Ohio Fibre Container Co., 209 Williamson Bldg., plans to build 2-story factory additions at East 103rd St. and Harvard Ave. Estimated cost, $75,000. D. Jones, secy.

CLEVELAND—The Otis Steel Co., Leader-News Bldg., has awarded the contract for the construction of five steel mill buildings, to be 2-story, 75x400-ft., 1-story, 90x400-ft., 1-story, 40x400-ft., and 1-story, 80x400-ft., on Jennings Rd. to the Amer. Bridge Co., 30 Church St., New York City. Estimated cost, $500,000.

CLEVELAND—The Perfection Rubber Co., 2097 Columbus Rd., is having plans prepared for the construction of a 2-story, 100x110-ft. factory building on Brook Park Rd. Estimated cost, $60,000. L. J. Johnson, vice pres.

CLEVELAND—The United States Gypsum Co., 1714 Merwin Ave., plans to rebuild the 2-story factory which was recently destroyed by fire. Estimated cost, $100,000. P. A. Ryder, supt.

GRAFTON—The village will receive bids about April 15 for the construction of a sewerage system and a sewage disposal plant, including two sedimentation tanks. Estimated cost, $30,000. R. Winthrop Pratt, Hippodrome Bldg., Cleveland, engr.

Oklahoma

OKEMAH—The town is having plans prepared for the construction of an entire new plant, including a disposal plant. Estimated cost, $90,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, engr.

Pennsylvania

LOCK HAVEN—The Castanea Paper Co. has awarded the contract for the construction of a paper mill, including a 2-story, 425x515-ft. mill, 1-story, 60x150-ft. storehouse, and a series of clay bins, to the Turner Constr. Co., 244 Madison Ave., New York City. Estimated cost, $1,250,000.

PLAINS—The city plans to construct a sewerage system, including a sewage disposal plant. Estimated cost, $400,000.

WILKES-BARRE—The Sheldon Axle Co., 221 Conyngham Ave., plans to build a 3-story, 100x200-ft. heat treating plant on Beaumont St. Estimated cost, $200,000.

Texas

BROWNWOOD—The city plans to construct a sewerage system and a sewage disposal plant, on the South Side of the city. This plant will be another unit to the present system. Estimated cost, $50,000. E. R. Brashear, city mgr.

HOUSTON—The Lone Star Steel & Bridge Co., 214 Carter Bldg., will soon have plans prepared for the construction of a fabricating plant, having a 1,000-ton capacity per month, on Harrisburg Blvd. and the Municipal R.R. tracks. G. E. Cole, pres.

Washington

VANCOUVER — The Columbia Dairy Products Co. plans to build a 2-story, 40x80-ft. dairy plant. Pasteurizing and condensing equipment will be installed in same. Estimated cost, $45,000.

West Virginia

ELKINS—The city plans to construct a pumping station and filtration plant. Estimated cost, $130,000.

Wisconsin

KILBOURN—A. Luettgerodt, city clk., will receive bids until March 10 for the construction of a sewerage system, including a 12x15-ft. septic tank. Estimated cost, $18,000 to $20,000. Parsons & Orbert, 627 M. & M. Book Bldg., Milwaukee, engrs.

MANITOWOC—The Wisconsin Aluminum Products Co., c/o B. Dalwig, mgr., 16th and Franklin Sts., plans to build a 4-story, 60x250-ft. aluminum products factory on 8th St. Estimated cost $250,000.

MILWAUKEE—The Milwaukee Rolling Mill Co. has awarded the contract for the construction of a 1-story, 380x425-ft. steel rolling mill, to the Northwestern Bridge & Iron Co., 32nd and Hopkins Sts. Annealing ovens and oven equipment will be installed in same. Estimated cost, $400,000.

MILWAUKEE—The Pelton Steel Co., 672 Kinnickinnic Ave., has awarded the contract for the construction of a 1-story, 60x100-ft. foundry addition, to Yunker Bros., 615 37th Ave. Estimated cost, $50,000. Noted Feb. 4.

SHEBOYGAN—The Armour Leather Co., 175 North Franklin St., Chicago, has awarded the contract for the construction of a tannery, here, to Westinghouse, Church, Kerr & Co., Inc., 37 Wall St., New York City. Estimated cost, $750,000.

SOUTH WILWAUKEE (Milwaukee P. O.)—C. P. Nourse, c/o Stowell Co., is in the market for plating machinery and japaning ovens.

Ontario

BRANTFORD—The Blue Bird Co. is in the market for acetylene welding equipment, etc.

GALT—The Galt Brass Co. will construct a 58x138-ft. foundry and a 40x90-ft. extension to its vitriol plant.

KITCHENER—The Kitchener-Waterloo Collegiate Bd. is having plans prepared for the construction of a 3-story collegiate institute. Chemical and physical laboratory supplies will be installed in same. Estimated cost, $500,000. S. B. Coon & Son, 810 Excelsior Life Bldg., Toronto, archts.

OTTAWA—The Bd. of Control will receive bids in the spring for the construction of laboratories and a press building on the exhibition grounds. Estimated cost, $50,000. A. F. Macallum, City Hall, engr.

OTTAWA—The Council of the County of Carleton will receive bids in the spring for furnishing one oil distributor with heater, etc., for the Highway Dept. Patterson & Byrne, 7½ Sparks St., engrs.

Quebec

BAY DE CHALEUR—Arthur Sande, consult. engr., Lister Bldg., Hamilton, Ont., will soon award the contract for the construction of a 200-ton sulphite pulp mill, here.

LACHINE—A. Laframboise, engr., City Hall, is preparing plans for the construction of a filtration plant, etc., for the city. Estimated cost, $300,000.

THREE RIVERS—The Wayagamack Pulp & Paper Co. is building a pulp mill, here. Estimated cost, $3,000,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CANADIAN MINING INSTITUTE will hold its annual meeting at the King Edward Hotel, Toronto, March 8 to 10.

THE FARADAY SOCIETY (London) will hold a joint meeting, March 1, with the London Section of the Society of Chemical Industry to receive and discuss a report of Dr. T. Martin Lowry, and E. C. Hemmings on the "Setting of Salts and Other Crystalline Substances." Another meeting will be held March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MATERIAL HANDLING MACHINERY MANUFACTORERS' ASSOCIATION will hold its convention at the Waldorf-Astoria Hotel, New York City, Feb. 26 and 27.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE TRUSCON STEEL CO. has opened a branch sales office in El Paso, Tex., and is carrying a stock of $100,000 in plates and girder connection. W. A. E. Wood is the local manager.

THE UNITED STATES RUBBER CO. has acquired the plant and business of the Dolgeville Felt Shoe Co., Dolgeville, N. Y. The present management will be continued.

THE MINE & SMELTER SUPPLY CO., Denver, Col., announces that W. A. Leddell has been appointed manager of its engineering department, with headquarters in Denver. Problems relating to Marcy mills, Wilfley tables and other Massco specialties and the preparation of flow sheets and specifications will come under the supervision of Mr. Leddell's department.

THE HAUCK MFG. CO., Brooklyn, N. Y., manufacturer of oil burners, has recently made some changes in the location of its burner service stations, for the purpose of improving its facilities for service and demonstration. The Pittsburgh station has been moved from 2930 Penn Ave. to 105 Wood Street; the Boston station from 70 Hight St. to 149 Berkeley St., cor. Columbus Ave.; the Cleveland station from 2114 Superior Viaduct to 1106 Walnut Ave.

JOHN JOHNSON CO., Brooklyn, N. Y., manufacturer of filter presses, announces that it has acquired the services of Colonel M. E. Brewster-Green, who has recently returned from two years' staff duty in France and Italy. Colonel Green was formerly assistant advertising manager for the Locomobile Co. of America.

THE ELECTROLABS CO., New York, announces the consolidation of all offices at 2635 Penn Ave., Pittsburgh, Pa. A branch office is maintained at 30 Church St., New York City.

HUMMEL & ROBINSON, New York, advises that arrangements have been made with W. R. Sturges to act as its representative and agent for the Southern territory for the sale of dry colors and chemicals. Mr. Sturges was formerly with Reichard-Coulston, Inc., New York.

BUTTERWORTH-JUDSON CORP., New York, announces the following appointments: Fred E. Signer, general sales manager, vice W. H. Clark, resigned; E. A. MacKinnon, assistant sales manager; J. D. Lowery, assistant sales manager, and George E. Green, traffic manager.

THE BOOTH ELECTRIC FURNACE CO. has opened a Detroit office in charge of M. A. Beltaire, Jr., with headquarters at 805 Hammond Bldg. and an office in Birmingham, Ala., in charge of Gassman & Cunningham, in the Brown & Marx Bldg.

THE PHOENIX IRON WORKS CO., Meadville, Pa., announces the appointment of K. B. Thorndike as sales engineer, in charge of its New York office, Fifth Ave. Bldg.; also the opening of a Boston office in the Old South Bldg., with Paul C. Rodgers, district sales manager, in charge. These changes are in line with the policy of this company, in order to make its branch offices of service to its customers not only as sales offices but also from an engineering standpoint.

THE CHICAGO PNEUMATIC TOOL CO. on Jan. 21 and 22 held a general conference of executives, plant and branch managers and salesmen at its Detroit plant, on the occasion of the formal opening of a large five-story addition.

THE MANSFIELD CLAY PRODUCTS CO., Mansfield, Ohio, has changed its name to the Mansfield Shale Products Co., the change being deemed advisable inasmuch as the operations of the company are confined chiefly to shale.

THE AMERICAN METALLURGICAL CORP., Philadelphia, Pa., at the annual stockholders' and directors' meeting elected the following officers and directors for the coming year: F. J. Ryan, president; S. R. Vanderbeck, vice-president; W. L. Taylor, treasurer; J. L. Hawley, assistant treasurer, and S. H. Ourbacker, secretary.

THE BURRELL TECHNICAL SUPPLY CO., INC., Pittsburgh, Pa., has been organized to conduct a general laboratory and technical supply business. A catalog devoted entirely to apparatus for gas analysis will soon be off the press. The officers of the company are Colonel G. A. Burrell, president; J. T. Ryan, vice-president; G. H. Deike, treasurer, and G. C. Nelms, secretary.

"THE NURSE IN INDUSTRY" is the title of a pamphlet published by the National Organization for Public Health Nursing, 156 5th Ave., New York City. Copies will be sent on request to those who are interested in the work of industrial nurses.

THE STEEL BARREL MANUFACTURERS ASSOCIATION held its annual meeting in Chicago in December. The activities of the Association during 1919 included efforts to standardize the different types of steel barrels and drums as well as size of threads and character of flanges and plugs. The committee having this in charge cooperated with the Bureau of Explosives and recommendations have been made for strengthening the I. C. C. specifications. The committee on minimum weights and various styles of packages did considerable work to protect the buyer from unscrupulous manufacturers. Other committees reported on publicity, legislation, railroad rates, and cost-accounting systems. The officers elected for the ensuing year were: G. A. Moore of the Detroit Range Boiler & Steel Barrel Co., president; Mr. Kinney of the Metal Barrel Corp., vice-president, and D. S. Hunter, secretary-treasurer.

THE JOSEPH BROWN CO., of Woonsocket, R. I., has been organized to manufacture chemicals, etc. The capital stock of the company is $100,000, and the incorporators are as follows: Joseph Brown, Arthur H. Heen and Arthur B. Martel, all of Woonsocket, R. I. All are experienced in the line of chemical goods, and business will be engaged in shortly. All communications should be addressed to Joseph Brown, care of Joseph Brown Co., Woonsocket, R. I.

New Publications

WAR INDUSTRIES BOARD Bull. 34. "Prices of Ferro-Alloys, Non-ferrous and Rare Metals," by H. R. Aldrich and Jacob Schmuckler.

GLUE USED IN AIRPLANE PARTS, Report No. 66, issued by the National Advisory Committee for Aëronautics, Washington, D. C.

THE ELECTRIC FURNACE is the title of a 16-page magazine published by the Electric Furnace Co., Alliance, Ohio. Vol. 1, No. 1, is dated January, 1920, and is to be succeeded by monthly issues.

THE NATIONAL RESEARCH COUNCIL of the National Academy of Sciences, Washington, D. C., has started the *Bulletin* of the National Research Council, which is to appear at irregular intervals. Vol. 1, Part 1, No. 1, dated October, 1919, has appeared. In this issue the national importance of scientific and industrial research is discussed by George E. Hale, Elihu Root, Henry S. Pritchett, Theodore N. Vail, Ambrose Swasey, A. W. Mellon, George Eastman, Walter Douglas, James R. MacColl and H. W. Howe.

THE REPORT ON PROPAGATION OF FLAME IN PIPES AND EFFECTIVENESS OF ARRESTORS, which is Special Investigation Series No. 528, dated Oct. 1, 1919, has been issued by the Underwriters Laboratories, Chicago, Ill.

METALLURGICAL PATENTS OWNED BY THE CHEMICAL FOUNDATION, INC., 81 Fulton St., New York City. This pamphlet contains abstracts of patents seized by the Alien Property Custodian and sold to the Chemical Foundation. Copies of the patents are available for examination at the office of the Chemical Foundation, Inc.

VAT DYE PATENTS OWNED BY THE CHEMICAL FOUNDATION, INC., 81 Fulton St., New York City. This pamphlet contains abstracts of patents seized by the Alien Property Custodian and sold to the Chemical Foundation. Copies of the patents are available for examination at the office of the Chemical Foundation, Inc.

Manufacturers' Catalogs

THE OXYGEN GAS CO., Kansas City, Mo., has issued pamphlets on "Oxygen and Hydrogen Gases," with particular reference to the use of hydrogen for oil hardening, and on the "Advantages of Nitrous Oxid-Oxygen as an Anesthetic."

THE BLAW-KNOX CO., Pittsburgh, Pa., has recently issued a new Blawforms folder, illustrating the application of Blaw steel forms for concrete construction.

VIELE, BLACKWELL & BUCK, New York City, have issued a series of bulletins which should prove of value to companies engaged in foreign trade. The organization maintains an engineering section to design, purchase and conduct all classes of industrial plants and a foreign trade section which handles both for export and import a great variety of raw, semi-finished and finished products, which are listed in Bulletin A. In other bulletins the company has compiled a vast amount of information on ferrous and non-ferrous metal products and heavy chemicals.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

ALAN G. WIKOFF
Assistant Editor
L. W. CHAPMAN
Western Editor
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 22 — New York, March 3, 1920 — *Number* 9

Colonel Fries Heads Chemical Warfare Service

ANNOUNCEMENT is made from Washington that Major-General WILLIAM L. SIBERT, who has been Director of the Chemical Warfare Service, has been relieved of his duties and ordered to Camp Gordon, Ga., to command the Fifth Division. Lieutenant-Colonel AMOS A. FRIES, who was in charge of Chemical Warfare Service overseas during the war, succeeds General SIBERT as Director. Both General SIBERT and Colonel FRIES have been active in support of the proposal to make the Chemical Warfare Service a separate branch of the Army instead of merging it with the Corps of Engineering. Their views have evidently prevailed, because the Army Reorganization Bill now before Congress recognizes the Chemical Warfare Service as a separate entity.

We regret the removal of General SIBERT from the Service, but welcome the appointment of Colonel FRIES as his successor. It is essential at this time to have an intelligent, sympathetic, enthusiastic officer at the head of the Service and Colonel FRIES embodies these qualities in quite as high a degree as did General SIBERT.

If our own wishes had been consulted, there would have been no change, but if it is impossible to have both of these officers in the organization, we are glad that one of them is still available.

Government Appropriation For the Forest Products Laboratory

AN APPROPRIATION has been requested from Congress by representatives of the wood-using industries for the support of the Forest Products Laboratory during the coming year. The Secretary of Agriculture has cut the original amount of $500,000 to $350,000, and the House Committee on Agriculture now further trims this sum.

The institution needs $500,000. The many industrial concerns dependent on its researches demand it. Yet we find Congress, under the guise of saving money, planning to handicap one of the most serviceable of Government establishments. The honorable gentlemen are surely acting without a real knowledge of the functions and scope of activity of the Laboratory. CHEMICAL & METALLURGICAL ENGINEERING outlined the features of this work in the December 24, 1919, issue, and additional data are available in the Government files. The future development of the art is largely dependent on research work at Madison. The legislator who runs must read. There is often a mistaken idea of "the broader view." Economy becomes an obsession and the most worthy cause is ruined through the money-saving mania.

Chemistry, Metallurgy and The Bureau of Standards

APPROPRIATIONS requested for chemical investigations and service to allied industries by the United States Bureau of Standards, meager as they have been in the past, will be still further curtailed if the appropriation bill as submitted to the House of Representatives passes without amendment in the form of increases. Investigation discloses the fact that all appropriations for supplying standard samples of iron and steel, ores, materials for calorimetry and acidimetry have been cut off, and that the appropriation for determining the physical constants of materials is also eliminated. Furthermore, several of the best-paid chemical positions in the Bureau are about to be abolished.

The appropriation for the Bureau of Standards for the fiscal year ending June 30, 1920, is $1,853,260. The requested appropriation for the fiscal year ending June 30, 1921, is $2,986,440. The appropriation carried by the bill now in the House for the next fiscal year is $1,217,360. We are hardly in accord with the idea of increasing at this time the annual appropriation for the Bureau by over one million dollars, but we are certain that last year's appropriation should not be scaled by over 30 per cent as proposed in the House bill.

Is Congress aware of the fact that preparation of standard samples was a money-making activity for the Bureau last year? In the recent report of the Director we note that the actual cash receipts from this work totaled more than $6,000, while only $5,000 was appropriated therefor. Even if this activity had not shown a cash profit, its service to the chemical and metallurgical industries is such that it should not be abandoned.

It is evident that if the industries want technical investigations by the Bureau to continue next year it will be necessary to lay the facts before the House Committee on Ways and Means. In all probability it will be found that the committee merely lacks the necessary information to enable it to appreciate the work which the Bureau is doing. Unless something is done to support this project, the work will be interrupted and the industries will be compelled to try to do for themselves individually those things which are natural functions of our national Bureau of Standards.

During the war no Federal bureau made more fundamental and important contributions to the national welfare than did the Bureau of Standards. Any organization which functioned as vitally as this Bureau at that time should not be handicapped in its normal development and operation, nor crippled in its peace-time industrial service.

Who Knows About Shale Oil?

OIL-SHALE promotion has passed the crest of the first wave. Two years ago, under the enthusiasm of a war-time need of rivers of gasoline to propel subchaser, tank, tractor, truck and airplane, many men convinced themselves and others that the failing supply from available crude could be quickly augmented from the stupendous reserves locked up in oil shale. So patriotic promoters immediately began their double campaign for oil production and thrifty investment with a vim, and made a deal of noise and collected not a few stray dollars, but, needless to say, produced no "gas" of a variety usable in internal combustion engines.

Since most of the stray pigeons were then plucked, it is now more popular to produce evidence of substantial effort toward the recovery of oil when selling stock certificates. Consequently not a few men have swelled the numbers of those already considering seriously ways and means to get oils, gases and fertilizers from shale. While a year ago it might fairly be said that the total production of oil from shale could be loaded on one truck, during the interval some experimental work on a semi-commercial scale has taken place in a few localities with a corresponding gain in knowledge, at least as to what kind of a plant should not be built.

Without desiring to add to the endless discussion as to whether the Scottish shale retorts should be adapted to American problems, whether byproduct coke ovens would be the proper point of departure, or whether some entirely new kind of muffle, roaster or calciner should be designed, it appears not unreasonable to believe that if a resourceful organization with proper financial backing should take more than a passing interest in the problem, a retort quite well suited to recover oil and gas from the particular shale to be treated could be soon devised. This is only a restatement of the opinion already voiced more than once in these columns that the successful utilization of shale will require a generous supply of competent technical and administrative talent.

At the present time, progress toward a solution of the problem is disappointingly slow, probably due to the fact that the resourceful organization has not yet become interested.

We have become accustomed to expect fruitful investigations of little-known natural resources from the Bureau of Mines, but this organization has badly diffused itself. The work begun at Salt Lake City has been halted; the Southern Pacific's retort plant at Elko, Nev., built under supervision of the Bureau's consultant, DAVID T. DAY, has not yet been fired up; a hopeful co-operative plant to be located in western Colorado has not yet materialized; and useful results from the work just initiated at Boulder, Col., cannot be expected for some time.

In the meantime, there is one big factor in the problem which has not been given the attention it deserves. It has been shown already that the oil produced on a small scale from various American shales has quite different characteristics from any of the crude petroleums now on the market. In fact, it is so different that grave doubts are entertained as to whether it can be sold in quantity to existing refineries. Such being the case, any organization intending large-scale production would be well advised to begin by purchasing a considerable quantity of shale oil from one of the plants now operating, and institute a vigorous research at some well-equipped laboratory—such as the Mellon Institute —to determine its composition, its proper treatment, and commercial outlets for various easily procured fractions.

After all is said, the composition of the oil from a given shale bed is not going to be vitally changed by the small changes which are likely to develop in the retorting process—differing proportions in the fractions will be the greatest effect noticed. The Bureau of Mines' work may eventually be expected to give such data as the specific heat of the shale, its conductivity, and the effect of fine grinding, rate of heating and such factors on the yield of oil. These figures will all be available for use in the technical design of retorts, but the oil will still be a big problem after the retorting has been standardized.

It therefore seems to be a wise procedure to study the oil intensively, so that a plant with a sizable output of shale oil may not find itself with a white elephant on its hands.

Professor Haber And the Nobel Prize

THERE has been considerable criticism of the award of the Nobel prize in chemistry to Professor HABER, on account of his activities in chemical warfare in the German army. Before expressing a definite opinion we should like more facts than are available at this writing.

Inquiry from an American physical chemist of the first rank has brought the following reply:

> So far as HABER'S scientific deserts are concerned, his fellow-countryman NERNST is the only physical chemist in the world who hasn't the prize already who deserves it as much as HABER.

We may say right here that if NERNST had received it we should have been ready to express an opinion without hesitation. He belongs to the class of brilliant, able, original men who aided in giving to the German people their present burden of reputation. Another of the same type in the technical world is Professor DUISBERG, who visited America in 1912 and gave an illuminating performance of German offensiveness. Our correspondent continues:

> NERNST was made a Count for his contributions to gas warfare, but their relative merits for the prize do not affect the issue. HABER is a brilliant, forceful, successful investigator who has worked in many branches of physical chemistry and has illuminated every one of them. I cannot recall another text book that has borne such rich fruit as his work on Thermodynamics of Technical Gas Reactions. His special work on the ammonia synthesis is but a single, isolated application of this broader study. He is a pioneer and leader in our science.
>
> Personally I cannot say much at first hand about him. but what little I saw I liked . . . American and English students sought him out in large numbers, and they all liked him very much. Indeed I know of no other German chemist of the period, unless it was LUTHER or ABEGG, whom the Americans seemed to like so well.
>
> So far as his activities in the war are concerned, I know nothing at first hand and have heard nothing authoritative about him. Some say he, others say NERNST, was the originator of gas warfare. It does not seem very likely that HABER began it, for he finished as a Captain. Most people who get in on the ground floor manage to do better.
>
> If with the gas problem already decided upon by the General Staff and under way, the government ordered him to assist and direct such work, he isn't in a very different boat from many of us here. If he did originate

and advocate gas warfare, realizing its terrible potentialities, he deserves the contempt and execration of humanity. And he will get it.

It is hard enough to render judgment on a man even when you know that you know the facts; it is criminal to condemn him when you know that you don't know the facts. One precious heritage of our Anglo-Saxon past is the recognition that a man is innocent until he is proved guilty. Why throw this over when mercy—the safety of the weak—and justice are the very things we have been fighting to preserve?

This seems a fair presentation.

All Germans are not alike, although in war they seem so. A couple of years ago they were united in the most outrageous attack ever known upon the welfare of humanity, and we earnestly hope that they have been sufficiently beaten to know that they must never do so any more.

As individuals, however, they continue to live, and if any of their number deserves credit we should not withhold it from him.

Mr. Sulman's Contribution To the Study of Flotation

IT SHOULD be the unvarying custom of the scientist and the engineer carefully to scrutinize all technical or scientific matters coming before them, and apply to them the analytical methods of scientific research. It behooves the editor of a scientific and technical magazine also consistently to maintain this attitude of mind and practice in his own particular province, and to apply critical scrutiny to the technical papers which come to his notice.

Some months ago H. L. SULMAN presented a long paper before the Institution of Mining and Metallurgy, London, on "A Contribution to the Study of Flotation." The great length of the paper probably has prevented its widespread republication, despite the superficial evidence of its importance. The appearance in print on so elaborate a scale of an article on flotation by Mr. SULMAN after years of silence on his part and evident censorship by his employer, Minerals Separation, Ltd., has been a cause for comment. Elsewhere in this issue we publish an analysis of some of the facts relating to this belated contribution of Mr. SULMAN. One cannot help asking whether the paper now published contains the essential data which its author presumably had prepared for publication many years ago. His statements and those of his critics who discussed the article leave one in a confused state of mind as to the sincerity and reliability of the contribution.

In view of the disclosures by the U. S. Federal Trade Commission of the close commercial relations maintained during the war by Minerals Separation, Ltd., with Beer, Sondheimer & Co., we cannot help suggesting to our brother engineers in London that they should use all proper caution to see that their Institution is not prostituted to the service of corporate greed in the form of the late enemies of the British Empire and of all mankind.

In the interest of science and justice we believe that they should also use their influence to see that the original scientific treatise prepared jointly by Messrs. SULMAN and PICARD shall be published as originally written without the crossing of a "t" or the dotting of an "i."

The scientific world is entitled to this paper, the cause of justice demands its production, and Mr. PICARD is entitled to its publication in a form to which he is willing to subscribe his name as co-author with Mr. SULMAN.

If purely scientific rather than business considerations have changed its authors' conceptions since this work was first written, proper footnotes could convince the public of their scientific disinterestedness.

The Wilson Dam At Muscle Shoals

AN ESSENTIAL part of the project to establish nitrogen fixation plants at Muscle Shoals was the construction of a dam and hydro-electric power plant at that point on the Tennessee River. Work on the project was authorized during the war, but it was soon found necessary to discontinue it for several reasons. In the first place, it was doubtful if the work could be completed before the war ended, and in the second place, it was a project of such magnitude as to require labor and materials which could not be diverted from other war needs. Now, however, the work is again under way, under the direction of the Engineers Corps of the Army, and a progress report is printed elsewhere in this issue.

With the controversies which have centered in this particular project we have no present concern. It is an undertaking which looks far into the future for its justification and we have little doubt as to the favorable judgment which will ultimately be pronounced. Certain it is that the project is located in a section of our country which has urgent need for the development of its industrial, agricultural and mineral resources, and in the long run we believe that the whole nation will profit. Political and sectional opposition and criticism against it may be expected from certain quarters, but in all probability it will be found of the same quality and inspiration which opposed the location of the nitrate plants at Muscle Shoals, but which promptly subsided when additional nitrate plants were "more favorably" located. The nitrate plants are at Muscle Shoals. They should be operated. The dam and power plant are essential to their operation, and the work should be completed at the earliest possible date.

Commercial Ambassadors In Mexico City

THE commercial conference called by the American Chamber of Commerce of Mexico in Mexico City last month was attended by representatives from many local civic bodies in the United States. President CARRANZA and other Mexican officials gave them a warm welcome.

Desire for trade begets peace in all civilizations. Mexico needs chemicals, pharmaceuticals, porcelain goods, paints, machinery of all kinds, textiles, bacteriological apparatus and other products necessary to constructive activities. In turn the United States desires in trade the tanning pod, fish oil, candelilla resin, vegetable wax, logwood, medical herbs, castor oil plant, lechuguilla fiber, vanilla beans, petroleum, etc. Mexico is a storehouse of wonderful raw materials for which the world should be her market.

This is something, then, larger than a deal in old jackknives. The meeting was a definite step toward peaceful relations and Mexican development, a consummation much to be desired.

Western Chemical and Metallurgical Field

Manufacture of High-Grade Superphosphate at Anaconda

THE proximity of a potential source of relatively cheap sulphuric acid and large deposits of high-grade phosphate rock occurs in the Rocky Mountain northwest. Sulphide ores of copper, lead and zinc are treated in the metallurgical plants in this district in large quantities. These ores, or the concentrates obtained therefrom, are in most cases roasted as a preliminary metallurgical operation. Recent developments in the production of sulphuric acid from these roaster gases indicate the possibility of the manufacture of this acid in large quantities at a low cost. At present only sufficient acid is made to take care of local consumption, since the acid will not stand transportation charges for any great distances. The unused sulphur dioxide is expelled to the air. This is not desirable, as there are certain requirements that have to be met wherever smelters are located in agricultural communities and the smoke problem is one that smeltermen would like to solve economically if possible. The removal of sulphur dioxide from these gases would avoid certain objections to the discharge of these gases into the air. Large deposits of phosphate rock occur in Idaho, Utah and Wyoming from which the rock can be mined and transported to the smelters at a reasonable cost. The production of superphosphate from these materials is a simple matter and would create an outlet for sulphuric acid, but the ordinary grade superphosphate will not stand the freight rates to the market, which is largely in the Eastern states.

Problem of Marketing Difficult

The Anaconda Copper Mining Co. has given this subject a great deal of attention and has worked out a process for the production of a superphosphate that contains 48 to 50 per cent available P_2O_5, or practically treble the percentage in the superphosphate that is ordinarily produced. This high-grade product will stand relatively high transportation costs, but the possibility of large-scale production depends upon the development of a market for this product. The marketing of this grade of superphosphate is not a simple proposition; in the first place, this material is too concentrated to be applied to the soil without mixing with inert material, and in the second place, the manufacturers of mixed fertilizers depend largely upon the inert material in ordinary phosphate to dilute high-grade nitrogen and potassium salts. The use of higher-grade fertilizers results in economy both in handling and in transportation and is desirable for both the consumer and producer. However, the education of the farmer along these lines has not as yet attained marked success. The use of larger amounts of phosphates is desirable especially in connection with the production of cereal crops; it is a characteristic of this element of plant food to bring these crops to maturity earlier and to increase the yield. Increased productivity of our agricultural lands is of national importance in view of the shortage of farm labor and the high wages demanded by experienced farm hands.

The Anaconda method of manufacturing superphosphate is to treat phosphate rock with sulphuric acid, producing a phosphoric acid, which is concentrated and used in treating additional phosphate rock. The rock is crushed in a Blake crusher, dried on a Ruggles-Cole drier and ground to pass an 80-mesh screen in a Hardinge mill, which is in closed circuit with a Newago screen. This product is treated with 60 deg. Bé. acid in a series of three Dorr agitators and the pulp washed by decantation in a series of three Dorr thickeners. The pulp is filtered and washed on an Oliver filter. The filtrate is added to the last Dorr thickener; the overflow from the second Dorr thickener is added to the first Dorr agitator. The Oliver cake is wasted. The overflow from the first Dorr thickener will contain between 22 and 25 per cent phosphoric acid. This is concentrated in a coal-fired, direct heat evaporator to about 65 per cent H_3PO_4. This concentrated acid is then mixed with ground phosphate rock in Pratt mixers, passed through a disintegrator, a Ruggles-Cole drier, ground in a Sturtevant "Ring-Roll" mill and discharged into a "den." This method of producing the superphosphate from ground phosphate rock and phosphoric acid is similar to the usual method using sulphuric acid. The product will, however, contain 45 to 50 per cent water-soluble phosphoric anhydride.

Operations at Ajo, Ariz.

The process being carried out at present at New Cornelia is the same as that originally recommended by Tobleman, and the results which have been obtained since the beginning of operation very closely check those he obtained in the experimental plants. There have been no material metallurgical or mechanical changes.

On Dec. 1, 1919, the leaching plant had operated 928 days, having leached during that time very nearly 4,000,000 tons of oxidized copper ore (3,600,000 metric tons), the total copper content of which averaged 1.52 per cent. Practically 72,000,000 lb. of electrolytic copper has been shipped and about 38,000,000 lb. of cement copper running approximately 60 per cent in copper (33,000,000 kg. and 17,000,000 kg. respectively).

The extraction obtained is somewhat over 80 per cent, while 0.7 lb. (0.32 kg.) of copper per gross kw.-hr. has been deposited in the tank house, this latter figure being but slightly less than was originally estimated. Likewise, the amount of discard necessary to prevent fouling of the solution has been very close to that originally reported, 90 gal. (340 l.) per min.

During the spring curtailment in production it was found that apparently the longer the time of leach and the lower the corresponding acid concentration, the less would be the amount of impurities which would be dissolved and consequently the greater the proportion of electrolytic copper to cement copper produced. This, of course, is a desirable condition.

Since nearly one-third of the oxidized ore has been consumed in the leaching process, a 500-ton experimental flotation plant has been constructed to determine the proper treatment for sulphide ores. This plant has been in operation since September, 1919. It is equipped with two rod mills, 42 in. x 9 ft. 8 in. and 60 in. x 10 ft., and a Hardinge mill, 8 ft. x 36 in. (1.07 m. x 2.95 m.; 1.54 m. x 3.05 m.; and 2.44 m. x 0.91 m. respectively); also Inspiration flotation cells and Deister tables. It is desired to determine the mills, flotation cells and tables best adapted to the ore, as well as the most efficient combination of oils. About 9,000 tons of ore had been milled up to Dec. 1.

British Chemical Industry

From our London Correspondent

London, February 1, 1920.

THE outstanding feature of the past month was undoubtedly the publication of the final report of the Nitrogen Products Committee on Jan. 15. Its appearance was the signal for vigorous criticism on all sides, particularly in regard to the delay in publication, the report having been in type since May, 1919. The 2,000-odd copies available for public as distinct from official distribution will probably be snapped up very quickly, and unless a second edition is printed it will be difficult for United States and foreign interests to obtain this valuable publication. It is understood that further details regarding physical data and the work of the Research Station, of which Dr. Harker is the Director, will be published shortly, and that the negotiations for the purchase by the Brunner-Mond interests of the Billingham Haber-type nitrate factory are practically completed.

Claude Process Viewed With Scepticism

The prospects of the Claude process recently acquired by Mr. Barton are viewed with some scepticism owing to the very high pressures involved. The statements made in the report regarding costs and manufacture of oxygen have been severely criticized and are said to be inaccurate. A proposal of the greatest interest is that of setting up standards of efficiency for large users of coal and for ammonia recovery based upon practice that has been uniformly realized under good working conditions. While a scheme of this kind would have been considered Utopian before the war, the suggestion is being treated seriously and in a national spirit of co-operation.

Policy of Amalgamation Continues

The policy of amalgamation noted in my last article[1] has continued, the Castner-Kellner interests having been practically acquired by Brunner-Mond. Similar operations have been carried out in the steel, coal, glass and oil industries, and while it is realized that such collective action by the larger firms may be a national gain, public opinion still looks with suspicion upon the formation of powerful trusts with their latent drawbacks in regard to the creation of artificial prices and trade conditions. As regards the glass industry, it is interesting to note that the new factories will nearly all operate under the Owens patents—an American invention.

Chemical Trade Active—Supplies Short

The chemical trade remains very active, with acute shortage of supplies, many firms being sold out to the end of the year. Soda ash, caustic soda and many other commodities are almost unobtainable. The rubber position is very interesting, prices showing an upward tendency on account of the fall in the American exchange and the rise in the price of silver, wages being chiefly paid in the latter commodity.

The Association of British Chemical Manufacturers has just published a directory of its members printed in seven languages, and assures purchasers that goods ordered by them are actually produced by the firm in question. While this statement is quite *bona fide*, it often happens just now that manufacturers list many more products than they are actually manufacturing at the time, and "borrowing" or importation is often necessary to make up the deficiency.

Trade Union Movement Spreading Among Chemists

As regards chemical merchants, signs are not wanting that these interests also will join forces in a more powerful association than that now existing, and the chemical trade dinner on Feb. 12 will no doubt prove an excellent lubricant. The trade union movement is now spreading its net to include even such chemists as belong to the National Association of Industrial Chemists, the British Association of Chemists, etc., the proposal being to join forces with similar "professional" interests, such as those of the engineering draftsmen, bank and insurance clerks, etc.

Universities Need Funds

At the universities, the claim of the Imperial College of Science to grant its own degrees is causing much heartburning, while the lead of Manchester University is likely to be the forerunner of many other appeals for additional funds to cope with the ever-increasing influx of students.

Fuel Situation Causes Worry

The fuel situation is attracting further attention, in view of the impending shortage of petrol due to the presumed increased American requirements. It is predicted that two years hence the United States will have no petrol to spare for export and that this country must resort mainly to benzol, alcohol and motor spirit derived from the distillation of coal, if the cost of motor fuel is to be kept within reasonable limits. The work done by Ernest Bury at the Skinningrove Co.'s works on the manufacture of alcohol from ethylene and the simultaneous appointment of Sir Frederic Nathan as power-alcohol investigation officer under the Fuel Research Board give some indication of the present trend of opinion, while in engineering circles much attention is being given to the possibilities of producer-gas units for vehicles propelled by internal combustion engines.

Co-operation With U. S. Desirable

The announcement that American chemical and physical societies are to create a fund for the verification and publication of physical data and constants should lead to co-operation with the Chemical Engineering Group of the Society of Chemical Industry, which is also to devote time and effort to this essential work.

[1] See CHEM. & MET. ENG., Feb. 4, 1920, p. 200.

Value of Last Year's Exports From United Kingdom to United States

The declared value of the exports from the United Kingdom to the United States in 1919 aggregated $359,671,231, exclusive of the Birmingham consular district and West Hartlepool agency, from which returns have not been received. The total in 1918 for the whole of the United Kingdom was $143,272,830. The following increased values in 1919 are noted by consular districts: London, $144,000,000; Liverpool, $18.500,000; Bradford, $17,000,000; Manchester, $12,000,000; Dundee, $11,000,000; Nottinghom, $5,500,000; Glasgow, $4,000,000. American vessels of 1,003,258 gross tons entered the port of London in 1919, against 134,823 tons in 1918, as shown by the records of the consulate general.

Senate Debate on Dye Bill

LIVELY debate was aroused in the Senate on Feb. 25, by the introduction on the Senate floor of the dye bill. That there will be opposition to the measure was indicated by the attitude of various Republicans and Democrats. The Republican objections are based on the fact that the bill is a departure from the usual form of protective legislation. Senator Kenyon of Iowa characterized it as "a very unusual bill and a rather strange application of the protective tariff theory." Senator Thomas of Colorado, a Democrat, assured the Senate that he would speak at length in opposition to the bill. After four hours of debate the bill was temporarily set aside to make way for the Peace Treaty discussion. No definite predictions can be made as to when the bill will be taken up anew.

Senator Kenyon opposed any haste in considering the bill, as he was avowedly suspicious at finding so many of the Democrats supporting what he termed a high-tariff measure. Senator Simmons, the ranking Democrat on the Finance Committee, explained, however, that the tariff rates had been reduced by the Senate to the rates in the present law which was passed by a Democratic Congress. Senator Kenyon called attention to the fact that there were other things in the bill besides rates and Senator Watson admitted that the bill is and was intended to be an embargo measure.

Magnesite and Chemical Glassware Bills Ready but Held Back

Senator Poindexter of Washington objected to the failure of the Finance Committee to report out, as well, the magnesite and other emergency tariff bills. This led to the revelation that the Finance Committee had decided to report favorably to the Senate the magnesite bill and chemical glassware bill, but that at the last minute the committee decided to withhold the report on these bills for the present. The reason for this unusual action, it was stated by Senator Smoot, had best not be revealed at this time.

Senator Poindexter was prompted by this admission to declare that "the fact that the report which has been ordered was suspended indicates that very likely some influence—probably that which is interested in Austrian mines—is endeavoring to prevent any report at all on magnesite." He insisted that before the dye bill was presented to the Senate for a vote the magnesite bill must be on the calendar.

Smoot for Straight Protective Tariff

Senator Smoot expressed his view of the dyestuffs legislation as follows: "If I had had my way about it, the dye measure would have been a straight protective bill, providing a specific duty that would protect the dye industry of this country. I would not have put an embargo provision on it or any license system as provided in the House bill. I believe in a protective tariff principle. I would have granted a reasonable rate of protection in this bill. I would not shy at a protective duty particularly if it were limited to three years, as in this bill the embargo provision is limited, to take care of special items. This bill is limited to three years and no industry within that time could be established and begin the manufacture, say, of vat dyes required by a large majority of the cotton manufacturers of the country."

At another point in his argument Senator Smoot made the following significant statement: "I will say frankly that if I had my way about it we would have an entire revision of the tariff, but whenever the tariff is revised, whether it be up or whether it be down, the business interests of this country are unsettled. What is the use of unsettling the business of the country when we know that a protective tariff bill would not be signed at the other end of the avenue?"

Senator Watson called the attention of the Senate to the fact that the favorable report made by the sub-committee on the dye bill was unanimous and that the report made by the full committee to the Senate also was unanimous.

Knox Supports Dye Bill

Speaking in support of the measure, Senator Knox of Pennsylvania said in part:

"The forces that held the legions of civilization at bay and almost overcame them were the spectacled chemists of Germany. The whole face of the world has been changed by the creative or synthetic chemist within the last ten or fifteen years.

"If this measure was a project to invest a billion dollars of Government money for the purpose of building up an industry that would save a billion dollars a year and be a great factor in our preparedness against another destructive war I would favor it, but it is not that. The gentlemen who proposed to build up these industries will do it at their own expense, and all that they ask the Government of the United States to do is to prevent for a period of three years the importation into this country of such dyes as are made here in merchantable quantities. The proposition is reasonable. It has nothing to do with the tariff. It is not a question of tariff legislation. It is a question of wise, far-seeing preparedness, and of wise, far-seeing economy."

Plans of Dye Section, A. C. S.

The second meeting of the Dye Section, American Chemical Society, will be held in St. Louis, beginning Wednesday, April 14. At this meeting the committee on permanent organization will submit bylaws for the consideration of the Section, the approval of which, by the Section and by the Council, will be the necessary steps to the permanent organization of the dye chemists of the United States, as the Dye Division of the American Chemical Society.

The secretary asks all scientific workers in the field of dyes to present the results of their researches and experiences at these meetings of the dye chemists. Papers on the manufacture, properties or application of dyes, both of coal-tar or natural origin, will be of timely interest. Any chemist having any such scientific information ready for presentation is asked to communicate at once with the secretary, giving subject and time for presentation.

As is usual, full details of the final program, time and place of meeting can be obtained by addressing Dr. C. L. Parsons, 1709 G Street, N. W., Washington, D. C., or Dr. R. Norris Shreve, secretary, 42 Fifth Ave., New York City.

Colloquium on Electrochemical Research

Electrochemists of New York City who would like to organize a fortnightly colloquium on current researches are asked to communicate with Prof. H. C. Cooper, College of the City of New York. The organization will be informal, voluntary and mutual. Several experienced men are expecting to attend.

Iron and Steel at the A.I.M.E.

A Summary of the Discussions and Papers Read at the Winter Meeting — Blast-Furnace Flue Dust, Malleable Iron, Alloy Steel, Boiler Plate, Gun Construction and Theoretical Metallurgy Were All Treated in a Most Interesting Manner

VERY interesting sessions devoted to iron and steel metallurgy were held both morning and afternoon of the closing day of the winter meeting of the American Institute of Mining and Metallurgical Engineers held Feb. 16-19 in New York City.

A synopsis of the papers read and commented upon by members present will be given below.

Flue Dust

A discussion of the causes of blast-furnace flue dust and a new furnace-top design to prevent its production was given in a paper by R. W. H. ATCHERSON. Blast-furnace dust is troublesome at best, but the amount produced seemed to have little connection to the fineness or origin of ore charged; rather a close attention to innumerable details of furnace and accessory construction and operation has enabled the industry to reduce materially the amount of dusting in the face of finer and finer ores. Since the charge must evidently act as a filter, as uniform a mixture as possible should be placed in the furnace, to prevent almost explosive rushes of blast, breaking through a finely packed stratum. In addition, ample areas of furnace dome, out-takes and downcomers are essential. Mr. Atcherson thought that the superiority of turbo-blowers was not so much on account of the lack of pulsations (which were effectually dampened before arrival at the tuyere) as of the excellent governors capable of keeping volume and pressure uniform in the face of wide variations in steam pressure —something which governors attached to reciprocating engines could not possibly do. The author's design calls for six gas-regulating goosenecks connected to two large downcomers, the entire system intended to reduce and equalize velocity, and control its pressure—all most important factors in dust production. As to the handling of the recovered dust, he observed that wet sludge is much easier and safer to handle than hot dust, and if his idea was correct, that the content of fine coke was the root of rehandling difficulties, and therefore that wet flue dust free from coke should not disturb any function of the furnace, it was proper to experiment along the line of effecting a wet separation of these two ingredients, rather than to use the coke as a fuel for sintering, a practice which results in material most difficult to smelt because of its content of iron sili-steel"!

SINTERED VS. RAW DUST

C. A. MEISSNER, in discussion, said that in general it slows down iron production to charge raw dust, although the lines of the furnace have a large influence on the amount of flue dust produced, or the capacity to smelt it when recharged. The speaker, however, was not ready to acknowledge that either turbo-compressor or blowing engine had a decisive advantage. In spite of the formation of silicates, Mr. Meissner thought that well-sintered dust was preferable for charging, especially in case fine coke could not be first separated if the raw dust was returned, since the finest coke tended to go through the furnace unconsumed, and entering the slag, make it extremely infusible.

Semi-Steel for Shells

"Manufacture of Semi-Steel for Shells" was described by F. E. HALL. Limiting the term to cupola metal resulting when ample steel scrap is charged, he described the chemical and physical requirements of good semi-steel. Cupola practice must be most carefully controlled if uniform results are to be attained, and the author notes many precautions to be observed.

HENRY D. HIBBARD called attention to the fact that "semi-steel" was a much abused term, and while it was not ideal for cupola metal described by Mr. Hall, it seemed to be so well established that it would be desirable to retain, exclusively if possible. At present "semi-steel" might also be applied to the low-carbon product of an air-furnace, to malleable iron castings, to cast iron synthesized from steel turnings, or, according to at least two modern unabridged dictionaries, to "puddled steel"!

USE FOR RESISTANCE TO ABRASION

Attention was called to the exceptional wearing qualities of some semi-steels by R. F. HARRINGTON, who thought that real information was needed as to whether cupola or air-furnace semi-steel was superior for abrasion-resistant parts such as locomotive cross-head shoes. Mechanics generally prefer cupola semi-steel, even if physical tests appear quite similar. For determining this essentially practical point, a good testing machine should be designed. THOMAS GILMORE observed that iron for molds varied enormously in durability, and when he could get a foundryman to make him a "white iron," with the proper amount of steel in the charge and cast to have a very fine grain, the wear obtainable would compare favorably with the best manganese steel. H. A. HIXON confirmed this statement as to the wearing qualities of crusher jaws and roll shells. If these are cast against chills, with soft iron strips in the back of the casting, they would outlive the best manganese steel pieces he had ever seen.

One-Piece Gun Construction

"An Experiment in One-Piece Gun Construction" was described by P. W. BRIDGMAN. He noted that when firing a gun the interior parts of the tube are stressed at a much higher rate than the outer portions, with the result that the intensity of stress varies considerably inside to outside. For safe strength, then, considerable weight of metal is always present, which does not work to very high efficiency. By the ordinary method of keeping the interior of the gun from being strained beyond the elastic limit, thus acquiring a permanent set to the utter destruction of its accuracy, it is usual to shrink

the jackets over the tube, thus initially compressing those portions which eventually withstand the highest tension. Another scheme which was tried under his direction was subjecting a one-piece forging to heavy internal hydrostatic pressure, causing the entire tube to flow and acquire a permanent set, and at the same time a much elevated elastic limit. After such a treatment, the bore could be rifled and the barrel was ready for mounting. Practically, the chief difficulty was to devise packing tight against such excessively high pressure (100,000 lb. per sq.in.) but this problem was solved in a satisfactory manner, as described in the paper. A 3-in. gun was made in this manner, which withstood successfully extra-vigorous testing, and the scheme was being elaborated for large-scale application when hostilities ended. It would reduce the number of operations necessary in manufacture, with a corresponding reduction in time and expense, and the method of fabrication would submit the tube to far greater stresses than it would ever receive in service.

Italian Gun Manufacture

It developed in the discussion that the French were using a similar scheme in making a composite barrel. The tube was expanded into the jacket by internal pressure, rather than the jacket shrunk on by heat. Dr. F. Giolitti also said that Ansaldo Co. in Italy had made very many guns during the last years of the war on exactly the same principle as described by Dr. Bridgman, in size up to 10 in. Their two difficulties were to produce the high pressure required with rather meager apparatus, and to so arrange the equipment that different pressures would be exerted at different parts in the tube, as required by their working resistances. He described a fixture which was devised to accomplish this, consisting of a bar slightly less in diameter than the gun bore. This was inserted into the tube, and the annular space packed at the limits of the area desired to compress, then hydrostatic pressure introduced by means of small openings through the bar.

Tensile Strength of Boiler Plate

H. J. French studied the "Tensile Properties of Boiler Plate at Elevated Temperatures" at the Bureau of Standards. A short rectangular test bar was gripped in a tension machine by special long jaws, and then a tubular electric furnace placed around it. When the test bar had reached a desired stationary temperature, a stress-strain curve was obtained by means of compensated extensometers affixed to the jaws by a wide yoke spanning the electric furnace. His results were tabulated and presented as graphs, and exhibit the fortunate fact that the tensile strength and elastic limit either are maintained or are actually increased up to about 200 deg. C., a fact important in the use of such materials for high-pressure steam boilers. A more detailed summary of his results follows:

"In both grades of plates (firebox and marine) increase in temperature from 70 to 870 deg. F. (21 to 466 deg. C.) is accompanied by distinct changes in strength and ductility, viz.: (*a*) The tensile strength at first decreases a few thousand lb. per sq.in., reaching a minimum at about 200 deg. F. (93 deg. C.). This is followed by an increase up to about 550 deg. F. (288 deg C.), where the tensile strength reaches a maximum about 10 per cent greater than the normal room temperature value, after which another and final decrease occurs. (*b*) The percentage elongation in 2 in. (5 cm.) decreases rather slowly up to about 200 deg. F. (93 deg. C.), after which it drops more rapidly, until a minimum is reached at about 470 deg. F. (243 deg. C.). This factor then increases throughout the balance of the range under consideration. (*c*) The reduction in area closely follows the inflections registered in the curve for elongation but has a minimum at slightly higher temperature than the elongation. (*d*) The proportional limit at first increases slightly and shows a maximum in the neighborhood of 400 deg. F. (204 deg. C.) for the firebox plate and the highest values between 200 and 300 deg. F. (93 and 149 deg. C.) for the marine plate. It is noted that both the actual and the percentage increases are much greater in the case of the firebox grade and that the subsequent and final decrease in proportional limit for this plate takes place more sharply than in the case of the marine grade of boiler plate.

"In the case of the firebox plate, the proportional limit is maintained above its original average room temperature value of 23,300 lb. per sq.in. to a higher temperature than is the case with the marine plate. It is probable that this may be associated with the greater mechanical work received by the firebox plate."

Graphitization of White Cast Iron

In a closely written paper on the above subject, R. S. Archer reaches the main conclusions that from the available evidence A_1 for a 1.0 per cent silicon iron is probably within 15 deg. of 750 deg. C. Annealing experiments on a typical hard iron showed that the combined carbon may be reduced to 0.05 by 168 hr. at 690 deg. C., or 135 hr. at 735 deg. C., both undoubtedly below A_1. However, annealing at 785 deg. C. showed 0.5 per cent graphite after 10 hr., 0.12 per cent after 11 hr. at 735 and but 0.06 per cent after 24 hr. at 690 deg. C. Further evidence as to the temperature ranges of graphitization is furnished by reheating completely graphitized iron, re-establishing the well-supported facts that there is no re-absorption at 749 deg. C., but a considerable reversion to combined carbon at 771 deg. C.

"It therefore appears to be a well-established fact that there is a temperature above which the graphite of a completely graphitized iron will go back into solution, to be reprecipitated on cooling as iron carbide. For iron of the composition used for malleable castings (0.5 to 1.0 per cent silicon) this temperature is approximately 765 deg. C. The conclusion seems inevitable that combined carbon cannot be completely converted to graphitic carbon under conditions that cause graphitic carbon previously formed to revert to dissolved carbon and, on moderately rapid cooling, to cementite. That is, it is not possible above this critical temperature to completely convert combined carbon to graphitic carbon. If this is true, it follows that the complete conversion regularly obtained in proper annealed malleable castings must, of necessity, take place in its final stages either at or below this critical temperature.

"Whether the completion of graphitization takes place at or below a definite critical temperature is a question of importance. If, as maintained by some writers, the complete conversion to graphite takes place at this critical temperature and not below it,

such conversion must consist in the direct precipitation of an iron-graphite eutectoid. For if the conversion took place simultaneously with the formation of pearlite, there is no reason to suppose that it would not continue at temperatures slightly below the critical."

Archer calls attention to the work of Merica and Gurevitch,[1] who tentatively suggest a curve of solubility of graphite in austenite which is very close to the corresponding line for cementite in the metastable diagram applied to steels. However, speed of cooling is an important factor in the final result—in other words, white iron annealed at 835 deg. C. for a sufficient time (20 hr.) to produce equilibrium contains approximately 0.84 per cent combined carbon when quickly cooled, but 0.67 per cent when cooled under ashes. The comparatively short time consumed in passing from 835 deg. C. to temperatures well below A_1 (say 650 deg. C.) where decomposition of cementite is vanishingly slow, is sufficient to allow the formation of 0.2 per cent more graphitic carbon.

Now if it be true, as indicated from Archer's experiments, that graphitization can be initiated and completed in white cast iron at temperatures below A_1, yet on the other hand cannot be *completed* at temperatures perhaps identical with A_1, then the accepted phenomena can be satisfactorily explained as follows:

"1. With the possible exception of the initial stages, graphitization takes place directly from solid solution.

"2. Graphitization may take place from any solid solution supersaturated with respect to graphitic carbon.

"3. The evidence at present available is not sufficient to determine whether the saturation values for a solid solution on the point of precipitating graphite are appreciably different from those for a solid solution on the point of precipitating cementite. Under conditions of equilibrium, two phases are present—graphitic carbon and the saturated solid solution. Metastable equilibrium may exist between the two phases iron carbide and solid solution. Theory indicates that the carbon concentration of solutions in stable equilibrium with graphite is less than that of solutions in metastable equilibrium with iron carbide. If the available experimental evidence is considered with allowance for the effect of impurities on the solubility of iron carbide, the solubility curve of the carbide may, for practical purposes, be used to determine the conditions of equilibrium in the stable system iron graphite."

Stable and Metastable Equilibrium

A. E. White, while disavowing any intention of discussing whether graphitization takes place from cementite or from solid solution, pointed out that there was nothing unusual about the fact that it proceeded below A_1, since the stable condition at low temperatures is evidently a system containing iron and graphite. Since the tendency to approach equilibrium is always present at all temperatures, the reheating must be to a degree only sufficient to provide sufficient molecular or atomic mobility for the ever-present tendency to make itself felt. Consequently time is the only requisite for graphitization at temperatures below the critical. In the speaker's opinion the stable equilibrium diagram is delineated with far from precision, still he introduced evidence strongly supporting Archer's figure of 750 deg. C. for A_1 for standard malleable analyses.

J. V. Emmons said that graphitization below the critical can easily take place, since he had found particles of carbon occuping the precise position which free cementite had previously occupied in a piece of tempered tool steel. However, since it was extremely doubtful to him whether any solid solution could exist below A_1, any graphite should result directly from the decomposition of cementite which does exist in very large quantity.

Francis B. Foley pointed out the danger of making inferences on insufficient data, saying that another hypothesis accounted as well for the facts brought out in Archer's paper as the one that graphitization proceeded directly from solid solution. That is this: when passing Ac_{cm} the metastable cementite just born immediately breaks up into its constituents according to the reaction

$$Fe_3C \leftrightharpoons 3Fe + C$$

Lag has its well-known effects on this reaction. Quenching prevents precipitation of carbide, and martensite results. Moderate cooling allows cementite to precipitate but not to decompose, while slow cooling favors complete dissociation of the carbide. Time at temperatures below A_1 will allow all free carbon then molecularly dispersed to accumulate in microscopic masses—a condition of total graphitization. Complete graphitization above A_1 is impossible, since the reaction then goes to the left to the saturation of austenite. It follows from this hypothesis that the carbide line and its eutectic are identical with the graphite line and eutectic, a conclusion recently favored by some students of the problem.

In reply to the discussion, Mr. Archer said he still held that the weight of evidence supported the idea that graphite was precipitated from solid solution. It is important to remember that the black masses in malleable iron are not solid carbon but rather layers of graphite carbon occurring between laminations of ferrite—quite similar to eutectic structure. Another ordinary appearance is to be explained, namely, that graphite accumulations are often surrounded by a shell of ferrite, which in turn is embedded in pearlite. Now if free carbon is not an element of the solid solution, how could the graphite arrive in quantity at such a center?

Distortion on Hardening

A paper entitled "Coefficient of Expansion of Alloy Steels" was read by John A. Mathews, in which he gave the complete history and physical properties of eleven liberty motor shafts of various analyses, together with the coefficient of expansion up to 270 deg. C., a set of data unfortunately somewhat unique. It is also mentioned that moderate coefficients of expansion such as normal steels possess have not nearly so great an effect on warping during heat treatment as the skill with which the manipulations are conducted. Some special analyses with expansions about the same as ordinary carbon steels will harden entirely free from distortion or volume change, even with moderate care; others give great trouble even when quenched in dies or by machinery. "This again illustrates the fact that the coefficient of expansion, in itself, is not a primary cause of distortion in heat treatment, al-

[1] *Bulletin*, A. I. M. E., No. 151; Chem. & Met. Eng., vol. 22, p. 40 (Jan. 7, 1920).

though, in general, hardening from a temperature just about that at which the maximum contraction takes place at decalescence would tend to improve the final results of hardening so far as distortion is concerned; this practice is now in use in some progressive plants where the end of decalescence is directly determined from pieces in the furnace rather than by relying upon the reading of the pyrometer located at a more or less remote spot in the furnace."

Nickel Steel

HOWARD SCOTT presented an important contribution on the "Critical Ranges of Some Commercial Nickel Steels," a study of a series of 40-point carbon alloys of great industrial importance. Using inverse rate heating and cooling curves, he was able to plot the effect of nickel up to 4 per cent on the critical ranges of 0.40 per cent carbon steel. In general, increasing nickel decreases the width of the critical ranges on

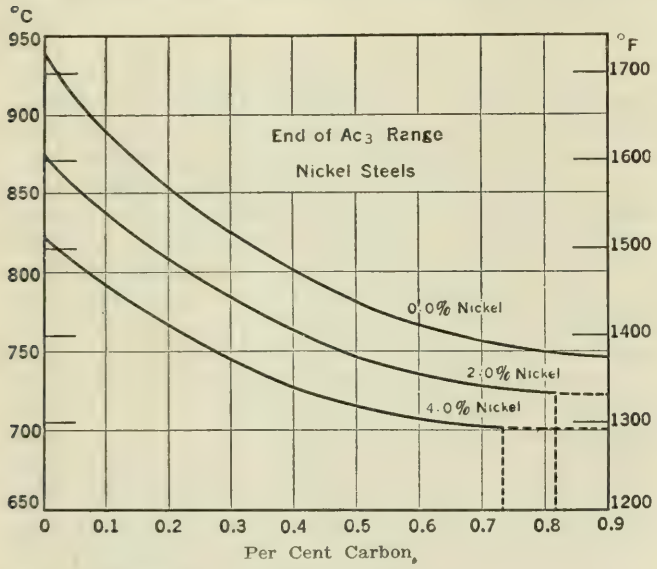


FIG. 1. EFFECT OF CARBON ON END OF Ac_3 FOR 0, 2 AND 4 PER CENT NICKEL

both heating and cooling, decreases the absolute temperature of the critical points, but with greater effect on the $Ar_{3,2}$ range. In particular, $Ac_{2,3}$ for a 40-point steel with no nickel begins at 732 and ends at 800, while if 4 per cent nickel is present the same range begins at 690 and ends at 730. $Ar_{3,2}$ for a 40-point steel with no nickel begins at 672 and ends at 745, while if 4 per cent nickel is present it begins at 587 and ends at 637 (all temperatures being closely approximate and in degrees C.). Quenching experiments show that the end of Ac_3 corresponds substantially to homogeneous austenite solution, consequently the results just quoted may be used as a basis for heat treatment with carbon-nickel steels covering a wide range.

Using in conjunction with the above data some records at the Bureau of Standards showing the effect of carbon on the Ac ranges in plain steels, and accepting the idea that a lowering of the critical ranges for carbon decreases the eutectoid composition, the curves given in Fig. 1 are presented for industrial use. In view of the steep slope for low carbon concentrations, the author emphasizes the fact that soft steels should be held within closer limits than plus or minus 5 points, since the tolerance can easily cause an error of 25 deg. in the subsequent heat treatment.

Forgeability of Iron-Nickel Alloys

A byproduct of an investigation of the magnetic properties of iron-nickel alloys was presented by T. D. YENSEN, in a paper of the above title. He found great difficulty in working pure iron-nickel alloys at ordinary forging temperatures, consequently in order to get a usable magnetic alloy, a composition had to be worked out which could be produced in commercial shapes. Whereas the degree of forgeability of a material depends on the relative strength of the crystalline and the intercrystalline—or amorphous—material, the forgeability of an ingot or casting can be ascertained only by actually attempting to deform the material, either by forging or rolling, or by tensile test. Metallography has not yet reached a stage where an inspection of the microstructure will give any definite information in this respect. Aluminum, carbon, magnesium or silicon was found to have little or no effect upon the forgeability, but the fact that manganese and titanium in amounts equal to 2 per cent of the lesser binary constituent transform iron-nickel alloys from non-forgeable to forgeable alloys means that these elements have the ability to strengthen the amorphous material that is generated between the crystals to such an extent as to make it stronger than the crystalline material.

C. G. FINK said that he investigated the same properties when developing a compound wire with a copper shell over a nickel-iron core. The two had to have about equal ductility so they would deform alike during wire-drawing. All his alloys containing 26 to 60 per cent nickel were very hard, and required continual annealing, but when the most extreme care was used to prevent carbon entering the alloy—even that amount usually introduced by an Arsem "vacuum" furnace—the same alloys could be made so soft they could be whittled with a knife. All the alloys contained manganese, which was necessary for the requisite tenacity.

CRITERION OF FORGEABILITY

ZAY JEFFRIES pointed out that Dr. Yensen's paper needed correction in that the condition of forgeability was not solely the possession of a strong crystalline cement, but, in addition, it should be strong enough to force the crystals to bear strain, and the latter in turn must be capable of being deformed. Thus, lead is forgeable, but not ductile—that is, it cannot be drawn through dies. In this case the cement is not strong enough to hold together and transfer the load to the deformable crystals. Fine grained chromium metal, again, has a very strong cement, but the metal cannot be forged because the crystal cannot be deformed. The rate at which the stress is applied has a great part in determining the apparent mobility of crystal as related to its cementing films, as has often been pointed out before.

Crystallography of Iron

"Microstructure of Iron and Steel at High Temperatures" was discussed by H. S. RAWDON and HOWARD SCOTT, in a profusely illustrated paper, difficult to abstract, but which we hope to publish in full. One of their principal conclusions is that heating *in vacuo* (using a modified Rosenhain furnace) pronouncedly decarburizes both hyper- and hypo-eutectoid steels, an experimental result at complete variance with Dr.

Henry M. Howe's proposition that excess constituent is extruded by austenite crystals to their surfaces.

The various reasons advanced by Dr. Howe to support this hypothesis were reviewed by E. E. THUM, who pointed out that a pseudo-mechanical "elbowing" action did not explain the observed phenomena of movement and agglomeration of insoluble ferrite or cementite as well as the incessant solution and reprecipitation continuing at all times, a balanced action producing equilibrium between any solvent and its solute. In one case only, which Dr. Howe substantiated with micrographs, was the solution theory at fault. That was that pro-eutectoid material tended to line the walls of cavities, either natural or artificial. Even in view of this case Mr. Thum felt that the true test of an "elbowing" action would be evidence that an insoluble particle, like a sonim, had been bodily moved solely by heat treatment.

Drs. F. GIOLITTI and Z. JEFFRIES both said that elbowing of solid materials was to their minds very doubtful, and that they had never seen any evidence that would point to transportation *en masse;* in fact, definite trials at temperatures up to 1,300 deg. C. had caused no bodily movements in the slag. The latter speaker said that some small movement might be caused by the fact that grain boundaries ordinarily contain inclusions, and the crystalline growth is often obstructed by such particles, especially if there were many of them present. Of course some movements in ferrite and cementite were not due to diffusion—for instance, spheroidizing of cementite was doubtless a surface tension effect. But the apparent habitat of pro-eutectoid material at grain boundaries was due in greatest part to the fact that the first portions to separate tend to draw like material to themselves, correspondingly impoverishing the surrounding region.

Changes in Iron at a Blue Heat

ZAY JEFFRIES presented the report of a National Research Council committee on the "Physical Changes in Iron and Steel Below the Thermal Critical Range." After an extended review of the literature on such aspects of the subject as the variation in tensile and electrical properties, the recovery of elasticity after overstrain, the effect of working at blue heat, aging, and low-temperature thermal evolutions, the author concludes that the best substantiated phenomena are well explained by assuming a low-temperature allotrope in iron.

More than a little opposition to this view was apparent, however. HOWARD SCOTT was under the impression that many phenomena simulating the properties of allotropes could be ascribed to a slow but long-continued precipitation of cementite, held at low temperature in metastable solution, an action similar to the aging of duralumin. Blue brittleness and unusual impact values, on the other hand, might be due to a very slight solubility of cementite in ferrite—absolute and complete insolubility is unlikely.

F. C. LANGENBURG also doubted if blue brittleness was more an evidence of allotropy than an inherent property of free ferrite. Honda had found a magnetic change in cementite at low temperatures, which could easily be responsible for many peculiarities in brittle steels—for instance, the improvement under impact of nickel-chromium steels after quenching from 600 deg. C. may result from a considerable content of such carbides.

R. S. ARCHER pointed out that although the α, β and γ states of iron had been established by a study of the physical properties, allotropy involved molecular rearrangement. Such molecular arrangements in nature are known to be simple, yet there were not so very many simple arrangements possible. Most of the evidence regarding elastic recovery after strain could be harmonized with Beilby's amorphous theory, especially since the phenomenon was by no means limited to iron. If a ferrite crystal be overstrained to the point where slip occurs at one plane, the freshly formed amorphous material along that slip plane is very weak and has a low adhesion—which is the reason why slip can take place by stages. This temporary great mobility at any rate passes quickly, and after a time the amorphous phase hardens and the adhesion becomes very great. If, however, the deformation takes place at about 300 deg. C., the hardening of the amorphous phase is much more rapid, with the result that the stress occurs in parallel planes. An equal deformation at this temperature is consequently accompanied by the development of a largely increased number of slip planes, a largely increased proportion of amorphous material, and a correspondingly enhanced brittleness.

F. N. SPELLER asked whether the so-called "crystallization of steel in use" was not another occurrence within the scope of this investigation. It at least apparently involved the formation of considerable amorphous material in such important grades as soft and medium steels. His experience indicated that there were other causes than alternating loads for "crystallization" failures, since granular fractures occurred at places well removed from loci of maximum strain.

W. E. RUDER agreed that magnetic aging was a peculiar fact which a very extensive investigation had failed to explain. The only clue discovered to date was that an annealing in hydrogen nearly but not entirely prevents magnetic aging in low-carbon steels. In such a complex series of evidence, however, he felt that it would be extremely surprising if one simple fact could be discovered which would completely explain it all.

S. L. HOYT argued that if allotropy were the material cause of some discontinuities—such as, for instance, a slight break in the rate of expansion of steel at a blue heat—the fact should be studied in the light of what we know about allotropy. In other words, the transformation should be reversible, and give evidence of lag, especially owing to sluggishness of atomic movement at low temperature. Thus, extensive tests on complete cycles of heating and cooling would be needed to establish Dr. Jeffries' contentions.

The author in reply acknowledged that Langenburg's point was well taken; in fact, he did not contend that blue brittleness of Ni-Cr steels (the so-called Krupp Krankheit) was due to a low-temperature allotrope. However, the peculiar variation of tensile properties with heat cannot be due to a carbide transformation, since they occur in pure iron as well as in steels. Even admitting that the general effect of stress and time is to produce slip bands and subsequent failure by virtue of a local, irreversible deformation, Dr. Jeffries felt that the quantitative effect in iron strained at blue heat was enormously greater

than could be ascribed to a theory similar to that adopted by Archer. In this connection he also called attention to a hypothesis advanced by Radcliffe Furness, that if ferrite goes to grain boundaries at temperatures above the low critical, then the same tendency will persist in sorbitic ferrite at a lower temperature. This tendency, being satisfied to a minute degree, would produce thin films of ductile ferrite at boundaries of sorbite grains, shells which though ductile are much weaker than the kernels they surround. Consequently intracrystalline fracture in such steels will simulate brittleness.

Added Life for Factory Roof Timbers*

It is only necessary for the investigator to view the roof trusses of a number of buildings housing chemical apparatus to note the rapid decay caused by high humidity and the inroads of acid fumes. It is believed that a number of the preservative treatments which are suggested in the following paragraphs, if applied either during construction or after erection, would mean increased returns to the company through added life given to the wood members.

The steeping process of preserving timber consists merely in soaking the timber in a water solution of a preservative such as zinc chloride, sodium fluoride or mercuric chloride. Thoroughly seasoned wood is used and left in the solution one day for each inch in thickness and one additional day.

After treatment the timber should be air dried before using. Zinc chloride attacks lead paint, but is very desirable otherwise. Mercuric chloride is very effective, but is poisonous and has a decided corrosive action on steel, so that steel tanks cannot be used with it. Sodium fluoride does not attack paint, is not corrosive, and in most other respects is very desirable.

Timbers may be coated with coal-tar creosote by brush treatment, by dipping in hot oil from 5 to 15 min., or the hot and cold bath method. This last method consists of submerging the lumber in hot oil for several hours and then either allowing the oil to cool down slowly with the wood in it or plunging the wood into cool oil and leaving it for several hours. This method of preservation is objected to by some insurance companies as a fire hazard, but whether or not it really does add greatly to the inflammability of wood is a debatable question.

Although pressure treatments are the most expensive, they are the most effective, because they result in the greatest absorption and penetration of preservatives. Roof planking should receive 8 to 12 lb. of creosote per cu.ft., or ½ lb. of the salt if zinc chloride is used. Such treatment should add at least 20 yr. to the life of roof planks.

The effectiveness of treating timbers depends upon maintaining a complete envelope of treated wood around the untreated interior of the piece. If this treated layer is broken through, decay can enter and destroy the untreated interior in spite of the treated outer layer. For this reason lumber should be cut to final dimensions before treatment. Whenever it does become necessary to cut into treated timber, the untreated wood exposed by cutting should be given two fresh coats of creosote or some other preservative.

*Abstracted from Forest Product Laboratory "Technical Notes."

American Institute of Baking

The American Institute of Baking, founded by the American Association of the Baking Industry, has begun work in Minneapolis under the direction of Dr. H. E. Barnard, assisted by an advisory committee of the National Research Council and in co-operation with the Dunwoody Institute. Dr. Barnard has been connected with the State Board of Health of Indiana for nearly nineteen years and was Federal food administrator of that state during the war.

For thousands of years bread-making has been a craft rather than a science, and in all its essentials and in many of its details it has remained practically unchanged for ages. The attempt is now to be made to make bread-making a science, or at least to found it on science. Some of the larger baking companies have already tested the value of science as applied to their business, and one of these companies, using more than a million barrels of flour a year, has introduced methods leading to great economies in its work. It was found that by furnishing the yeast with certain stimulants and special chemical foods a saving of some of both the flour and sugar formerly consumed by the yeast during its growth was made. This is not only a saving to the baker but also a conservation of valuable human food materials without any diminution in the quality or food value of the bread.

However, but few of the 28,000 bakers in the United States are in a position to conduct scientific experiments or to have them conducted for them separately. Of these 28,000 bakers, only 7,500 use more than 50 bbl. of flour a month, while only 2,500 use more than 200 bbl. a month. For each one of these bakers to try to engage in scientific research would obviously result in a waste of effort even if the expenses could be met, but by working in co-operation, as now arranged by the new Institute of Baking with the scientific aid of the specialists on food and nutrition, agriculture, chemistry and physics of the advisory committee of the National Research Council, all of these bakers can get the advantage of a strong scientific effort for the rational improvement of their methods.

War Zone Reconstruction

The European technical press estimates that there was over 3,000,000 tons of copper thrown from artillery in France and Belgium, and 100 tons of steel per acre (250 tons per hectare) buried in large districts where heavy bombardment persisted. One-third of the total copper and a much larger percentage of the steel will be recovered.

Reconstruction in the French steel and iron industry will require from eight to ten years, mainly because the towns in which the plants are located were 98 per cent destroyed. While nothing has been done toward clearing away the débris around the large steel plants, out of the 500 smaller metal-treating and fabricating plants of the regions 47 per cent have resumed operation, employing, however, only 14 per cent of the original working force.

The damage in the Lens coal district is estimated as 80 per cent of the total valuation of the property. Before pumping can be commenced the holes in concrete shaft linings and tunnels must be discovered and restored, as no headway can be made against the seepage in the moist territory surrounding until this is done.

A Contribution to the Study of Flotation

An Analysis of Circumstances Connected With a Paper by H. L. Sulman in the "Transactions" of the Institution of Mining and Metallurgy—Doubt Cast on the Reliability and Sincerity of the Contribution

BY AN OCCASIONAL CONTRIBUTOR

THERE has recently appeared in the *Transactions* of the Institution of Mining and Metallurgy a paper by H. L. Sulman entitled "A Contribution to the Study of Flotation,"[1] which, because of the many circumstances surrounding its origin, requires more careful and dispassionate scrutiny to give it the value in technical literature which should be attached to it than any other paper appearing in recent years.

Mr. Sulman is a past president of the Institution of Mining and Metallurgy and in the part which he has taken in the discussions at the Institution's meetings he has shown himself to be an astute student of science. But he has also occupied another relationship to the development of science and industry, in that he has been engaged in the invention and patenting of processes of ore-treatment and is now and for years past has continuously been in the employ of one of the most widely known companies which has patented and exploited concentration processes.

The greatest of all Teachers long since uttered a truth of universal application when He said: "No man can serve two masters, for either he will hate the one and love the other, or else he will hold to one and despise the other. Ye cannot serve God and Mammon."

Let us look into the facts in the case and, if we can, ascertain which master Mr. Sulman is serving at this time.

H. L. Sulman and H. F. K. Picard wrote a treatise on flotation concentration some years since. In the preface of the first edition of his work entitled "Concentration of Ores by Flotation," published in July, 1912, Theodore J. Hoover, now professor of mining and metallurgy at Leland Stanford Junior University, states:

> To H. Livingstone Sulman and Hugh F. K. Picard, of the firm of Sulman & Picard, I am indebted for many ideas absorbed from them through three years of pleasant professional association, during which time they were consulting metallurgists to the above company (i.e., Minerals Separation, Ltd.). They have in preparation a book on the "Theories of Concentration Processes Involving Surface Tension," which will be a work of high scientific merit. I have endeavored, I hope successfully, not to trespass on any new and unpublished ground, the announcement of which rightfully belongs to them; further it is not my desire to present the subject in so profound a manner as they will do, deeming it of considerable more use to engineers to leave for another occasion the discussion of mathematical and physical laws involved.

In the third edition of the same work, published in 1916, Mr. Hoover says on pages 257 and 258:

> G. D. Van Arsdale has given some excellent results of his investigation of surface films and contact angles, and brings the solution of a number of hitherto unsolved problems measurably nearer. Without detracting in the least from the merit of his work, or in any way depreciating his discoveries, it is only right to say that these things and many others of equal, if not greater, importance to science have been discovered and clearly and definitely quantified by H. L. Sulman and H. F. K. Picard. As mentioned in the preface to the first edition, they have for years been working on the physical factors involved in flotation processes, and have had for many years a voluminous work completed and ready for publication.
>
> This manuscript is among the archives of the Minerals Separation, Ltd., who adopt the attitude, in this case, of censors. If it is the intention of the company to regard themselves as being in a state of war against the whole metallurgical industry, there might be some justification for an embargo on the publication of scientific information; but they have received at the hands of the state a valuable monopoly in a great industry, against which they should not wage war; but, on the contrary, they should act with frankness and candor toward those with whom they seek to do business, and from whom they expect to draw the revenue assured to them by their monopoly.

Mr. Hoover's references to this book indicate such familiarity with its contents as could only come from a detailed and continued study of it.

In the *Mining Magazine*,[2] in an editorial upon the presentation of Mr. Sulman's paper to the Institution, we read in part as follows:

> And here it is appropriate for us to say that the reading of the paper has been delayed many years, owing to the litigation in connection with Minerals Separation's patents. In the meantime other investigators have published views and theories, and they and their friends have prided themselves that they knew more of the physics of the process than the original patentees. But though Mr. Sulman never wrote anything on the subject, he was immersed in study and research from the beginning. A dozen years ago the present writer saw a book[3] which Mr. Sulman had ready for publication. All the diagrams figuring in the paper were in this book, as well as the word "hysteresis," which Prof. Boys said the other night was invented three years ago. Naturally much research has been done since then, and the services of the principles of colloid chemistry and adsorption have been requisitioned. But the fact remains that Mr. Sulman was a pioneer in the scientific study of the physics of the process as well as an inventor of the successful process.

The *Bulletin* of the Institution of Mining and Metallurgy for January, 1920, is given up largely to a discussion of Mr. Sulman's paper and to a paper by Walter Broadbridge entitled "Froth Flotation—Its Commercial Application and Its Influence on Modern Concentration and Smelting Practice."

The comments upon the Sulman paper vary from the laudatory to the most sharply critical.

Sir Thomas K. Rose, whose "Metallurgy of Gold" has long been considered a classic and an authority, commented that "he had heard that Mr. Sulman had written a book on the subject, ten or twelve years ago, which had never been published, and that most of the paper was contained in it. He wished he could have seen that twelve years ago, because by this time he might have been in a position to discuss the matter usefully."[4]

[1] *Bulletin* Institution of Mining and Metallurgy, November, 1919.

[2] *Mining Magazine*, December, 1919, p. 323.

[3] This was probably a copy of the treatise referred to in Hoover's "Concentration of Ores by Flotation."

[4] *Bull.* I. M. M., January, 1920, p. 10.

Sir Thomas also commented upon the fact that the paper should have contained some data upon which is based the revelation that cassiterite has been proved to be concentratable by flotation.

E. Hatschek reviews the Sulman paper *in extenso* from the standpoint of the physicist,[5] and differs from many of the author's conclusions. He states, in italics, that the *"facts are incorrectly stated in every essential particular"* (p. 75) as regards the fundamental phenomenon, cataphoresis. (*Ibid.*, p. 19.)

He further comments: "Considering the large amount of theoretical matter of an elementary nature which Mr. Sulman has included in his paper, there is a surprising absence of reference to recent work which has the closest bearing on several of the issues raised in it."

In an editorial in the *Mining and Scientific Press*,[6] T. A. Rickard says:

> We think it proper to record a strong protest against Mr. Sulman's unscholarly failure to make the customary references to previous writers on his subject. In the concluding paragraph of the paper he excuses himself for his lapse of good manners by presenting a bouquet to his business associate, John Ballot, until recently the chairman of Minerals Separation, Ltd. Mr. Sulman describes his partner as "one of the original inventors" of the process, when it is well known, on the evidence of Mr. Ballot himself, that he merely instructed a member of his staff, A. H. Higgins, to make a series of experiments, ringing the changes on various proportions of oil, rates of agitation, and so forth, the consequence being to confirm the results obtained a year before by F. A. Beauchamp and Wilton Shellshear in the Central mill at Broken Hill—results of which Mr. Ballot must necessarily have been aware, because his own representative, G. A. Chapman, was on the spot and participating in the Australian experiments.

In replying to the criticisms of his paper Sulman says:[7] "Mr. Hatschek is correct as to my faultiness in matters of form. I am aware that many references are lacking; as before stated, these will be inserted in any reprint of the paper. I also feel that apologies are due for several misprints and for one or two obvious slips; I can only urge that the paper was written under considerable pressure as to time, and that my reading of the proofs was similarly hurried."

Sulman Scientist a Sulman Protagonist?

All of which tends to but deepen the mystery. As has been previously stated, it is known that many years ago Sulman and Picard had "completed and ready for publication" a book on "Theories of Concentration Processes Involving Surface Tension," "which will be a work of high scientific merit."[8] Yet in 1919 we find a paper coming out under the signature of Sulman alone and in a form which Mr. Sulman admits is occasion for apology because of the hastiness and unworkmanlike shape in which it is presented.

It is inconceivable that it is Mr. Sulman, devotee of science, who has not found the time in a dozen years in which to prepare his paper according to the conventions observed by scientists in the presentation of "contributions" to knowledge.

Is it not possible that it is Mr. Sulman, follower of the law and the profits, who has answered an emergency call to publish something promptly which will answer the accusation that his employers have steadily placed a brake upon the spread of knowledge and the development of science? And is it not possible that Mr. Picard, who we have been assured was a co-author with Mr. Sulman in the writing of a treatise prepared years ago, finds it impossible or impolitic to appear as co-author of the paper now hurriedly published?

That these things may be true is suggested by the fact that these gentlemen have for years been debarred from publishing their original scientific treatise by their employer, Minerals Separation, Ltd., which company has been litigating their patents for many years. The suppression of the publication of what is alleged to be a purely scientific treatise strongly suggests that the claims which Minerals Separation, Ltd., has been attempting to establish in the courts have in fact the insecure foundation which has been credited to them by the American mining industry. For if they could stand the full light of science there would never have been any reason for suppressing a scientific discussion of the physical basis of flotation.

American Branch of Minerals Separation, Ltd., Under Federal Scrutiny

The Federal Trade Commission of the United States of America has had the American branch of Minerals Separation, Ltd., under most careful scrutiny. George L. Nye, special counsel for the American Mining Congress in the Federal Trade Commission inquiry, at the St. Louis Convention of the American Mining Congress points out[9] that the British employers of Mr. Sulman were throughout most of the World War maintaining commercial relations with Beer, Sondheimer & Co., and taking all necessary crafty steps to see that that German company which was on the British blacklist should reap the full benefits of its part ownership and management of Minerals Separation's patents. This should be a shock to all good Britishers and be given most serious consideration by the loyal British members of the Institution of Mining and Metallurgy.

Mr. Nye also calls attention to the fact that the license contract issued by Minerals Separation, Ltd., to users of the process covered by its patents "provides that the licensee shall not, without the consent of licensor, communicate any details connected with the working of any of said inventions, modifications, additions, or improvements to any third party. This again emphasizes the restraint imposed by Minerals Separation, Ltd., upon any dissemination of information except under its direction and control. This restraint upon the spread of knowledge is not only adverse to the public interests but is certainly against public policy."[10]

May not this well merited criticism of the suppression of knowledge by one chosen to represent the whole American mining industry, and the investigation by the Federal Trade Commission explain the panic to publish something sounding very scientific, which led to the hasty and slovenly preparation of the Sulman paper?

May not the same necessity for camouflage also explain the appearance in the *Bulletin* of the Institution for January, 1920, of a paper by Mr. Broadbridge, general manager for Minerals Separation, Ltd., which, like the Sulman paper, creates the impression that information of value is being furnished when it is not, and which errs fully as flagrantly as does Mr. Sulman's paper in not giving proper credit to the various engineers who have contributed to making flotation concentration an established art?

---

[5] *Bull.* I. M. M., Jan. 29, 1920, p. 16 *et seq.*
[6] *Mining and Scientific Press*, Dec. 13, 1919, p. 849.
[7] *Trans.* I. M. M., Dec., 1920, p. 48.
[8] Hoover, "Concentrating Ores by Flotation," third ed., p. 258.
[9] *Mining and Scientific Press*, Dec. 13, 1919.
[10] *Mining and Scientific Press*, Dec. 13, 1919, p. 852.

The Effect of Nitrogen on Steel

A Résumé of the Important Literature on Amount of Nitrogen in Various Classes of Steels, Its Method of Occurrence and Effect on Physical Properties, Together With Some Recent Experiments on Its Action During Heat Treatment

BY GEORGE F. COMSTOCK* AND W. E. RUDER†

THE subject of the influence of nitrogen on steel is one that has awakened scant interest among metallurgists until quite recent years, because in spite of the undoubtedly strong effect of this element when presented in small amounts in iron, the amounts actually found in commercial products are generally so excessively minute that even their determination is difficult and the assignment of definite effects to them is nearly impossible in the presence of so many more potent disturbing factors. Perhaps in no other branch of ferrous metallurgy is the conflict between the theorists or laboratory workers and the practical men more pronounced; for in laboratory tests nitrogen appears to be one of the most detrimental of all impurities in steel, while in commercial practice it has not been easy to show any consistent effect. An outline of the published researches on nitrogen in steel will be given below to show the state of our knowledge of the subject at the present time.

EARLY WORK

One of the earliest references to this subject is a paper by A. H. Allen in the *Journal*, Iron and Steel Institute for 1880 (No. 1, p. 181), where an analytical method for nitrogen in steel is given, and results are quoted that indicate its presence in all ordinary steel. The effects of nitrogen were not described in this paper, but in 1887 an article by H. N. Warren in *Chemical News* (vol. 55, p. 155) mentioned the fact that great brittleness could be caused in steel by nitrogen absorbed during heating to a bright red in an atmosphere of ammonia. It was stated that only 0.5 per cent of nitrogen would make steel bars so brittle as to break when dropped from a height of 6 ft. In 1889 H. Tholander published an article in *Jernkontorets Annaler* (vol. 43, No. 7) discussing the practical effects of nitrogen in commercial steel. He found 0.012 to 0.022 per cent nitrogen in bessemer "ingot iron," and 0.005 to 0.013 per cent in open-hearth steel plate, stating his opinion that the difference in quality between these grades of steel was largely due to the difference in nitrogen content. He also suggested that the damage done by overblowing bessemer metal was due to nitrogen absorption rather than to over-oxidation.

In regard to the form in which nitrogen exists in steel, G. I. Fowler in 1894 published an article in *Chemical News* (vol. 68, p. 152) stating his agreement with an earlier writer, Stahlschmidt, that only one nitride of iron, Fe_2N, exists. Two years later a "Note on the Presence of Fixed Nitrogen in Steel," by Harbord and Twynam, appeared in the *Journal*, Iron and Steel Institute (1896, No. 2, p. 161), recognizing that nitrogen may be both mechanically occluded and chemically combined in steel. They investigated the presence in steel of Mn_6N_2, which compound is formed when manganese is heated in nitrogen, but could find no proof of its occurrence in steel. Good average steel was found to contain from 0.006 to 0.017 per cent nitrogen, and no difference in the content of this element was found between bessemer and open-hearth steel, although crucible steel was found to contain less. No connection was found between the nitrogen content and the quality of the steel, although one rail which failed from a flaw was found to be unusually high in nitrogen.

BRAUNE'S PUBLICATIONS IN 1905

After this preliminary work, no more important papers appeared on nitrogen until 1905, when H. Braune published several articles (*Stahl und Eisen*, vol. 25, p. 1,195; *Revue de Metallurgie*, 1905, p. 497; *Jernkontorets Annaler*, vol. 59, p. 636) discussing the influence of nitrogen on iron. He found that nitrogen increased the strength but decreased the elongation of iron. From 0.02 to 0.062 per cent was found in commercial steels. In general it did not have much effect on low-carbon wrought-iron; but in ingot metal or steel 0.035 per cent nitrogen was enough to destroy the elongation when the carbon was high, 0.045 per cent destroyed the elongation of 0.50 per cent carbon steel, and 0.06 per cent made soft acid bessemer steel brittle. Nitrogen was found to affect the magnetic properties the same as carbon. It was thought to occur as the nitride Fe_8N_2 in solid solution in ferrite. When 0.075 per cent nitrogen was present, the grain-size was reduced to one-tenth its normal size, and a brittle substance began to appear at the boundaries. With 0.2 per cent, the steel had a pearlitic appearance, or, as discussed by Le Chatelier, it may be said to show Neumann's lines which were often found by Osmond in brittle steel. Braune stated that steel will absorb nitrogen in every metallurgical process with high temperature, basic slag, and reducing conditions or in presence of carbon. He described a case where nitrogen produced brittleness in Lancashire hearth-iron made from pig coming from a blast furnace that produced large quantities of cyanide.

BRAUNE'S WORK CRITICIZED

This work of Braune was rather severely criticized in several quarters, Pourcel in the *Revue Universelle des Mines* (vol. 15, p. 229) contending Braune's statements were not probable, that nitrogen would be absorbed or retained in steel made in the oxidizing atmosphere of both bessemer and open-hearth processes. Grabe in *Revue de Metallurgie* (vol. 5, p. 353) and Petren and Grabe in *Jernkontorets Annaler* (vol. 60, p. 1) maintained that Braune's chemical methods were incorrect, giving too high results for nitrogen. They conclude that the minute percentages of nitrogen actually existing in

*Metallurgist, Titanium Alloy Manufacturing Co.
†Metallurgist, General Electric Co.

commercial steels had no influence on mechanical quality.

The first of the *Carnegie Scholarship Memoirs* (1909) of the Iron and Steel Institute contain some notes on the "Influence of Nitrogen on Steel," by Walter Geisen. He states that the elongation of steel entirely disappears with an increase in nitrogen from 0.037 to 0.041 per cent, and that hard steels are more sensitive to nitrogen than soft ones. The superiority of crucible steel was explained by its low nitrogen content, and vanadium's value in steel was thought to be due to its removal of nitrogen.

Nitrogen and Phosphorus in Boiler Plate

The next important reference to nitrogen in steel is C. E. Stromeyer's work, published in the *Journal*, Iron and Steel Institute (1909, No. 1, p. 404) under the title "Aging of Mild Steel and Influence of Nitrogen." In his exhaustive investigation of the effect of aging on steel, no reason was found by tests for the occasional brittleness of plates failing in service, except the influence of phosphorus and nitrogen. The worst steels were found to contain either the highest nitrogen or phosphorus, or both, and nitrogen was found to have a much greater effect than phosphorus. Results from cold bend tests by impact on plates previously bent at a blue heat were found to depend distinctly on nitrogen and phosphorus, and it was advised that these elements be reduced as low as possible in high-class boiler steels. The following suggestive formula for the tenacity of such steel in tons per sq.in. is advanced by Stromeyer:

$$T = 17.2 + 35C + 10Si + 2.5(Mn - 1.72S) + 30P + 300N$$

In another paper, before the British Institute of Naval Architects in 1910, the same author stated that the sum of the phosphorus content plus five times the nitrogen content should not exceed 0.08 per cent in good mild plate steel. He also mentioned some boiler plate that appeared very bad in tests, although containing only 0.047 per cent phosphorus; but it had 0.0123 per cent nitrogen, over twice as much as was found in good mild plate steel.

Stromeyer's conclusions were, however, not accepted in some quarters, Saniter especially throwing considerable doubt on them in discussing the paper. It was pointed out by him that all Stromeyer's steels were quite pure, and others had found good steel to contain more nitrogen than was shown by his samples. Furthermore by not considering the samples with over 0.06 per cent phosphorus, he showed that Stromeyer's results on bending did not really bear much relation to the nitrogen contents, or to the phosphorus plus five times the nitrogen, which was the merit figure used by Stromeyer.

Nitrogen's Influence on Steel

An interesting letter in Metallurgical & Chemical Engineering (vol. 11, 1913, p. 121) by "E. D. A." entitled "Nitrogen, Its Influence on Steel," also discusses these results. This letter admits that in general nitrogen promotes brittleness in steel, although the manner in which this is effected is not known. In various steels the nitrogen content was found to run from 0.003 to 0.014 per cent. Open-hearth steels averaged lowest in nitrogen, electric steels next, and one bessemer rail showed the most. One electric steel treated with ferrotitanium showed less nitrogen than the untreated average. In comparing actual physical test results with Stromeyer's merit figures derived from the nitrogen contents as mentioned above, the latter were found to be of small significance, as two out of the three best steels stood lowest in regard to the phosphorus and nitrogen merit figure. Merit figures are thus concluded to be not uniform or consistent.

Suppression of Transformations by Nitrogen

Probably the most important work that has been done along theoretical or laboratory lines on nitrogen in steel is that by J. H. Andrew, published in two papers by the Iron and Steel Institute. One of these was on "The Influence of Gases Upon the Critical Ranges of the Iron-Carbon Alloys," published in the *Carnegie Scholarship Memoirs* (vol. 3, 1911, p. 236); the second was entitled "Iron and Nitrogen" and appeared in the *Journal* (1912, No. 2, p. 210). Andrew found that heating and cooling in ammonia gas had a marked effect on the critical points of steel, which effect was overcome by reheating a number of times *in vacuo*. The effect was explained by his finding that while CO, CO_2 and hydrogen had no action on the critical changes in iron, 0.3 per cent nitrogen entirely suppressed them. In a 0.60 per cent carbon steel, 0.25 per cent nitrogen lowered the Ar_1 point decidedly. The embrittling effect of nitrogen on steel was considered due to the tendency of the dissolved nitride to retain iron in the gamma state and the carbide in solution. Only a very small amount of nitrogen is needed, and the nitride is not unstable, remelting or prolonged heating *in vacuo* being necessary to extract it all. Iron nitride was considered by Andrew to prevent the coalescence of the iron molecules at the critical point, thus retarding the changes. Iron and iron-carbon alloys were found to absorb small amounts of nitrogen when melted under a high pressure of the gas, so that ammonia is not essential to this absorption.

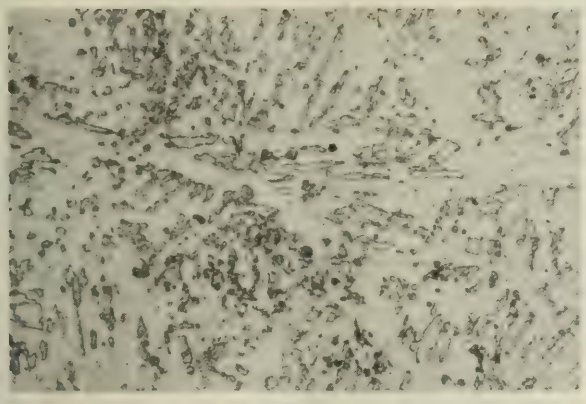
Needles, Neumann's or Slip Bands

Photomicrographs of nitrogenized iron are given by Andrew, showing needles called Neumann lines, and near the edges of the sample a pearlitic structure with a dark needle-like constituent and a pale yellow substance surrounding it. A quickly cooled specimen with 0.16 per cent carbon, nitrogenized while molten, showed a white constituent like cementite. This was stated not to be pure nitride or carbide, because the sample showed neither critical points nor carbide change; but it was considered a solution of iron-nitride in iron. Dr. E. Colver-Glauert, in a rather theoretical discussion of Andrew's paper, stated that he considered the needles or cementite-like substance to be nitride of iron, and he believed the carbon was expelled from the steel, probably as a cyanide, during the nitrogenizing treatment, and was not dissolved in the steel or nitride.

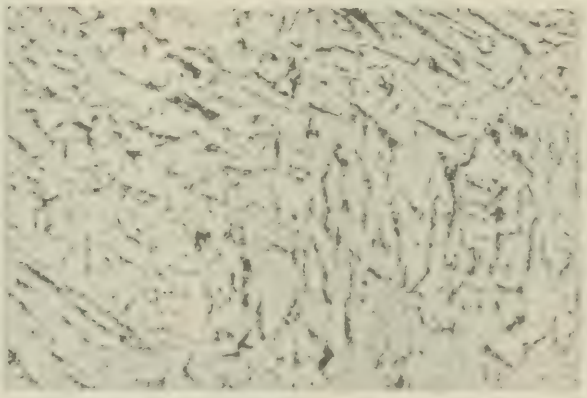
A German investigation of nitrogen in steel by B. Strauss (*Stahl und Eisen*, 1914, vol. 34, p. 1,814, and *Iron Age*, 1916, vol. 97, p. 432) resulted in the conclusions that it raised the elastic limit and tensile strength, but reduced the ductility; also that it impaired the magnetic properties, raising the hysteresis and coercive force, and lowering the permeability. This writer thought the needles or Neumann lines in nitrogenized iron were slip bands due to brittleness of the iron caused by solution of nitrogen in it, the slips being produced in polishing or cutting the specimens. Pearlitic and other structures were described due to the combination of nitrogen with carbon in steel, and it was stated that the nitrogen was quickly given off from the steel by annealing in air, hydrogen, or vacuum.

1

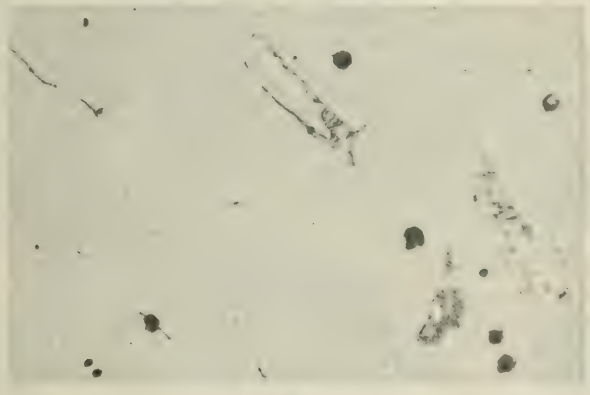
2



3

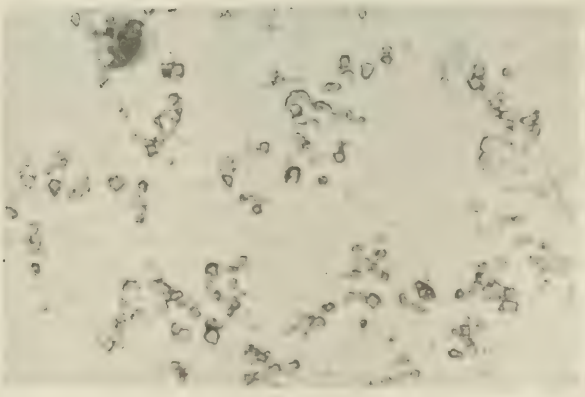


4



5

6



7

Fig. 1—Nitrogen forming needles and laminated patches. Fig. 2—Nitrogen in laminated area. Fig. 3—Nitrogen in rapidly cooled arc weld. Fig. 4—Nitrogen in slowly cooled arc weld. Fig. 5—Nitrogen particles in full blown bessemer metal. Fig. 6—Titanium nitride in 0.50 per cent C electric steel. Fig. 7—Titanium nitride in special arc weld. Fig. 2 × 1,200. Fig. 6 × 200. Others × 400.

A voluminous treatise on "The Occurrence and Influence of Nitrogen on Iron and Steel," by N. Tschischewski, appeared recently in the *Journal*, Iron and Steel Institute (1915, No. 2, p. 47). The author considered that the injurious influence of nitrogen on the mechanical properties of iron had then been firmly proved. He found that it increased hardness, reduced elasticity, and caused cold-shortness in steel; and that bessemer steel contained five times as much nitrogen as open-hearth. Metallographic work on iron nitrogenized in the laboratory with ammonia showed a very brittle outer film, found to contain 11 per cent nitrogen, which was considered to be the compound Fe_2N. A hard, less brittle layer below was considered $Fe_{12}N$, with 2 per cent nitrogen. The needles in the interior were believed to be this compound. Different structures were found due to different rates of cooling: needles, or spots like a eutectic, or even massive like martensite when quenched. Nitrogen was said to be indistinguishable under the microscope when present in less quantity than 0.05 per cent. Wire with 0.3 per cent nitrogen was very brittle.

In the discussion of this paper both Stead and Stromeyer agreed that bessemer steel contained more nitrogen than open-hearth. It was suggested that the form in which nitrogen occurred in the steel, whether uniformly distributed or around the grains, would have an important influence on its effects on the properties; also the nitrogen absorbed from ammonia might have a different effect than that added directly from air as in a converter. Stead considered that temperature conditions must affect the absorption of nitrogen in practice. Pourcel considered this paper impractical, as ordinary steel never contained over 0.015 per cent nitrogen, and higher contents than this, as sometimes found in titanium steels, never did any harm. Even nitrogenized steel showed only about 0.015 per cent nitrogen after remelting.

It was brought out in connection with this paper that a committee of prominent English metallurgists are investigating this subject of nitrogen in steel thoroughly, to decide between the conflicting reports, and they should have their final opinion published soon.

Removal by Titanium or Vanadium

Another interesting reference to nitrogen in steel is an abstract of an article by Tschischewski and Blinow in *Revue de Metallurgie* (Extraits, 1915, vol. 12, p. 473). It was found by these investigators that neither 33.5 per cent ferrovanadium nor metallic titanium 83.2 per cent pure removed nitrogen from iron, but formed soluble nitrides, thus sometimes even increasing the nitrogen content, especially in the presence of manganese and silicon. They advised a shortening of the melting period of titanium or vanadium steels to prevent the absorption of too much nitrogen.

Their conclusions, however, are directly at variance with results obtained by the Titanium Alloy Manufacturing Co. on nitrogen in titanium-treated and untreated rail steels A dozen pairs of open-hearth steel rails were investigated for nitrogen in the company's laboratory; each sample representing a different heat, but each titanium-treated sample coming from the same rolling as the corresponding untreated sample. Practically all these samples were "A" rails, or from the tops of ingots, and the treated steels received 0.1 per cent metallic titanium in the form of ferro-carbon-titanium alloy in the ladle. They were analyzed according to the method described by L. E. Barton in the *Journal of Industrial and Engineering Chemistry*, vol. 6, p. 1,012 ("Improved Method for the Determination of Nitrogen in Steel"), and the writer is also indebted to Mr. Barton for the results tabulated in Table I and obtained under his personal supervision.

TABLE I. NITROGEN CONTENTS OF OPEN-HEARTH RAILS

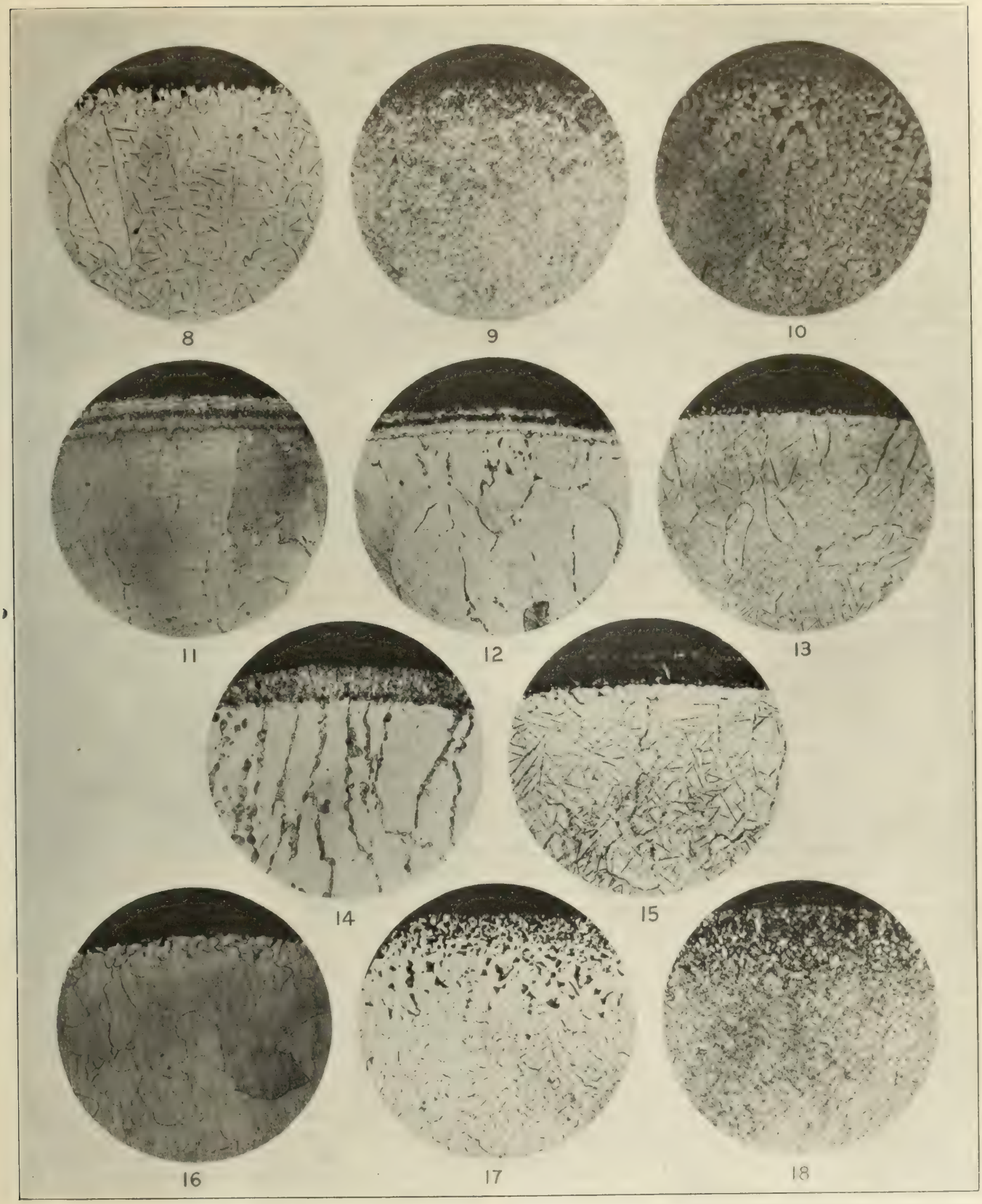
Mill	Rolling	Untreated Samples	Titanium-treated Samples
A	1	0.0038	0.0027
A	2	0.0054	0.0035
A	3	0.0047	0.0044
		0.0039	0.0035
		0.0034	0.0031
A	4	0.0040	0.0032
A	5	0.0048	0.0038
		0.0040	0.0034
B	1	0.0056	0.0034
B	2	0.0059	0.0029
B	3	0.0046	0.0046
B	4	0.0048	0.0040
Average		0.0046	0.0035

These figures show a quite consistent decrease in nitrogen content in the titanium-treated steels, and indicate without much doubt that titanium has an influence on nitrogen in steel. In bessemer and electric steel considerably more nitrogen has been found, the results usually being around 0.02 per cent. This agrees with the conclusions of most other investigators, that in the bessemer process where air is blown through the steel, or in the reducing conditions of the electric furnace, more nitrogen is absorbed than in the oxidizing open hearth, where the slag intervenes between the air and metal.

On Nov. 12, 1918, the Faraday Society held a general discussion on occlusion of gases by metals, and this subject was covered thoroughly by several authorities. Most of the discussion was, however, along the lines of the contamination of metals by all gases in general, and the effects and prevention of the resulting unsoundness. Sir Robert Hadfield in the introductory remarks of this symposium reviewed some of the previous important work on the subject, and gave a bibliography including the work on nitrogen in steel, as well as on the general subject of the occlusion of gases.

Nitrogen in Fusion Welds

The recent increase in interest in the art of fusion welding of steel by the arc or oxy-acetylene processes, on account of their use in place of riveting in ship construction, has caused attention to be drawn to the absorption of nitrogen during this operation. One of the earliest articles dealing with this phase of the nitrogen question was that by B. Strauss mentioned above, which appeared first in *Stahl und Eisen*, and was abstracted later in the *Iron Age* (1916, vol. 97, p. 432). Another was written by S. W. Miller, entitled "Some Structures in Steel Fusion Welds" which appeared in the *Transactions* (1918, vol. 58, p. 700), American Institute of Mining Engineers. Miller gave numerous illustrations and careful descriptions of the needles and other structures due to nitrogen occurring in iron deposited in his welds, but he then considered that the constituent producing these structures was cementite. Later he admitted that the needles, etc., were probably due to nitrogen, and in another paper, "Path of Rupture in Steel Fusion Welds" (*Bulletin*, American Institute of Mining Engineers, No. 146, Feb., 1919, p. 311), he gave another interesting series of illustrations of these structures. He reached the conclusion here that the brittleness of steel fusion welds was primarily due not to the needles or other forms of occurrence of nitrogen, but to extremely thin intercrystalline films presumably of oxide.



Heat Treatment of Nitrogenized Iron

Fig. 8—Vacuum fused electrolytic iron, nitrogenized in NH_3.

Fig. 9—Same metal as Fig. 8, heated to 600 deg. C. for 15 min., quenched in water.

Fig. 10—Same bar as shown in Fig. 9, after being heated to 600 deg. C. and quenched in water, then reheated to 600 deg. C. and slowly cooled.

Fig. 11—Same metal as Fig. 8, heated to 700 deg. C. for 15 min., quenched in water.

Fig. 12—Same as Fig. 11, more deeply etched.

Fig. 13—Same bar as shown in Fig. 11, after being heated to 700 deg. C. for 15 min. and quenched, then reheated to the same temperature and slowly cooled.

Fig. 14—Same metal as Fig. 8, heated to 800 deg. C. for 15 min. and then quenched in water.

Fig. 15—Same bar as shown in Fig. 14, after being heated to 800 deg. C. for 15 min. and quenched in water, then reheated to the same temperature and slowly cooled.

Fig. 16—Same metal as Fig. 8, heated to 950 deg. C. for 15 min. and quenched in water.

Fig. 17—Same bar as shown in Fig. 16, after being heated to 950 deg. C. for 15 min. and quenched in water, then reheated to the same temperature and slowly cooled.

Fig. 18—Same metal as Fig. 8, annealed at 1,000 deg. C. for 15 min. and slowly cooled.

All × 50

The microstructure of a fusion weld containing nitrogen, both as made and after heat-treatment, was described in a paper by G. F. Comstock entitled "Microstructure of Iron Deposited by Electric Arc Welding" in the January, 1919, *Bulletin*, American Institute of Mining Engineers (No. 145, p. 43). It was found that the nitride was not easily removed from the steel by heating in air, and that there is no simple metallographic method for distinguishing between iron nitride and carbide (cementite) in steel. A more comprehensive description of the structures of nitrogenized iron and iron deposited by the electric arc was given in an article by W. E. Ruder, "The Metallurgy of the Arc Weld," published in the December, 1918, number of *General Electric Review* (vol. 21, p. 941). Nitrogen is here stated to occur in iron in the form of lines or plates, or as dark eutectoid patches not unlike pearlite, or as a cement between the grains. In carbon steels there may be no metallographic evidence of nitrogen, although 0.15 per cent may actually be present. As little as 0.06 per cent nitrogen will reduce the elongation of a 0.20 per cent carbon steel from 28 per cent to 5 per cent. In regular steel it is present in only very small amounts (0.02 per cent in bessemer to 0.005 per cent in open-hearth), but under the conditions of arc welding it seems to become much more active, and combines either directly with the iron vapor or indirectly by means of nitrogen-oxygen compounds. Ruder states that both nitrides and oxides must be removed before such a weld can be ductile, but no scavenging agent has yet been found which will retain any efficacy after passing through the arc. Various experiments are described by Ruder which resulted in proving that the lines or needles found in welds are certainly due to nitrogen.

Microscopy

Some photomicrographs are included in this article to illustrate some of the structures produced by nitrogen in steel. Fig. 1 shows some iron specially nitrogenized in the General Electric Co.'s laboratory, illustrating two forms of occurrence, needles and pearlitic masses. This specimen was etched with boiling alkaline sodium picrate to darken the nitride, and was photographed at a magnification of 400 diameters. Fig. 2 shows one of the pearlitic masses in the same specimen magnified three times as much. Figs. 3 and 4 show two modes of occurrence of nitrogen in an electric arc weld, both taken at a magnification of 400 diameters after etching with nitric acid. The former shows the weld as made, cooled very rapidly by the cold steel plate that was welded; the latter is a slightly annealed specimen cooled more slowly. Fig. 5 shows some needles or small particles of nitride found in bessemer blown metal cast without deoxidation or recarburization. The sample was of course very porous, and full of oxide globules. This was etched with picric acid and magnified 400 diameters. Figs. 6 and 7 show typical crystals of titanium nitride in steel, both unetched, the former in a titanium-treated 0.50 per cent carbon electric steel, magnified 200 diameters, and the latter in an arc weld made with a hollow electrode filled with pulverized metallic titanium, magnified 400 diameters. These titanium nitride crystals are very hard and angular, and are orange-pink in medium- or high-carbon steel, and yellow when the carbon is low. They are thus easily recognized with the microscope by their color and form.

From this outline of the present knowledge regarding nitrogen in steel, it appears that many of the theoretical aspects are still to be worked out. The structures, for instance, have not been thoroughly explained, nor the compounds, solubilities and other properties definitely settled. Neither is it clear why the structures change on heat-treatment as they do, since the alloys lack critical points.

The embrittling effect of nitrogen on steel has been definitely established beyond question, but no practical cure for this condition in fusion welds has been proposed so far. In ordinary commercial steel there is yet considerable doubt and difference of opinion as to just what practical importance attaches to the very minute amounts of nitrogen that can be found. Considering all the evidence available, it does not seem proved that the amounts of nitrogen present in commercial steel, except in circumstances so extraordinary as to be negligible in the long run, are of any particular detriment to the quality. There are also differences of opinion in regard to the removal of nitrogen from steel by titanium treatment when melted. Unquestionably, however, a nitride of titanium is formed, and a majority of the evidence supports the view that this nitride tends to separate and rise from the steel. The idiomorphic character of the crystals shows that they are insoluble in the liquid steel. At any rate when present in the form of these crystals, the nitrogen could not have the same embrittling effect as it might have when dissolved as iron nitride in the ferrite. G. F. C.

Recent Experiments on Nitrogenized Iron

Having noted the variety of opinions expressed by previous writers as to the metallographic appearance of nitrogenized iron and the effect of annealing upon the structure of fusion arc welds (see Figs. 3 and 4, also Ruder, *General Electric Review*, vol. 21, p. 941), the following experiments were undertaken to determine the effect of heat treatment, particularly the rate of cooling, upon the microstructure of nitrogenized pure iron.

A ¼-in. swaged bar of pure vacuum-fused electrolytic iron was nitrogenized by heating to 700 deg. C. for about 3 hr. in a stream of pure NH_3. It was then cut up into five parts, each of which had a structure as shown in Fig. 8.

Piece 1 was then heated to 600 deg. C. for 15 min. and quenched in water (Fig. 9). After examination it was again heated to 600 deg. C. for 15 min. and allowed to cool with the furnace (Fig. 10). The micrographs show that this short heating to 600 deg. was sufficient to cause absorption of the needles by the ferrite and in the quenched sample the nitride needles are largely held in solution. Upon slow cooling from this temperature the nitride does not re-appear as needles but as pearlitic patches (as in Fig. 2) and intergranular material.

Sample 2 was then heated to 700 deg. C. for 15 min. and quenched in water (Figs. 11 and 12), following which it was reheated to 700 deg. C. for 15 min. and slowly cooled. Quenched from this temperature the grains are much larger than when quenched from 600 deg. C. and the only appearance of the presence of nitrogen is at the grain boundaries, which widen and become more distinct upon deeper etching. On slowly cooling the reheated sample, however (Fig. 13), the needles again make their appearance. Apparently a temperature of at least 700 deg. C. with slow cooling is required to show any needles. In this case the nitrogen appears both as needles and widened grain boundaries.

Sample 3 was treated the same as the previous ones, except that in this case the temperature was 800 deg. C.

The results were about the same as when treated at 700 deg. C., except that the grain boundaries are wider and not quite so dark (Fig. 14). On slow cooling the needles reappear as before (Fig. 15). Subsequent reheating and quenching brought back the structure shown in Fig. 14.

Sample 4 was treated in the same manner except that the temperature was 950 deg. C. At this temperature practically all the nitride is absorbed in the ferrite and is retained in solution by quenching, so that the micrographic appearance is practically that of pure ferrite. On slow cooling, the grain is much smaller and the nitride appears as needles and at the grain boundaries. Considerable diffusion of the outside nitride band inward has also taken place. This is significant in view of Strauss' contention that the dark pearlitic areas are due to the presence of carbon introduced by impurities in the ammonia. Inasmuch as these particles do not occur in the original bar as nitrogenized (Fig. 8), but do occur and disappear with heat treatment, it would seem that carbon had nothing to do with their occurrence.

Fig. 18 shows the appearance of the bar when heated to 1,000 deg. C. and slowly cooled. Both needles and widened grain boundaries are shown. Decided grain refinement with rapid diffusion inward of the outside nitride band is also evident.

Conclusions

In view of these results it seems evident that nitrogen may occur in a variety of forms, depending upon the rate of cooling and the degree of heat applied. The needles now commonly accepted as indicating the presence of nitrogen may not be visible at all, even in highly nitrogenized steel. The same is true of the widened grain boundaries. The presence of carbon does not seem to be necessary to the formation of the dark pearlitic-appearing patches. They are rather a function of the percentage of nitrogen present and the rate of cooling.

To call these needles Neumann lines or slip bands caused by cutting for polishing is erroneous, for if they were the former they should disappear on heating above Ac_3, which they do not, and if the latter, they should appear in the quenched as well as in the slowly cooled samples. These lines appear rather to be a nitride of iron which is entirely soluble at temperatures above 700 deg. C. in ferrite and retained in solution by quenching but rejected at the boundaries and cleavage planes on slow cooling.

Experiments described in a previous paper (*General Electric Review*, vol. 21, p. 941) show that nitrogen in steel is quite stable and may be driven off only after prolonged heating at a high temperature *in vacuo*, or by passing hydrogen over the sample at about 600 to 700 deg. C.

W. E. R.

Rubber Tires in China

It is reported that the rubber tire industry is getting to be so large in China that manufacturers are talking of starting their own factories in that country. While Peking has less than 1,000 automobiles, there will be many thousands of motor vehicles in operation in the near future.

The typical vehicle of today is the jinrikisha, and rubber tires are being employed. Every 24 hours 50,000 of these jinrikishas pass through the great central gateway of Peking.

Problems Investigated at the Color Laboratory, Bureau of Chemistry

By H. D. Gibbs

THE Color Laboratory of the Bureau of Chemistry was organized early in 1916, for the purpose of studying colors, their formation and uses. Shortly after its organization Congress appropriated $50,000 for the first year, and since that time two appropriations of $75,000 each for the second and third years, and for the fourth year, beginning last July, $100,000 has been secured to carry on the work, providing for personnel, building and equipment. The immediate object of the work has been to make detailed studies of reactions, processes and apparatus, with a view to assist the development of the American chemical industries, with special reference to the organic preparations that are necessary in the production of dyes and also to carry on studies in the natural agricultural products that have such great value in industry. It has been realized from the start and is being more and more appreciated by American industries that success depends upon the ability to produce compounds at a low cost. To do this the factor of yields is the most important, and detailed studies throwing light upon the mechanism or reactions have been undertaken. In many cases the long and tedious investigations necessary to work of this nature cannot be undertaken by industrial research laboratories where the press of factory problems is very great.

In order to carry on this work an old building at Arlington, Va., was taken over and remodeled so far as possible to suit the need. Various lines of research were started in the meantime in the laboratories of the Bureau of Chemistry. The plant at Arlington is unique in that it combines manufacturing facilities with complete laboratory equipment.

The technical part of the plant is being equipped with an extensive variety of large-scale apparatus. This is to be operated, not for the purpose of manufacturing, but for the purpose of studying manufacturing operations. It is quite possible that where the industries of the country are not able or willing to furnish compounds that are required we will be able to manufacture and supply the demand until the industries are in a position to undertake the work.

Photographic Sensitizing Dyes

One investigation has now arrived at this stage of development. I refer to the production of the photosensitizing dyes of the quinoline type. Of these pinaverdol, pinacyanol, or thochrome, dicyanine, and dicyanine A have been successfully synthesized and tested by physicists, astrophysicists and plate manufacturers. A number of plate manufacturers have been very successful in incorporating several of these dyes in photographic gelatine emulsions, and tests of the plates so produced show them very satisfactory and the dyes to be at least equal in performance to the corresponding dyes formerly produced by Meister Lucius and Brüning. The American patents on some of these dyes were formerly owned by the Höchst concern, but are now the property of the Chemical Foundation. The Color Laboratory is prepared to instruct chemists who will undertake the commercial manufacture of these dyes and assist in any way in stimulating the production of

these valuable aids to the physicist and photographic plate manufacturer.

With the exception of the photographic sensitizing dyes, the investigations so far undertaken have been quite general in character and include vapor phase studies in chlorination, oxidation and sulphonation, a study of caustic fusions, a study of the derivatives of cymene, at present a waste product of the sulphite spruce paper industry, and there is also under way in the laboratory at this time a study of the vapor pressure curves of a number of aromatic organic compounds.

Thirty-one papers have been written by the laboratory staff, more than twenty of which have already appeared in print, and many others are in course of preparation. Owing to the demands of the industries for chemists and the interference of the war, the personnel of the Color Laboratory has undergone many changes, in fact almost completely changed twice, and our plant has been greatly delayed in construction. For these reasons it has been very difficult to carry research to a conclusion.

FIG. 1. ELECTRIC TRANSMISSION LINE, 6,600 VOLTS. A VIEW OF NORTH AND WEST SIDES

I will describe very briefly a few of the investigations that so far have not been published.

Vapor Phase Chlorination

The chlorination of toluene in the vapor phase, catalyzed by ultra violet light, for the production of benzyl chloride, benzal chloride and benzotrichloride, has been studied. The work to the present has indicated that the extent of the chlorination can be controlled to a considerable extent by the character of the light, the relation between the reacting gases and the temperature. Low-pressure quartz mercury lamps tend to produce mostly benzal chloride, while high-pressure lamps produce more benzotrichloride. G. A. Geiger, A. B. Clark and H. A. Lubs have published some preliminary analytical papers on this work.

Vapor Phase Oxidation and Vapor Phase Sulphonation

Studies of the vapor phase oxidation of various hydrocarbons and other compounds by means of atmospheric air in the presence of catalysts have shown that toluene can be oxidized to benzaldehyde and benzoic acid, naphthalene to phthalic anhydride and benzoic acid, anthracene to anthraquinone, phenanthrene to phenanthraquinone. Preliminary publications are being prepared by C. Conover, K. P. Monroe and myself.

A number of methods are in practical application for the sulphonation of various compounds. The most common consists in the mixing of sulphuric acid of suitable strength and the compounds to be sulphonated in an iron pot, stirring the mixture rapidly with or without the application of external heat; the Tyrer process,[1] consisting in the passing of the vapors of the substance to be sulphonated through sulphuric acid heated to the desired temperature; the Downs method,[2] consisting in heating the substance being sulphonated and the sulphuric acid *in vacuo* for the purpose of removing the water and sulphuric acid by distillation; and the Kendall process,[3] providing for the addition of the compound to be sulphonated to the molten liquid form of certain acid sulphates or pyrosulphates. All of these are batch processes. The first continuous process is that devised by Dennis[4] and perfected by Bull,[5] which has been used for the production of the monosulphonic acid of benzene. It consists in pumping benzene through sulphuric acid and then into water, producing a continuous circulation of the benzene, and the process depends upon the fact that small quantities of benzene monosulphonic acid are dissolved in the benzene and carried to the water, where it is washed out and the benzene re-circulated through the sulphuric acid. Our process differs materially from any of the above in that it is continuous, the products of the reaction are removed very rapidly, as formed, and in that various compounds can be sulphonated successfully at any required temperature.

The sulphonation of various hydrocarbons in the vapor phase with sulphuric acid of varying strengths has been successfully carried out by this process on a small scale.

Benzene can be sulphonated with chamber acid (55 deg. Bé. = 70 per cent). Naphthalene can be made to yield a product containing disulphonic acids of which the 2.7-derivative constitutes about 85 per cent, while the 2.6-derivative makes up the remainder of about 15 per cent. The former furnishes a valuable starting material for the much used H acid. J. A. Ambler, C. E. Senseman and William J. Cotton are preparing preliminary papers on this work.

War Work

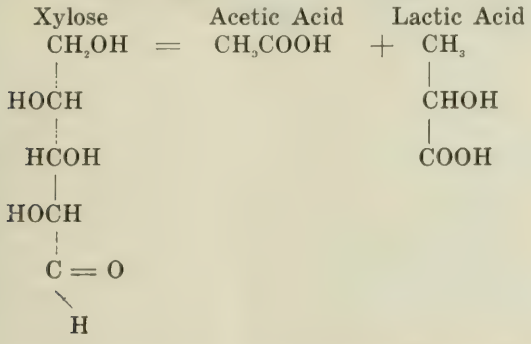
During the war the incompleted building at Arlington was loaned to the Nitrate Division of the Ordnance, and the laboratories and almost the entire personnel of the Color Laboratory were engaged in work for the Chemical Department of the Science and Research Division of the Bureau of Aircraft Production. Some of the chemical problems solved for the Air Service were rather interesting, and I will outline a few of them.

Early in the prosecution of the airplane program it became evident that new sources of acetic acid and its derivatives must be developed, since the manufacture of smokeless powder promised to require all of the acetone production in sight. Two entirely new processes employing raw materials not heretofore used for any purpose were developed, the first to produce acetic acid, the second to produce acetone.

Hudson, Harding and La Forge, of the Bureau of Chemistry, very recently devised a method for the

[1] U. S. Pat. 1,210,725.
[2] U. S. Pats. 1,279,295; 1,279,296; 1,301,785.
[3] U. S. Pat. 1,217,462.
[4] U. S. Pats. 1,211,923; 1,212,612; 1,227,252; 1,228,415; 1,229,593.
[5] U. S. Pat. 1,247,499; also CHEM. & MET. ENG. Sept. 1, 1918, pp. 255-260.

manufacture of xylose on a commercial basis at a very low cost, from such abundant materials as corncobs and wood, and L. A. Round, also of the Bureau of Chemistry, had isolated an organism that would ferment xylose, with the production of acetic acid. It seemed very desirable that this process should be investigated to determine if it were practicable for commercial application. Substances rich in xylane, such as corn silage, sauerkraut and manure, seemed most likely to contain xylose-fermenting bacteria. It was found that pure cultures could be obtained by fishing from plates and seeding into liquid 2 per cent xylose yeast medium. The fermentation process was found to proceed very nearly quantitatively as represented by the splitting of one molecule of xylose into one molecule of acetic acid and one molecule of lactic acid, according to the equation:



It has been found that the oxygen supply within wide limits has little effect. The process has been successfully carried out on a small scale by grinding corncobs, hydrolyzing and inoculating the solution so formed, thus reducing the expense of the process in that it is not necessary first to isolate the xylose. An article descriptive of this work, by Fred, Peterson and Davenport, appeared in the September issue of the *Journal of Biological Chemistry.*

Isopropyl Alcohol and Acetone

It has been found that the waste gases of the Burton process for cracking petroleum can be used for the production of isopropyl alcohol and acetone. These gases contain from 8 to 14 per cent of propylene, which can be absorbed in sulphuric acid of the proper strength. This solution, on hydrolysis, gives isopropyl alcohol, and a continuous catalytic process has been devised for converting isopropyl alcohol into acetone. This consists in passing the vapors of isopropyl alcohol, mixed with atmospheric air, over a catalyst and thus removing two hydrogen atoms from the isopropyl alcohol, the result being acetone. It has been estimated that from 50,000 to 100,000 gal. of acetone can be produced daily by this process if all of the waste gases from the Burton stills were utilized. A paper, by R. R. Williams and myself, descriptive of this work will appear shortly.

FIG. 2. AN AIRPLANE VIEW OF A PLANE IN PROCESS OF PRODUCING ARTIFICIAL CLOUD

The Discharge of Clouds From Airplanes

A number of uses for clouds discharged from airplanes were suggested, and the following three that were investigated by R. R. Williams are interesting, only two, however, being of real value:

It was found that signals could be discharged from airplanes in a very satisfactory manner by a series of colored clouds in the form of smoke balls or streamers released at irregular intervals, somewhat in the manner of Morse or Continental codes. For this purpose a solution of volatile dye in a volatile solvent may be discharged into the engine exhaust. The result is a smoke colored according to the dye used. A saturated chloroform solution of Sudan II[6] gave very satisfactory results. The smoke was cherry red and very clearly visible at an altitude of 5,000 ft. Observers state that they believe it would have been visible at 10,000 ft.

Another possible use for smoke on airplanes is the imitation of a plane in flames. This was fairly satisfactorily demonstrated by spilling 15 lb. of lampblack at a uniform rate from a position near the observer's seat on a plane that was in the meantime maneuvering to imitate loss of control.

Several men connected with the force at Langley Field, who saw this test in operation, without knowledge of its object, were deceived by it and shouted to call attention to the machine on fire.

Color Laboratory,
U. S. Bureau of Chemistry,
Washington, D. C.

[6]Sudan II, Schultz (1914), No. 76, xylidine and β-naphthol.

School of Optics

There has been established at Paris an optical institute that will work in the interest of the manufacturers of opticians' supplies, according to *Science;* it will not be conducted for commercial profit, but solely for the purpose of advancing optical science and the optical industries for the common welfare. The forms of activity of this new scientific institute will be: (1) a training school of optics; (2) a laboratory of research and experiment, and (3) a professional school for advanced study. The school of optics will train experts in the manufacture of optical goods. C. Fabry, at present professor of general physics at the Faculté des sciences de Marseilles, has been selected as the head of the new institution. Lucien Poincaré, rector of the University of Paris, has evinced an especial interest in the institute and has expressed his intention of requesting a professional chair of optics at the Sorbonne. The laboratories will comprise a research department in which the instructors of the school may conduct their theoretical and practical researches with relation to the various kinds of glass, optical instruments and opticians' accessories, and a department for the study of manufactured products or any matter of importance submitted for examination by the institute. These laboratories will serve likewise for the training of students.

Pumping Acid With Compressed Air

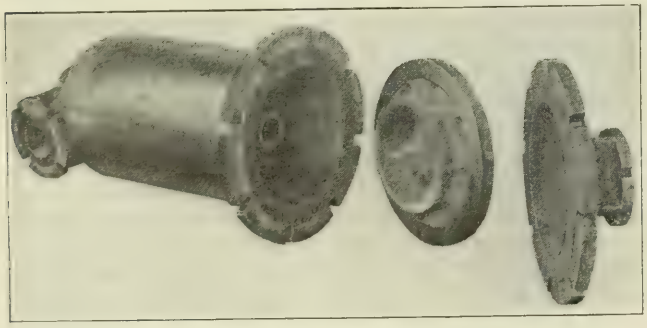
By John Oliphant
Chief Engineer, Pumping Dept., Sullivan Machinery Co.

During the past two or three years, the use of compressed air for handling, elevating and transferring acids and chemical solutions has been greatly extended, and as the more modern principles of air-lift pumping have been applied to the chemical field, the efficiency and convenience of the system have made rapid strides. The advantages of the air-lift system for handling acid as compared with mechanical pumps or other less modern mehods and as demonstrated by actual installations made by the company with which the writer is associated may be enumerated briefly as follows:

Durability—The foot pieces and separator heads may be made of any desired acid-resisting material, such as hard or soft lead, rubber, cast iron or cast steel, "Duriron," etc. There are no moving parts to cause wear, and the free open passage characteristic of this apparatus secures a much longer life than that enjoyed by mechanical pumps.

Flexibility—The normal delivery may be increased as much as 25 per cent or decreased by the same amount with very little change in operating efficiency. Still greater variation may be obtained, although with a sacrifice in efficiency. This is accomplished by the movement of a valve controlling the air supply.

Principles of the Air Lift—The principle of the air lift is to lighten the column of water in the eduction pipe with air so that the weight per sq.in. of the eduction column mixed with air at the air jet is less than the submergence head. For a low percentage of submergence, more air must be used than with a high percentage of submergence for the same lift in order to keep the weight of the eduction column below the submergence head. However, with the low submergence, a lower pressure is required, so that the power is theoretically equal. The question of velocity and air expansion, in a low lift with a low submergence, is one that requires especially careful designing. With acids, however, the high specific gravity and high temperature of



SEPARATOR HEAD

the liquids to be handled give better results with low percentage of submergence than is secured with water.

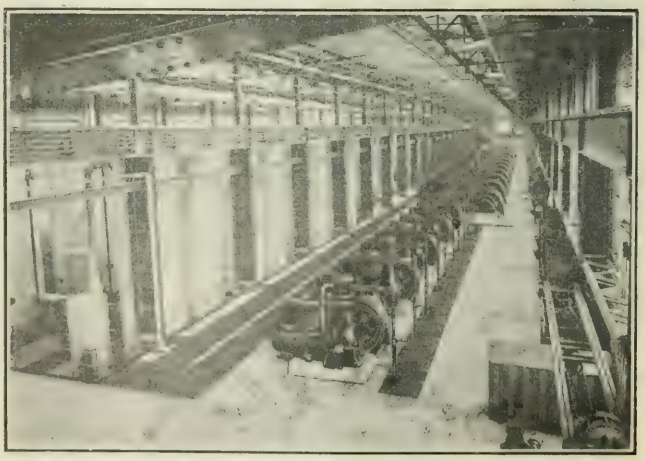
Submergence—Submergence is a term used to indicate a head into the intake of an air lift pump and controls the pressure at which the pump operates. It is expressed in feet to the point above the foot piece to which the liquid would rise in the eduction pipe without the aid of the air. The submergence added to the lift is called 100 per cent and the percentage of submergence is always a complement of the percentage of lift. For instance, 60 per cent submergence would always mean 40 per cent lift, 35 per cent submergence 65 per cent lift. The percentage of submergence may vary with the lift. In pumping water a higher per cent of submergence is desirable for low lift and the percentage of submergence may be decreased as the lift increases up to certain points. The air-lift is usually thought of as suitable only for deep wells, but with improved apparatus and careful engineering, excellent results in overall efficiency are being shown on relatively low submergences. In cases not permitting wells or

ACID FOOT PIECE AND MIXING TUBE

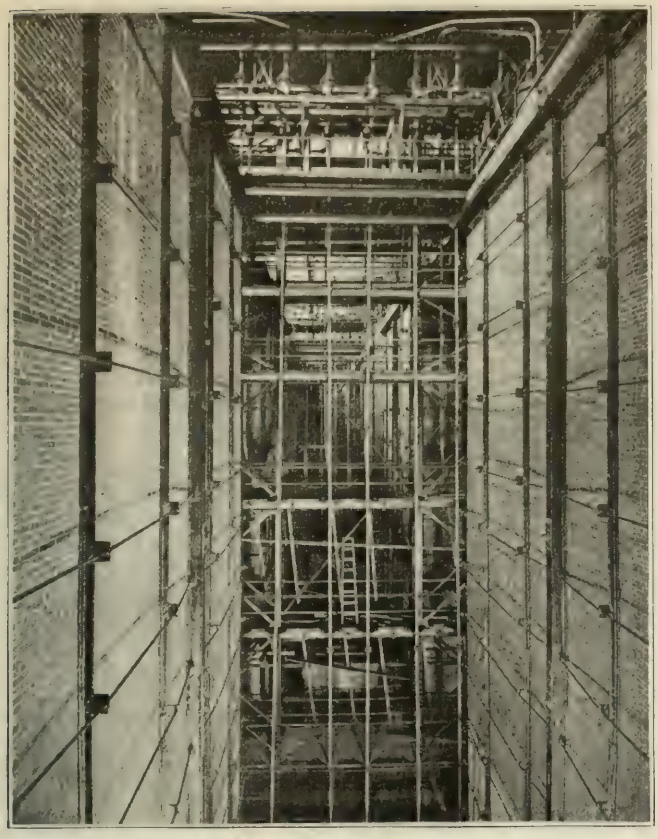
holes to be drilled to secure the necessary submergence, the compound lift may be employed. This involves lifting the acid or other fluids to a sufficient elevation to give adequate submergence for the final lift.

Central Power Supply—The air-lift foot pieces or jets may be located at any desired point in the plant and operated by air from a central station with little loss in friction and no loss such as that of condensation or drop in power as is experienced with steam or electric transmission. The compressor is under the eye of the operating engineer, and attendance of mechanics at the point of use is unnecessary, as would be the case for repair or adjustment of mechanical pumps. The towermen readily control the volume pumped from each unit as well as the starting or stopping of it by means of air valves.

Efficiency—The equipment and system employed by this company in its air-lift apparatus secure the thorough mixing of the air and the fluid to be raised by means of a large number of fine jets of air, discharging into a thin sheet of the fluid. With this equipment and with careful installation, the pump efficiency averages from 30 to 35 per cent. While this may be exceeded by mechanical pumps under test conditions, it is found, under actual practice, that the air-lift is more efficient and maintains its efficiency at a higher point, after a short period of operation. This is on account of the



SERVICE COMPRESSORS, LIQUID AIR BUILDING PLANT NO. 2



ACID LIFTS AND SEPARATING HEADS IN ABSORPTION BUILDING, PLANT NO. 2

detrimental effect of the acid on mechanically operated pumps of either the centrifugal or plunger type; while at the same time the cost of repairs and attendance is eliminated.

Safety—The separator head furnished by this company performs another service, namely, that of conveying away the fumes or air integrated with the acid, so that the employees are not exposed to this dangerous element. The fumes can thus be carried into the tower or to any other point desired.

Design—A word of caution may be in order in reference to air-lift installations. While as described above, when proper equipment is selected and the installation made by experienced engineers, the results are superior to those obtained by other means, seemingly unimportant differences in pipe areas and in the handling of the air many times make a considerable difference in the effectiveness of the installation.

Nitrate Plant No. 1

An example of this compound lift is found at the United States Nitrate Plant No. 1, Sheffield, Ala. The problem consisted in raising the acids through a tank 60 ft. above the surface from a sump or selecting pit 20 ft. in depth. Two rows of Sullivan Compound Jets and Pumps were installed on either side of a steel tower containing the tank. The acid was delivered at a point a foot or two above the surface and the drop into the pit gave a submergence of 20 ft. Using a submergence of 50 per cent, a discharge was obtained at a point 20 ft. above the surface. The air and acid were separated in a separator tank at that point, the acid being then carried back to the second foot piece, at which a submergence of 40 ft. was obtained for the second lift. Figuring the submergence at 50 per cent, the acid was carried readily to the final elevation 60 ft. above the surface.

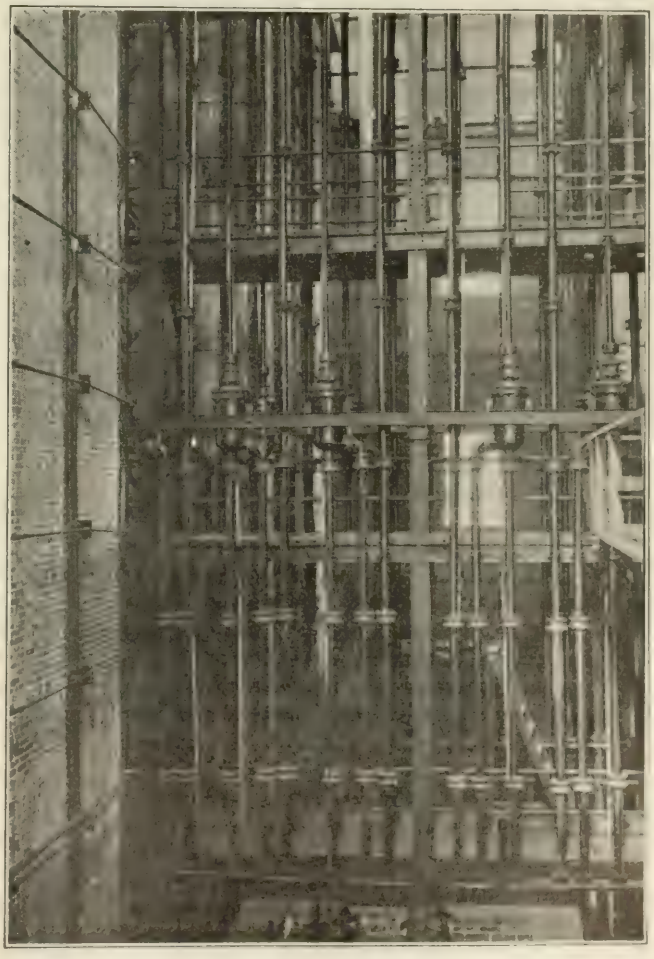
While this arrangement requires more air than a single lift, a lower pressure is sufficient. The actual power needed is no greater than that necessary for a single lift of 60 ft. with 50 per cent submergence.

Compressed air at 40 lb. pressure for the lifts described above is supplied from the central power house, where two Sullivan Corliss Tandem Compound Duplex Air Compressors, type WC, are situated. These compressors supply 1,500 cu.ft. of free air per min. each.

The purpose of handling the liquid at both No. 1 and No. 2 plants, the latter to be described later, was to convert water into nitric acid by bringing it in contact with a nitrous gas. At one end of the absorption tower building the solution was practically water, viz., a 5 per cent solution, and was pumped up into the tank at the top of the absorption tower building, where it absorbed a certain amount of acid from the gas with which it came in contact and was then discharged into the next well and thus pumped back and forth, until after passing through several stages (six in Plant No. 1) it left the building at 50 per cent strength.

Nitrate Plant No. 2

The problem in Nitrate Plant No. 2 was to lift approximately 50 gal. of acid per min. with each lift from the bottom to the top of the tower. The actual lift to be performed was approximately 70 ft. As the tower bottom was only about 3 ft. above the ground level, 12-in. iron casings were sunk to a depth of 100 ft. in



AIR LIFT INSTALLATION AND ABSORPTION TOWERS, PLANT NO. 1. SEPARATOR HEADS IN CENTER

AIR-END VIEW OF THE SIX TWIN ANGLE-COMPOUND COMPRESSORS, PLANT NO. 2

the ground below the building. Pipes 3 in. in diameter carried the acid from the foot of the tower to the top of the wells, and then down to the Sullivan foot pieces at the bottom of the wells. At this point air was introduced and the air-lift took effect through a 3-in. eduction pipe, lifting the acid to the top of the tower. These pipes were made principally of aluminum and Duriron and the nitric acid, as stated above, varied from 5 to 50 per cent strength. There were 120 of these wells sunk, some on each side of the steel towers.

At the top of the tower the air was separated from the acid by use of a simple separating head designed by the Sullivan Machinery Co. and made of Duriron. The acid was drained out over and into the tower through distributors, and the air which had been used in lifting the acid was carried out of the building through main headers, so that the fumes would not injure the workmen. By this method relatively low pressure could be used and perfect regulation of the pumping was secured. The diameter of the air supply pipes leading to the bottom of the well was 1¼ in. and these were made of aluminum. Air valves as well as the valves on the acid pipe line were used for regulating the flow of the acid and for the starting and stopping of each individual lift. The type of nozzle or foot-piece used on both Plant No. 2 and No. 1 is illustrated in the accompanying photograph. The air was mixed with the acid by a large number of jets which discharged into a sheet of the acid, securing an almost perfect emulsion.

Air Installation, Plant No. 2

Compressed air at 100 lb. pressure for the acid lift at No. 2 plant was supplied by six WN-4 Twin-Angle Compound Compressors with a capacity of 2,600 cu.ft. per min. This plant is shown in the accompanying illustration.

These compressors are equipped with plate valves of the end-rolling finger pattern and are operated by direct-connected electric motors mounted on the crank shaft of each compressor.

We are indebted to the officials of the Ordnance Department, U. S. Army, for the permission to use these photographs and data, which were supplied by the Chemical Construction Co., engineer and subcontractor for the chemical installations at Plants Nos. 1 and 2; to the Duriron Castings Co., of Dayton, Ohio, by whom the air lift pumps and separators, designed by Sullivan pneumatic pumping engineers, were made up, and to the American Cyanamid Corporation.

New Ceramic Research Station at Rutgers College

By E. C. Millen

WITH the ratification of a bill by the New Jersey State Senate, Feb. 2, covering an appropriation of $100,000 for the erection of a new ceramic building at Rutgers College, New Brunswick, there is every indication that this measure will be approved by the State Assembly, receive the Governor's signature and so become a law. This fund will give New Jersey what it has long needed—a first-class ceramic institution for instruction and research work.

The movement for this new building has been under way for the past few months, receiving the united support of those prominent in the clay-working and affiliated industries throughout the state. The bill referred to provides for the construction of a building, together with the proper machinery, apparatus and equipment, at an expense of 100,000, to be paid by the state, and an additional appropriation of $12,000 annually, beginning in 1921, for salaries, supplies, etc.

Ceramic Industries in New Jersey

In bringing forward proof of the necessity for this new building, it is pointed out that in the ceramic industries New Jersey is second in importance of all the states, being exceeded only by the State of Ohio. The clay deposits of the state are the most important on the Atlantic seaboard, while the local plastic clay resources rank first among those of the entire country—for firebrick and refractory manufacture they are unsurpassed. There are about 18,000 persons engaged in the industry in New Jersey at the present time and in this connection, recent statistics compiled by the Bureau of Industrial Statistics, State Department of Labor, are of particular interest in showing the number of plants, capital invested and value of production. These, computed in 1918, are:

	Number of Plants	Capital Invested	Annual Value, Products
Brick and terra cotta	68	$24,495,287	$15,501,229
Potteries	56	13,577,633	12,948,702
Glass plants	42	10,057,375	11,021,834
Tile	11	1,274,147	1,261,150
Lime and cement	11	12,038,834	4,521,529
Clay mines	39	1,035,703	790,796
Total	227	$62,478,979	$46,045,240

To bring these figures up to date, it is estimated that the capital invested is over $65,000,000 at this time, and the annual value of production close to $50,000,000.

The present ceramic building at Rutgers College is small in comparison with the three other recognized schools of this character in the country, which are at the Ohio State University, University of Illinois and Alfred University.

Plans for Research

At the new building in New Jersey, it is proposed to have broad facilities for research work in the solution of everyday problems arising in the industry, assisting state manufacturers in all phases of the industry in their work. It is estimated that this department will be self-supporting in a short time. The departments for instruction will be of modern and efficient status, providing everything necessary in this line. The work, as heretofore, will be under the direction of Prof. George H. Brown.

Theoretical Study of Nitrogen Fixation by the Electric Arc—III

Chemical Dynamics of the Nitrogen-Oxygen Reactions at the Temperature of the Arc and During Cooling—Multiple Arcs With Intermediate Cooling—Speculation on Cooling of the Arc by Adiabatic Expansion and by Molecular Diffusion*

By CHARLES P. STEINMETZ

EXTREMELY rapid cooling of the gases from the arc stream thus appears essential to save the NO produced by the arc. This is usually done by mixing the arc gases with a mass of relatively cool air, that is, passing only a part of the air through the arc. Since, however, the thermal equilibrium concentration of NO in air is not very high even at arc temperatures and a part thereof is lost by dissociation, further reduction of concentration by the admixture of cold air results in a very low concentration, 1 to 1½ per cent. As the result thereof, a very extensive NO absorption system is required, so that it is claimed that most of the cost of both installation and operation is due to the absorption system.

This makes it of interest to investigate whether higher concentrations could be produced by passing the air successively through a number of arcs with intermediate cooling. That is, a part of the air passes through the arc and then mixes with the rest for rapid cooling to the temperature where NO has become relatively stable; then the gas mixture is cooled again, a part passed through the next arc and mixed with the rest for rapid cooling, etc.

By this procedure, the NO content of that part of the gas mixture coming from the arc which passes through the next arc is lost, and thus, with increasing number of successive arcs, the efficiency decreases while the concentration increases.

As an $n$fold increase of concentration would reduce the absorption plant to $\frac{1}{n}$ or less, it is a commercial question how far the sacrifice of efficiency would be justified by an increase of concentration.

Assuming that the part q of the air is passed through the arc, and then immediately mixed with the remaining part $(1 - q)$ of the air for effective cooling, the gas mixture then is cooled and the part q passed through the second arc, etc.

Let T_1 = temperature of the gas mixture before coming to the arc, and T_2 the temperature of the gas mixture after the part q has passed through the arc. Let T_a = temperature of the arc, T_o = initial air temperature and T_c = temperature of the cooling surfaces (water or steam pipes, etc.) and s = cooling coefficient.

Let a_o = residual NO concentration of the arc gases, that is, that part of the NO concentration produced by the arc which is not dissociated before cooling. Let a_1 and a_2 be the NO concentration of the gas mixture before and after passing through the arc. Therefore, of the gas mixture of temperature T_1, and concentration a_1, the part q passes through the arc, and there acquires temperature T_a and concentration a_o, then mixes with the rest $(1 - q)$ of the gas mixture and this mixture thereby acquires the temperature

$$T_2 = (1 - q)T_1 + qT_a = T_1 + q(T_a - T_1) \quad (65)$$

and the concentration

$$a_2 = (1 - q)a_1 + qa_o = a_1 + q(a_o - a_1) \quad (66)$$

Then the gas mixture, passing over the cooler of temperature T_c, cools to the temperature

$$T_1' = T_2 - s(T_2 - T_c) \quad (67)$$

and at this temperature passes to the next arc at a concentration:

$$a_1' = a_2$$

For the first arc, it is:

$$a_1 = o$$
$$T_1 = T_o$$

Thus, after passing through n successive arcs, the NO concentration is

$$a_n = qa_o + (1 - q)[qa_o + (1 - q)]$$
$$[qa_o + (1 - q)][\ldots + qa_o]$$
$$= qa_o[1 + (1 - q) + (1 - q)^2 + \ldots + (1 - q)^{n-1}]$$
$$a_n = a_o[1 - (1 - q)^n] \quad (68)$$

The temperature reaches constant final value where the cooling from T_1 to T_1' is the same as the increase by the arc from T_1 to T_2, and thus $T_1' = T_1$. Substituting this into (67) and (65) gives the two equations for T_1 and T_2, the temperature of the gas mixture before and after passing the arc:

$$T_1 = T_2 - s(T_2 - T_c)$$
$$T_2 = (1 - q)\ T_1 + qT_a$$

These give:

$$T_1 = \frac{q\ (1 - s)\ T_a + sT_c}{1 - (1 - q)\ (1 - s)} = \frac{q\ (1 - s)\ T_a + sT_c}{q + s - qs} \quad (69)$$

$$T_2 = \frac{qT_a + s\ (1 - q)\ T_c}{1 - (1 - q)\ (1 - s)} = \frac{qT_a + s\ (1 - q)\ T_c}{q + s - qs} \quad (70)$$

As one arc gives the concentration:

$$a = qa_o \quad (71)$$

n arcs, if they have the same joint efficiency, should give the concentration:

$$na = nqa_o \quad (72)$$

and as, by (68), they give the concentration

$$a_n = a_o[1 - (1 - q)^n]$$

the efficiency of n successive arcs, compared with that of a single arc, is

$$n = \frac{a_n}{na} = \frac{1 - (1 - q)^n}{nq} \quad (73)$$

but the concentration is increased from a to a_n, that is, by the ratio

$$\log_{10} = \frac{a_n}{a} = \frac{1 - (1 - q)^n}{q} \quad (74)$$

As an instance let the arc temperature be assumed as T_a = 3600 deg. abs., and the temperature of the cooler as T_c = 400 deg. abs. At 3600 deg. abs., the

*For Parts I and II see CHEM. & MET. ENG., vol. 22, Nos. 7 and 8, Feb. 18 and 25, 1920, pp. 299 and 353.

equilibrium concentration is 6.15 per cent, but assuming a rate of cooling, by admixture, of $b = 10^7$ deg. per sec., the residual concentration of the arc gases is reduced to $a_o = 3.75$ per cent.

Assuming a cooling coefficient $s = 0.5$, and assuming $T_2 = 1400$ deg. abs. as the highest temperature at which the dissociation is still negligible, we get by substituting into (6):

$$1400 = \frac{3600q + 200\,(1 - q)}{1 + 0.5\,(1 - q)} = \frac{400 + 6800q}{1 + q}$$

Thus:

$$q = \frac{1}{5.4} = 0.185$$

This gives by (69):

$$T_1 = 900 \text{ deg. abs.}$$

In Table IX are given, for 12 successive arcs, the temperature, T_1 and T_2, before and after passing through each arc; the NO concentration in per cent and relative, and the efficiency ratio n. As seen, after 4 to 5 arcs, the temperatures have practically reached their maximum values. The same are plotted in Fig. 9.

Table X gives the same quantities, with the air mixture constant q chosen so that not the final temperature, but the temperature after passing through 1, or through 2 or 3 arcs, has reached the chosen temperature limit $T_2 = 1400$. On Fig. 9 these values are plotted as circles, three-cornered and four-cornered stars, for the same nq.

The larger the number of successive arcs, n, the smaller can be the air quantity q which passes the arc,

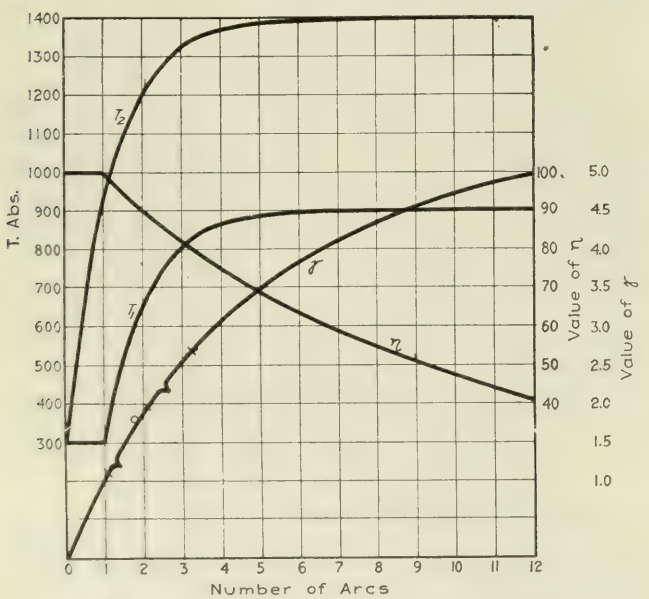


FIG. 9. MULTIPLE ARC NITRIFICATION

and the cooling coefficient s, to give the same concentration and efficiency. It is of interest then to consider the limiting values of a very large number of successive arcs, if acting upon a very small part of the air only, with very little intermediate cooling.

Substituting thus for n, q and s the values pn, $\frac{q}{p}$ and $\frac{s}{p}$, and then making lim. $p = \infty$, gives the final limit approached by the use of many arcs.

Equation (68) then becomes:

$$a_n = a_o \left[1 - \left(1 - \frac{q}{p}\right)^{pn}\right]$$

and for $p = \infty$, this becomes:

$$a_n = a_o\,(1 - e^{-qn}) \qquad (75)$$

For comparison are added in Table IX the values of a taken from the exponential limit equation (75) and denoted by a.

From (70) follows:

$$q = \frac{s\,(T_2 - T_s)}{T_a - T_2 + s\,(T_2 - T_s)} = \frac{1}{1 + \frac{T_a - T_2}{s(T_2 - T_s)}} \qquad (76)$$

assuming then:

$T_a = 3600$; $T_2 = 1400$; $T_o = 400$, (12) gives:

$$q = \frac{1}{1 + \frac{2.2}{s}} \qquad (77)$$

substituting in (68) then gives:

$$\frac{a_n}{a_o} = 1 - \left[\frac{1}{1 + \frac{s\,(T_2 - T_s)}{T_a - T_2}}\right]^n = 1 - \frac{1}{\left(1 + \frac{s}{2.2}\right)^n} \qquad (78)$$

assuming then the desired relative concentration, as for instance:

$$b = \frac{a_n}{a_o} = \frac{2}{3}$$

(78) gives:

$$n = \frac{\log_{10}\frac{1}{1 - b}}{\log_{10} 1 + \frac{s\,(T_2 - T_s)}{T_a - T_2}} \doteq \frac{0.477}{\log_{10} 1 + \frac{s}{2.2}} \qquad (79)$$

The relative efficiency is:

$$\eta = \frac{a_n}{nqa_o} \qquad (80)$$

nq represents the part of the air which is exposed to the arc, and nq = const., thus would represent constant expenditure of electric energy, assuming that the same size of arcs is used.

TABLE IX. MULTIPLE ARCS

$T_o = 300$; $T_a = 3600$; $T_s = 400$; $s = 0.5$; $b = 10^7$
$q = 0.185$

No. of Arc n	Temp. of Gas Mixt. Before Passing Arc T_1	Temp. of Gas Mixt. After Passing Arc T_2	NO Concentration Per Cent a	NO Concentration Relative γ	Relative Efficiency η
1	300	910	0.694	1.00	1.00
2	655	1200	1.260	1.815	0.907
3	800	1320	1.733	2.50	0.833
4	860	1370	2.106	3.025	0.756
5	885	1390	2.410	3.46	0.692
6	895	1395	2.670	3.84	0.640
7	898	1398	2.870	4.13	0.590
8	900	1400	3.034	4.37	0.546
9	900	1400	3.167	4.55	0.506
10	900	1400	3.278	4.72	0.472
11	900	1400	3.366	4.84	0.440
12	900	1400	3.437	4.95	0.412

TABLE X. MULTIPLE ARC

$T_o = 300$; $T_a = 3600$; $T_s = 400$; $T_2 = 1400$;
$s = 0.5$; $b = 10^7$

n	q	T_1	T_2	a	γ	η
1	0.33	300	1400	1.250	1.00	1.00
1	0.232	300	1065	0.870	1.00	1.00
2	.....	735	1400	1.540	1.77	0.885
1	0.203	300	970	0.763	1.00	1.00
2	.....	685	1280	1.372	1.80	0.90
3	.....	840	1400	1.851	2.43	0.81

The investigation of a_n, n, etc., at constant nq thus represents the effect of the arrangement of the arcs, or arc furnaces, in series or in multiple.

Table XI then gives, with the cooling constant s as parameter, and for the same values of $T_a = 3600$, $T_2 = 1400$ $T_s = 400$, $a_o = 3.75$ per cent, the values of q, n, nq, for $b = \frac{2}{3}$, that is, the final concentration $a_n = 2.5$ per cent NO.

TABLE XI. MULTIPLE ARCS

$T_a = 3600$; $T_s = 1400$; $T_c = 400$; $a_o = 3.75$; $f = \frac{1}{4}$

s =	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
q =	0 0222	0 0435	0.0833	0.120	0.154	0.185	0.215	0.241	0.267	0.290	0.313
n =	49 7	25 7	13.8	8.6	6.6	5.4	4.6	4.0	3.5	3.2	3.0
nq =	1 10	1.12	1 15	1.03	1 01	0.99	0.98	0.96	0.945	0.935	0.93
η =	0.62	0.60	0.58	0.64	0.66	0.67	0.68	0.695	0.705	0.71	0.72

As seen from this table, which is plotted in Fig. 10, the efficiency is best with the use of as small number of arcs in series as feasible. Thus, with four arcs in series, we get a concentration of 2.5 per cent at $q = 0.24$, and an efficiency of about 70 per cent. Thus, to double the NO concentration in the arc gases from the average of the single arc furnaces of 1.25 per cent to 2.5 per cent would require series connection of four furnaces, at a sacrifice of 30 per cent of output.

If then the cost (operation plus interest on the investment) of the absorption plant is 70 per cent, that of the furnace (including power, etc.) is 30 per cent, as has been stated, series connection of four arcs would give a reduction of cost of 35 per cent in the absorption plant but an increase of 13 per cent in the furnace plant, thus a resultant saving of 22 per cent in the cost, assuming the same type of furnace and absorption system.

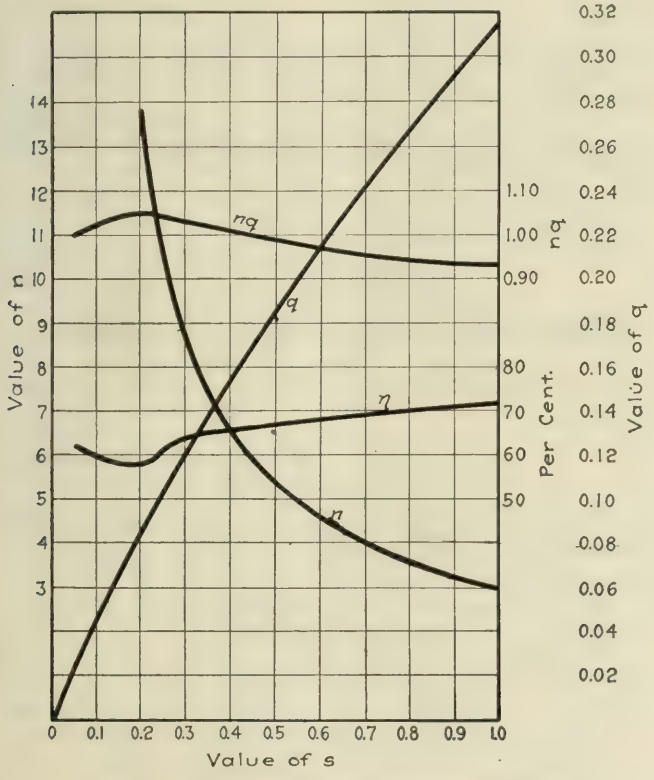


FIG. 10. MULTIPLE ARC NITRIFICATION

As furnaces are more quickly built than absorption systems, with the present plants it would permit in emergencies to double the capacity, within a short time, by commandeering more power—if these theoretical reasons are verified by experience.

Speculation on Cooling of Arc by Adiabatic Expansion and by Molecular Diffusion

When establishing an arc in air, the air in the path of the arc stream is raised to arc temperature, say 4000 deg. abs., and thereby expands in volume. If the arc is formed slowly, or moves slowly through the air, the air may expand and thereby be set in motion during its heating by the arc, so that the pressure in the arc stream remains constant, and the temperature rise occurs at constant pressure. If, however, the arc is established with extreme suddenness, the air would be heated to arc temperature before it had time to increase in volume by expansion, as a finite time is necessary to set the air in motion. In this case, the heating of the air in the arc stream would occur at constant volume, and the pressure in the arc stream would rise proportional to the temperature rise.[1] This would require materially less heat energy. The air would then expand and thereby drop in temperature by adiabatic expansion or, if the arc persists, additional heat energy will be required to maintain the arc temperature. In either case, the air, while being heated by the arc stream, is set in motion in expanding, and then, after falling again to atmospheric pressure, would continue to move, over-expand to a pressure below atmosphere, with corresponding drop of temperature, until the atmospheric pressure stops the further expansion, and the gas contracts again.

Probably, with the rapidly moving or rapidly started interrupted arcs of nitrogen furnaces, the actual condition is somewhere intermediate between constant pressure and constant volume heating.

As the cooling of the air in the arc stream by the expansion and over-expansion discussed above may lower the temperature down to or near the values where NO is relatively stable, it may be a factor in saving a large part of the NO concentration corresponding to the arc temperature equilibrium, and this would depend on the diameter, that is, the current of the arc, and the manner of its starting, moving, etc., so that the possible magnitude of the effect needs considering.

For this purpose it obviously will be sufficient to consider the air as an ideal gas, and apply the equations pertaining to such.

Thermodynamic Equations of Air as Ideal Gas

The general equation is:

$$pv = \frac{r}{M} T = RT \qquad (81)$$

where:

p = pressure, kg. per sq.m.
v = volume, cu.m. per kg.
T = abs. temperature.
M = molecular weight, = 29
r = gas constant = 845
R = 29.2

The adiabatic equation is:

$$pv^a = \text{const.} \qquad (82)$$

where:

a = adiabatic constant,
= 1.4 for air.

From (1) and (2) follow, for adiabatic expansion or compression between the limits p_o, v_o, T_o and p, v, T:

[1] In agreement wherewith would be the higher voltage required by a transient arc: the arc voltage rises with the pressure.

$$\frac{p}{p_o} = \left(\frac{v_o}{v}\right)^a = \left(\frac{T}{T_o}\right)^{\frac{a}{a-1}}$$
$$\frac{v}{v_o} = \left(\frac{p_o}{p}\right)^{\frac{1}{a}} = \left(\frac{T_o}{T}\right)^{\frac{1}{a-1}}$$
$$\frac{T}{T_o} = \left(\frac{p}{p_o}\right)^{\frac{a-1}{a}} = \left(\frac{v_o}{v}\right)^{a-1} \quad (83)$$

The adiabatic expansion energy is, when expanding or compressing adiabatically between the limits p, v, T, and p_2, v_2, T_2; p_o, v_o, T_o being one point of the adiabatic curve:

$$E = \int_1^2 p\,dv$$
$$= \frac{R}{a-1}(T_1 - T_2)$$
$$= \frac{p_o v_o}{a-1}\left[\left(\frac{v_o}{v_1}\right)^{a-1} - \left(\frac{v_o}{v_2}\right)^{a-1}\right] = \frac{RT_o}{a-1}\left[\left(\frac{v_o}{v_2}\right)^{a-1}\left(\frac{v_o}{v_2}\right)^{a-1}\right]$$
$$= \frac{p_o v_o}{a-1}\left[\left(\frac{p_1}{p_o}\right)^{\frac{a-1}{a}} - \left(\frac{p_2}{p_1}\right)^{\frac{a-1}{a}}\right] = \frac{RT_o}{a-1}\left[\left(\frac{p_1}{p_o}\right)^{\frac{a-1}{a}}\left(\frac{p_2}{p_o}\right)^{\frac{a-1}{a}}\right]$$
$$= \frac{RT_1}{a-1}\left[1 - \left(\frac{v_1}{v_2}\right)^{a-1}\right] = \frac{RT_2}{a-1}\left[\left(\frac{v_2}{v_1}\right)^{a-1} - 1\right]$$
$$= \frac{RT_1}{a-1}\left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{a-1}{a}}\right] = \frac{RT_2}{a-1}\left[\left(\frac{p_1}{p_2}\right)^{\frac{a-1}{a}} - 1\right] \quad (84)$$

If the energy of adiabatic expansion is converted into velocity, the kinetic energy of the velocity s being, per unit weight or kg.

$$E = \frac{s^2}{2g} \quad (85)$$

where
$g = 9.83$
= acceleration of gravity,
it follows from (85) and (84):

$$s = \sqrt{2gE} = \sqrt{\frac{2gR}{a-1}(T_1 - T_2)} \quad (86)$$

$= 37.7\sqrt{T_1 - T_2}$ meter seconds for air,
as the velocity of adiabatic expansion.

At constant pressure p' the expansion energy of unit weight (kg.) of gas between volumes v_1 and v_2 is:

$$E = p'(v_2 - v_1) \quad (87)$$

Applying now the gas equations to the thermodynamic phenomena occurring in a suddenly started and suddenly interrupted arc stream:

Let a gas cylinder of diameter d_1, of pressure p_1, and temperature T_1 be suddenly heated to temperature T_2, at constant volume: $v_2 = v_1$, by an arc of stream diameter d_1.

The pressure of the gas stream is thereby raised to: (81)

$$p_2 = p_1\frac{T_2}{T_1} \quad (88)$$

The gas then expands adiabatically back to the pressure p_1 of the surrounding atmosphere and thereby increases in volume and drops in temperature to: (83)

$$v_3 = v_1\left(\frac{p_2}{p_1}\right)^{\frac{1}{a}}$$
$$T_3 = T_2\left(\frac{p_1}{p_2}\right)^{\frac{a-1}{a}} \quad (89)$$

and the diameter of the gas stream thereby increases to:

$$d_3 = d_1\sqrt{\frac{v_3}{v_1}} = d_1\left(\frac{p_2}{p_1}\right)^{\frac{1}{2a}} \quad (90)$$

In expanding then adiabatically, from p_2, v_2, $=v_3$, T_2, to $p_3 = p_1$, V_3, T_3, the gas gives the energy: (84)

$$E_o = \frac{R}{a-1}(T_2 - T_3) \quad (84)$$

Of this, the energy (87):

$$E' = p_1(v_3 - v_1) = RT_1\left[\left(\frac{p_2}{p_1}\right)^{\frac{1}{a}} - 1\right] = RT_1\left[\left(\frac{T_2}{T_1}\right)^{\frac{1}{a}} - 1\right] \quad (91)$$

is consumed in pushing away the surrounding atmosphere, thus leaving the energy:

$$E = E_o - E_1$$

This energy E, doing no external work, becomes kinetic, and the gas thus assumes the velocity.

$$s = \sqrt{gE} = \sqrt{g(E_o - E_1)}$$

When the expanding air has again reached atmospheric pressure p_1, at temperature T_3, it thus has the velocity s, and continues to move with this velocity radially outward, thus over-expands, until its kinetic energy has been spent in pushing away the surrounding atmosphere of pressure p_1, at pressure p_4, volume v_4 and temperature T_4.

At this point, the work done in pushing away the surrounding atmosphere: (81) and (83)

$$E'' = p_1(v_4 - v_1) = RT_1\left[\frac{v_4}{v_1} - 1\right] = RT_1\left[\left(\frac{T_2}{T_4}\right)^{\frac{1}{a-1}} - 1\right] \quad (92)$$

has become equal to the total energy of expansion:

$$E_{oo} = \frac{R}{a-1}(T_2 - T_4)$$

Thus,

$$T_1\left[\left(\frac{T_2}{T_4}\right)^{\frac{1}{a-1}} - 1\right] = \frac{T_2 - T_4}{a-1} \quad (93)$$

This gives the temperature T_4, and herefrom the pressure p_4 and the volume v_4, and the diameter d_4 of the gas column.

The average velocity of expansion from volume v_1 to v_3 to v_4 is (assuming parabolic law):

$$s_0 = \tfrac{2}{3}s$$

TABLE XII. ADIABATIC EXPANSION OF ARC

$p_1 = 10_4 = 1$ kg. sq.cm.
$T_1 = 400$ deg. abs.
$v_1 = \frac{RT_1}{p_1} = 1.168$ cu.m.
$T_2 = 4000$ deg. abs.
$p_2 = 10$ kg. sq.cm.
$v_2 = v_1$
$T_3 = \frac{T_2}{1.93} = 2080$ deg. abs.
$p_3 = p_1 = 1$ kg. sq.cm.
$v_3 = 5.18\,v_1 = 5.97$ cu.m.

$E_0 = 140{,}200$ kg.m.
$E_1 = 48{,}000$ kg.m.
$E = 92{,}200$ kg.m.
$s = 952$ m.sec.
$s_0 = 635$ m.sec.
$T_4 = 1255$ deg. abs.
$p_4 = \frac{p_2}{57.6} = 0.184$ kg.sq.cm.
$v_4 = 18.1\,v_1 = 21.1$ cu.m.

$a_0 = 7.95$ per cent at $T_2 = 4000$ deg. abs.

$d_1 = d_2 =$	0.1	0.2	0.5	1.0	2.0	5.0	10.0	cm.
$d_3 = 2.276\,d_1 =$	0.2276	0.455	1.138	2.276	4.55	11.38	22.76	cm.
$d_4 = 4.25\,d_1 =$	0.425	0.85	2.13	4.25	8.5	21.3	42.5	cm.
$t_3 =$	1.0	2.0	5.0	10.0	20.0	50.0	100.0	micro sec.
$t_4 =$	1.55	3.1	7.8	15.5	31.0	78.0	155.0	micro sec.
$b_3 =$	19.2	9.6	3.84	1.92	0.96	0.384	0.192×10^8	
$b_4 =$	5.4	2.7	1.08	0.54	0.27	0.108	0.054×10^8	
$\log_{10} b_3 =$	9.283	8.982	8.584	8.283	7.982	7.584	7.283	.....
$a =$	5.30	5.05	4.86	4.63	4.39	4.15	3.94	% NO
$\frac{a}{a_0} =$	66.7	63.5	61.1	58.2	55.2	51.8	49.6	per cent

The average distance traveled by the expanding gas of the cylindrical column is:

From $\frac{d_1}{3}$ to $\frac{d_3}{3}$ to $\frac{d_4}{3}$

or $\frac{d_3 - d_1}{3}$ and $\frac{d_4 - d_3}{3}$

At average velocity s_o, this gives the time, during which the gas expands:

$$t_3 = \frac{d_3 - d_1}{2s} \qquad t_4 = \frac{d_4 - d_3}{2s} \tag{94}$$

and as the temperature drop during the two periods of gas travel is:

$$T_2 - T_3 \text{ and } T_3 - T_4,$$

it gives the average rate of cooling, or the cooling constants:

$$b_3 = \frac{T_2 - T_3}{t_3} = \frac{2s\,(T_2 - T_3)}{d_3 - d_1} \qquad b_4 = \frac{T_3 - T_4}{t_4} = \frac{2s\,(T_3 - T_4)}{d_4 - d_3} \tag{95}$$

and from the cooling constants b follows, by the previous considerations, the residual NO concentration a, which escapes dissociation.

As an instance may be considered, for arc temperature $T_2 = 4000$, and initial air temperature $T_1 = 400$ at atmospheric pressure $p_1 = 10^4 = 1$ kg. per sq.cm. (which is about the average atmospheric pressure), the values corresponding to various arc diameters from $d_1 = 0.1$ to $d_1 = 10$ cm., for the values:

$$d_1 = 0.1 \;\; 0.2 \;\; 0.5 \;\; 1 \;\; 2 \;\; 5 \;\; 10 \text{ cm.}$$

The values are recorded in Table XII, showing a decreasing recovery $\frac{a}{a_o}$ with increasing diameter of the arc stream.

Substituting in (86)

$$T_2 = 0$$

gives:

$$s_o = \sqrt{\frac{2gR}{a-1}}\,T = 37.7\sqrt{T} \tag{96}$$

as the limiting velocity of expansion from temperature T into a perfect vacuum, representing the conditions where all the heat energy of the molecules is converted into the kinetic energy of motion, and this velocity s then represents the molecular energy of the heat energy.

For the arc temperature

$$T = 4000$$

This gives:

$$s_o = 2380 \text{ m.sec.}$$

This would then be the velocity, with which the molecule of the hot gas diffuses into the surrounding cold air.

As the molecular velocities are in all directions, the component of the velocity in the radial direction is only

$$s_1 = \frac{2}{\pi}\,s_o = 1510 \text{ m.sec.}$$

With an arc diameter of $d_1 = 1$ cm., thus an average distance of <0.5 cm. to travel, this would give a time of travel of $t = <3.3$ microsec. At a surrounding air temperature of 400 deg. abs., thus a temperature difference of 3600 deg., this would give a cooling constant of $b = <10.9 \times 10^8$. This would give a residual concentration of $a = 5.1$ per cent, out of $a_o = 7.95$ per cent, corresponding to 4000 deg. abs., or 64 per cent.

Thus, the highest concentration which would be expected from a 1-cm. arc by molecular diffusion would be less than 5.1 per cent, and this only if the gas pressure is so low that the free path of the molecules is of the magnitude of 1 cm.

Assuming then an arc terminates in the throat of an expansion nozzle, and the gases are sucked through the arc into the nozzle, expanding therein to lower pressures and thus lower temperatures.

Let p_o = initial pressure of the gas, and T_o = arc temperature at this pressure.

Expanding to lower pressure p, and corresponding temperature T, the expansion velocity is, by (86):

$$s = \sqrt{\frac{2gR}{a-1}\,(T_o - T)} \tag{86}$$

The section of the gas stream at velocities s is:

$$S = \frac{v}{s}$$

where v is the volume per unit time.
as by (83):

$$\frac{v}{v_o} = \left(\frac{T_o}{T}\right)^{\frac{1}{a-1}}$$

It is:

$$S = \frac{v_o T_o^{\frac{1}{a-1}}}{s T^{\frac{1}{a-1}}}$$

and by (86)

$$S = \frac{v_o T_o^{\frac{1}{a-1}}}{\sqrt{\frac{2gR}{a-1}}}\,T^{-\frac{1}{a-1}}\,(T_o - T)^{-0.5}$$

and this section is a minimum for:

$$\frac{dS}{dT} = 0, \text{ or: } \frac{d}{dT}\left[T^{\frac{2}{a-1}}\,(T_o - T)^{\frac{1}{a-1}}\right] = 0$$

this gives:

$$\frac{T_1}{T_o} = \frac{2}{a+1} = \frac{5}{6} \text{ for air} \tag{97}$$

This gives the temperature at the nozzle throat, and by (83):

$$\frac{p_1}{p_o} = \left(\frac{T_1}{T_o}\right)^{\frac{a}{a-1}} = \left(\frac{5}{6}\right)^{3.5} = 0.528 \tag{98}$$

That is, the pressure at the nozzle throat is 0.529 p_o. The velocity at the nozzle throat is, by (101) or (86):

$$s_1 = 37.7\sqrt{T_o - T_1} = \frac{37.7\sqrt{T_o}}{\sqrt{6}} = 15.4\sqrt{T_o} \tag{99}$$

Thus, at arc temperature $T_o = 3600$ deg. abs.,

$$s_1 = 924 \text{ m.sec.}$$

If now the arc terminates at the nozzle throat, and the arc gases further expand to the pressure p and temperature T, Table XIII gives values of $\frac{T}{T_o}$ for various values of $\frac{p}{p_o}$ by equation (83).

Assuming now that the divergence of the nozzle is such that the temperature along the nozzle drops by expansion at the rate of $\delta = 1000$ deg. per cm. The

TABLE XIII. ELECTRO-THERMAL EQUILIBRIUM

I

Cooling rate: $b = 10^5$ deg. per sec.

$$T_1 = \frac{\log_{10}(33 - a) + 12.971}{5.731} \times 10^3$$

Residual contentration, per cent: a =	0	4	8	12	16	20	24	28	30	32	32.5	32.9
Arc temperature, deg. abs.: T_1 =	2535	2525	2515	2500	2480	2460	2430	2380	2350	2270	2215	2090

cooling constant along the path of the expanding gas then would be

$$b = 100\delta s = s \times 10^5 \qquad (100)$$

Where the factor 100 reduces from meters to centimeters.

Assuming as an instance an expansion ratio: $\frac{p}{p_o} = 0.2$.

This would give a temperature ratio: $\frac{T}{T_o} = \left(\frac{p}{p_o}\right)\frac{1}{3.5} = 0.631$.

Hence, at $T_o = 3600$, an expansion temperature: $T = 2270$ deg. abs., and at this temperature the reaction velocity has already dropped so that by rapid further cooling, little loss may be expected.

This gives a velocity, by (86): $s = 37.7\sqrt{T_o - T} = 1375$ m.sec.

This gives a cooling rate: $b = 1.375 \times 10^5$.

Hence a residual concentration: $a = 4.5$ per cent. While the throat velocity: $s_1 = 924$, would give a cooling rate $b_1 = 0.924 \times 10^5$.

Hence a residual concentration: $a_1 = 4.4$ per cent.

Thus an average NO concentration of about 4.45 per cent might be expected, while the initial concentration, at 3600 deg. abs., is 6.15 per cent.

It is interesting to note that the rapid expansion by terminating the arc in the throat of an expansion nozzle would give very high concentrations, that is, save most of the NO produced by the arc, without diluting the gases with masses of cold air, and thereby lowering the concentration and thus requiring the enormous absorption plant: a concentration of 4.45 per cent would reduce the size of the absorption plant—which is the largest part of the cost of installation—to about one-quarter of the present size.

Thus this method requires further experimental investigation regarding its feasibility.

Water-cooled nozzles of a high ferrotungsten would probably stand the temperature for a considerable time, especially if the throat is made replaceable. A turbine wheel in front of the nozzle would further cool the gases and abstract their velocity, without any temperature rise due to the destruction of their kinetic energy. A steel wheel would probably stand the temperature of the gases indefinitely, as it is exposed to it only intermittently for a very short time.

When expanding from atmospheric pressure p_o to $p = \frac{1}{5}$ to $\frac{1}{10}$ of an atmosphere, it would need recompressing the gases before they can be sent into the absorption system and then returned into the air. It thus would be preferable to initially compress the air to a pressure of $p_o = 5$ to 10 atmospheres, and then expand to atmospheric pressure. The turbine wheel abstracting the kinetic energy of the gas jet would then, if of reasonable efficiency, give ample power for the initial compression.

However, in this case the serious question arises whether an arc at 5 to 10 atmospheres pressure is not materially hotter than one at atmospheric pressure, and as the result thereof the temperature drop during the adiabatic expansion would not be sufficient to carry down to safe temperatures.

An investigation of the temperature of air arcs at various pressures would therefore be of primary importance.

(*Part IV, the last of the series on theoretical study of nitrogen fixation by the electric arc, will be published in our next issue.*)

Phosphate Reserves of Pacific Islands

According to a memorandum laid on the table of the New Zealand House of Representatives by the President of the Board of Agriculture, the reserves of phosphate of the Island of Nauru, in the Pacific, are sufficient to meet the demands of the world for two hundred years. Information obtained from a reliable source, says the *Board of Trade Journal*, indicates that anything from 80,000,000 to 100,000,000 tons are available, and possibly more. The quality of the phosphate is said to be of the highest grade (85 to 86 per cent), and it is claimed that this island contains the largest known quantities of high-grade phosphate in the world. The present output of the island has been somewhat interfered with by the war, but the average yearly production is in the neighborhood of 150,000 tons.

There are several phosphate islands in the Pacific, these including Ocean Island, where the Pacific Phosphate Co. has the mining rights, this company also holding an interest in a French company which works the Makatea Island deposits; Christmas Island; Angaur Island, which, according to a German authority, contains 2,500,000 tons ranging from 81 to 83.6 per cent, though another authority places the available phosphate between 300,000 and 600,000 tons; Surprise Island; Clipperton Island; Walpole Island, and Malden Island. Christmas Island, referred to above, must not be confounded with an island of the same name near Java.

Phosphate Deposits in the Netherlands

Phosphate deposits have been discovered in the eastern part of Holland, at a place called Ootmarsum, in the Twente District. About thirty tons of 15 to 20 per cent phosphate are being produced each day, and are being sold locally at prices corresponding to the prices of imported phosphate. The stratum varies from 7 in. to 3 ft. in thickness, but on account of the fact that it is not continuous the work of extracting the rock is very expensive. In some places the stratum is on the surface, in others it is as much as 25 ft. beneath the surface.

DAM SITES AND FIXED NITROGEN PLANTS

Muscle Shoals Hydro-Electric Development

Wilson Dam on the Tennessee River in Alabama—Corps of Engineers, U. S. Army, Making Rapid Progress Toward Completion in 1922—Power Generated Will Reduce Operation Costs at Nitrate Plant No. 2

BY CHESTER H. JONES

MANY persons interested in the discussions at Washington over the fixed nitrogen situation are not fully informed as to the location of the Government nitrate plants and water-power development and the relation between them. The name Muscle Shoals has been used in referring to both water-power and chemical plants, causing much confusion. The map shown herewith will clarify this misunderstanding.

Muscle Shoals originally designated the stretch of river up stream from the city of Florence and was later also applied to the permanent village erected by the Government on the 2,200-acre tract in connection with Nitrate Plant No. 2. It is here the $70,000,000 cyanamide plant now stands idle. The rated capacity is 110,000 tons of ammonium nitrate (38,500 tons fixed nitrogen) per annum. The process has proved successful and the plant is practically completed.

Tract No. 1 (1,700 acres), southwest of Sheffield, is the site of Nitrate Plant No. 1, where the modified Haber process plant was installed by the Ordnance Department, U. S. Army, under the advisement of the General Chemical Co., and a permanent village was built. This plant, also standing idle, has a capacity of about 18,350 tons of ammonium nitrate (6,425 tons fixed nitrogen) annual production and the construction is completed, with a total cost of property, including village, of about $14,000,000. The process did not operate successfully, but may be developed to do so through research.

Nitrate Plants Nos. 3 and 4, located at Toledo and Cincinnati respectively, were partially completed in the erection of factory buildings. These are being used as storehouses for ordnance material. The bills now before Congress refer only to the industrial properties in Alabama and research laboratories elsewhere.

On June 3, 1916, Section 124, H. R. 12,766, carrying an appropriation of $20,000,000, became a law (Public Document 85) and was directed chiefly toward the erection of the dams, although about $6,000,000 was expended in building Plant No. 1. The money for Plant No. 2 was taken from another general war fund of over $300,000,000 subsequently appropriated by Congress.

The nitrate plants have always been under the direction of the Nitrate Division, Ordnance Department,

SOUTH ABUTMENT—EFFECTS OF BLASTS IN DRILL WELL HOLES

LOOKING NORTH TOWARD JACKSON ISLAND—MAIN CAMP ON NORTH BANK

CONCRETE FORMS FOR HIGH LEVEL CONSTRUCTION BRIDGE ON JACKSON ISLAND

while the dams were handled, separately and apart, by the Corps of Engineers, U. S. Army.

Practically nothing was accomplished toward construction of the dams during the war, because it was known that water power could not be secured in time to meet the emergency. The work was therefore delayed until such time as labor conditions became more favorable.

The operations at the Wilson Dam (Dam No. 2) are now proceeding under the immediate direction of Colonel Lytell Brown at Muscle Shoals, who reports to the Chief of the Corps of Engineers in Washington. About 5,000 workmen are engaged. Prior to Jan. 1, 1920, $3,679,000 was expended, leaving about $14,000,000 on hand. It is roughly estimated that the total cost of this dam will

LOOKING SOUTH, COFFER DAM NO. 1 AND JACKSON ISLAND

be somewhat in excess of $20,000,000 under existing conditions and the work completed in 1922. No immediate construction will be carried out on Dams No. 1 and No. 3 and the navigation features.

Wilson Dam Details

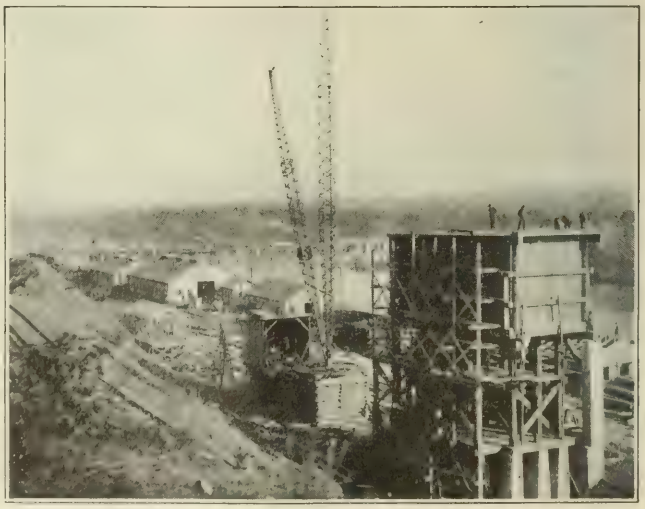
The development is run-of-river, there being no storage capacity for reserve water. The plans of construction closely follow those outlined in the report prepared by Major H. Burgess, Corps of Engineers, and submitted to Congress through military channels during June, 1916, House Document 1,262, Sixty-Fourth Congress, First Session, Serial 25; 6,979.

This report embraces the whole project of three dams and canal through the river shoals. The old canal is inoperative for about six months each year and is limited to the passage of smallest river boats. The navigation improvement will require the eventual erection of Dam No. 3.

The Wilson Dam (No. 2), crossing Jackson Island (the latter shown in dotted outline on the map), has a spillway crest of 3,080 ft., a height of 94 ft. and a total base of 177 ft. Of this base dimension 57 ft. is

DOWNSTREAM HALF OF COFFER DAM NO. 1, PUMPED OUT, AND HIGH LEVEL CONSTRUCTION BRIDGE

taken up by a spillway apron, anchored to the river bed and provided with necessary weepholes. While the river bed is composed of country rock, harder than concrete, it is liable to become dislodged in large blocks. Hence the wide apron is necessary.



NORTH SHORE MIXING PLANT, SHOPS AND WAREHOUSE

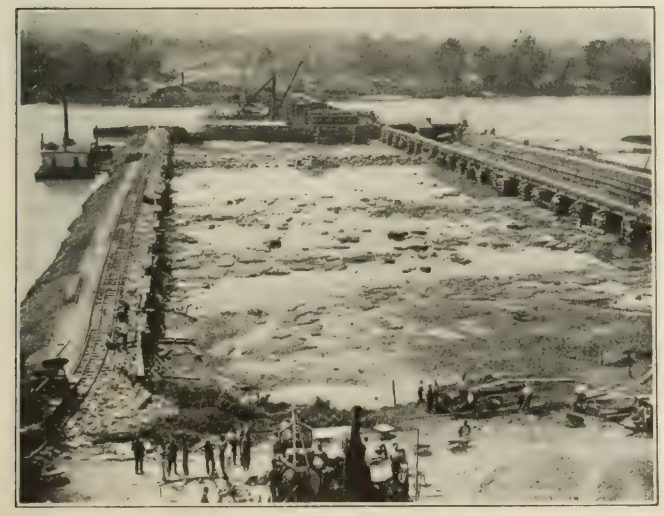
UPSTREAM HALF OF COFFER DAM NO. 1, PUMPED OUT

The design provides for a maximum depth of water on the crest of 13 ft. at a river discharge of 500,000 cu.ft. per sec. The wasteway section will carry 10,000 cu.ft. per sec. The working head is between 95 and 92 ft.

Power Arrangements

The power house will contain foundations for twelve 40,000-hp. water turbines, single runner type. The estimated primary power is 100,000 kw., with a total primary and secondary power of 300,000 kw.

The 60,000-kw. steam plant on the site of Nitrate Plant No. 2, connected by an 80-mile transmission line with the 30,000-kw. steam plant on the Black Warrior River, may be operated in conjunction with the hydro-electric units. Both steam plants, together with the transmission line, are Government properties and have been tested and run in connection with the chemical process operation.



COFFER DAM NO. 1, PUMPED OUT, SHOWING CHARACTER OF ROCK BOTTOM

The accompanying illustrations give an idea of the progress made on the Wilson Dam at the beginning of 1920. A large number of the workmen occupy living quarters in the village at Nitrate Plant No. 2. Several hundred thousand dollars' worth of materials left over from the construction work at the chemical plant is being turned to good use in the work at the dam.

The writer is indebted to Colonel Pillsbury for information which he supplied during the preparation of this article.

Legal Notes

By Wellington Gustin

A Lesson on Aluminum and Sales Contracts

The Supreme Court of Errors of Connecticut has handed down its decision in the suit brought by the Brown Bag Filling Machine Co. against the United Smelting & Aluminum Co. for breach of contract to buy "rod aluminum." (107 Atl., 619.)

The facts out of which this action arose, as stated by the court, appear to be that in February, 1916, the plaintiff had on hand about 34,000 lb. of aluminum rods of various sizes, and the right by contract to about 4,400 lb. of aluminum not drawn and to be specified. Plaintiff was not a dealer in the metal, but had this quantity on hand as a result of his failure to place a certain contract requiring the use of aluminum.

Acceptance of Part of Order

It was admitted that about Feb. 18, 1916, the parties entered into a written contract by which the defendant agreed to buy of the plaintiff 34,078 lb. of aluminum rods at 80c. per lb., to be drawn in sizes to be specified by the purchaser. Now, 1,490 lb. of this aluminum was delivered to and received by the defendant, not needing to be changed in size.

This action was brought to recover damages by the refusal of the defendant to take and pay for the balance of the aluminum rod described in the contract. The defendant smelting company in defense contended that the aluminum rod of plaintiff was not pure aluminum, and set up a counter-claim for damages from plaintiff's failure to deliver pure aluminum. Now, the substantial controversy was whether the contract called for pure aluminum or the aluminum rods of commerce as understood in the aluminum trade, and whether, by acceptance of a part of the rods, the defendants in law accepted the whole.

In the second count of his complaint the plaintiff sought to recover the price of the rods and coils of aluminum wire which were delivered. The item 4,400 lb. became the subject of a separate contract as to which no question arises in this case.

Does Rod Aluminum Mean Pure Aluminum?

The order given by defendant described the material as "rod aluminum," to be "drawn to specifications." By the direction of the defendant the plaintiff sent the rod to the mill to be redrawn according to specifications furnished by the defendant. The defendant then requested that two sample coils of $\frac{5}{32}$-in. wire be drawn and sent to it for examination. The plaintiff advised defendant that the manufacturer was of the opinion that the rods were too hard to furnish a satisfactory wire of that size. However, two coils of wire were drawn and sent to the defendant, who refused to give further specifications or to accept the wire at the mill on the ground that the rod aluminum offered by the plaintiff was not of the quality purchased.

The Supreme Court said the case turns upon the meaning of the terms of the written contract, it having appeared that the trade designation of the rods of plaintiff was 15S or 15SH. Now, 15S is a grade of alloyed aluminum containing about 86½ per cent pure aluminum. H is the symbol for annealed hard. O is a symbol for annealed soft, while 2S is the symbol for commercially pure aluminum, that being 98 to 99

per cent aluminum. In its narrow sense the question was whether rod of the 15S quality, or alloy, in the trade answered to the description and filled the order for "rod aluminum." The jury in the trial court found that it did, or found an acceptance of the rod by the defendant, and rendered a verdict for the plaintiff on both counts of the complaint. From this verdict the defendant appealed.

On the appeal the Supreme Court found that the negotiations were entirely in writing, including letters and telegrams, and shown in the evidence. They conclude with the direction by the defendant to ship the rod to the mill for redrawing and without exception referred to the material as "rod aluminum." If, in accordance with the meaning of the term in the trade, the aluminum in question was rod aluminum, the contract was met by the plaintiff, said the court. Much testimony by witnesses skilled in the business was given at the trial as to whether "rod aluminum," either standing alone in the purchase order or with the additional words "to be drawn to our specifications," without further description, had a definite established meaning in the trade, and if so whether the meaning was pure aluminum or a standard alloy, or, the court said, to put it more definitely, whether the alloy 15S, containing 86½ per cent of aluminum, furnished or offered by the plaintiff, in the trade filled a contract for rod aluminum.

Points to Be Considered by the Jury

Further, the court said the 1,490 lb. was shipped to defendant, as needing no redrawing, and upon its order, and resold by defendant in the original package. Now, the defendant claimed that this was sold under the belief that it was pure aluminum, and that two months later its purchaser made a claim based upon the fact that these rods were not pure, but were only 93 per cent aluminum. However, there was evidence, the court said, from which the jury might have found that no complaint was ever made about this rod by defendant and that it was accepted as part of the entire purchase. Further, the court held, the jury was entitled to consider from the negotiations whether the order was not for the specific goods that plaintiff had, and that if the rods delivered or offered were those and only those the plaintiff had on hand when plaintiff made its first inquiry, and were in fact rod aluminum as understood in the trade, then the plaintiff filled its contract, whatever the specific alloy might be. Upon the charge as given by the trial court the jury was fully warranted in rendering a verdict for the plaintiff, said the Supreme Court.

But the defendant contended that the trial court erred in instructing the jury that it might take into account the experience, or lack of experience, of the parties in the aluminum trade in determining the meaning of the term "rod aluminum" in the contract. It claimed that this language would mislead the jury to the injury of the defendant, as tending to excuse the plaintiff for its lack of knowledge if otherwise the facts should turn out to be to his disadvantage. And so the court held. It said that upon the facts generally no special meaning was presumed to be attached to the term other than the ordinary meaning as used in the trade, to which both parties were bound, whether ignorant or skilled.

Since the sole question was whether "rod aluminum" means pure aluminum the lower court was held to have erred in instructing the jury to determine whether the words "to be drawn to our specifications" had any distinct well-known meaning in the trade, applied to both size and composition, or to size only, and whether the plaintiff knew or ought to have known that the words were used in such special sense. Further, the Supreme Court held that the sale being of specific goods designated as "rod aluminum" in the written contract and in the written negotiations leading up to the contract, it was the duty of the seller to furnish "rod aluminum" as that term was ordinarily used in the trade.

On the point as to the receipt and retention of a portion of the goods shipped by the plaintiff to defendant the court held that the retention of possession without any claim indicating that the buyer had any fault to find with the goods was sufficient to justify instructing the jury that under the circumstances such retention amounted to an acceptance.

Again, the lower court directed the jury's attention to letters bearing on the construction the parties took of the contract. These appeared to be self-serving letters, said the court, and not a practical construction of the contract agreed upon by the parties. They greatly favored the plaintiff, and since there was no ambiguity in the contract other than in the meaning of a technical trade term, the Supreme Court held this erroneous.

On the proposition that defendant's acceptance of a part of the goods under the order was an acceptance of the whole, the court held that the acceptance of a single lot of "rod aluminum" did not preclude the buyer from refusing to accept subsequent deliveries which in fact did not conform to the contract.

Controversy as to Damages

Some controversy arose over the court's instruction as to damages, which said: "Such damage would include whatever loss the plaintiff has sustained by reason of the loss of his bargain." But this was followed by more: "Damage for breach of a contract to buy goods ordinarily consists of the difference between the contract price and the market value of the goods at the time the buyer ought to have taken them."

The court held this not to be error and as following the sales act. However, it had been agreed between the parties that the plaintiff would claim damages on a market value of 50c. a lb. for the rods the defendant refused to take, and that the defendant on its counter claim would base its claim at $1.12½ per lb. for pure aluminum which it claimed to have bought; the contract price being 80c. per lb.

However, because of the error pointed out by the Supreme Court, the judgment was set aside and the case remanded.

New Source of Food Supply

Prof. P. W. Claassen of Cornell University published an article in a late number of the *Scientific Monthly* on "A Possible New Source of Food Supply," in which he called attention to an excellent, palatable flour from the roots of the common cat-tail *(Typha)* that grows abundantly in swamps. There are in the United States exclusive of Alaska, about 139,855 square miles of swamp land, and thousands of acres of this land are cat-tail marshes. An ordinary cat-tail swamp would yield 5,500 lb. an acre of edible flour which has substantially the same food value as corn or rice flour. The flour is said to be pleasing and palatable. The Indians used it freely.

Preventing Accidents in Gas Plants*

By J. F. Conner

THE title may lead persons unacquainted with the operation of gas plants to assume that employment in such plants is an extra-hazardous occupation, fraught with unusual danger. With few exceptions, the accident hazards met in gas plants do not materially differ from those found in other industries where mechanical and construction operations are the rule.

My conclusion in this respect is based on experience gained from a close acquaintance with such operations, receiving reports of accidents and investigating their causes, and from making accident hazard inspections of many gas plants.

Inherent Hazards of the Industry

The industry has, of course, inherent hazards. There are certain zones in gas works where in the course of operation pockets of gas may accumulate and, with the admixture of air, serious explosive hazards may form. Precautions should be taken against such conditions arising. The ventilation, lighting and the lighting system of such zones are questions for consideration. Such places should be as well ventilated as conditions will permit. In the lighting system, approved types of keyless socket, vapor-proof globe electric lamps with remote switch controls should be used, to guard against the possibility of the gaseous atmosphere being fired by an electric arc. Warning signs of size sufficient to attract attention, cautioning against smoking and the carrying of naked flames in such zones, should be posted in conspicuous places.

Precautions Against Dust Explosions

Like precautions should also be taken to guard against dust explosions in coal crusher rooms and pits where the air may be heavily charged, especially while the crushers are in operation, with minute particles of carbon which may be ignited and exploded by contact with an exposed flame. Dust explosions, while infrequent in gas plants, have been known to occur frequently in other industries with disastrous results.

It may be unnecessary to state that all warning signs should be kept in clear, legible condition if any benefit is to be derived from their posting. The writer has found, in the course of inspections, instances of lettering on painted wooden signs having become illegible from exposure to weather, and enamelled metal signs covered by accretions of smut and dust.

Respirators for Emergency Work

Emergency conditions may arise which will require working against live gas. In such instances, the workman should be protected by a suitable type of respirator. The same precaution should be taken when a workman is required to enter any gas-charged atmosphere and in every instance he should be under the clear observation of a person outside the danger zone, who should be prepared to render immediate assistance. Oil and other tanks in which gases are present should, where conditions will permit, be first purged by steam and well ventilated before entrance is made to such enclosure. Life lines can in such work be used to advantage.

Generally speaking, gas plants are usually well guarded mechanically. Occasionally, however, accidents occur on machinery due to guards being temporarily removed during repairs and failure to replace guards before putting the machines in operation again, or possibly to an exposure being considered too remote to warrant guarding.

Simple Hazards Cause Most Accidents

A review of cases reported shows that the causes responsible for the greater number of accidents are due to the simple hazards found in all industrial establishments such as tripping, falling, slipping, and lifting, protruding nails, to the use of defective hand tools, ladders, scaffolds and makeshift supports that give insecure footing, and other like minor hazards, and to disregard of instructions to wear goggles when engaged in work in which the eyes are exposed to flying particles or splashing liquors.

Education the Greatest Safeguard

The safeguarding of machinery and the installation of other mechanical devices for the prevention of accidents is unquestionably a necessary measure in any well-ordered plant, but in many cases the guards cannot be made absolutely fool-proof, so that in the final analysis, the greater reliance for preventing accidents must be placed on the human agency. If we are to continue to look forward to a reduction in the accident frequency, greater efforts must be made to educate the workman to know the dangers that beset him and others, from carelessness, thoughtlessness, and inattention on his part, and to arouse and maintain the accident prevention spirit in him.

Methods of Reaching the Workmen

How we shall best reach the workmen by educational propaganda is a question of personal opinion. Reasoning with the men collectively is usually attended by good results. In obdurate cases, however, resort to individual approach brings the best results. We should not, however, be too hasty in censure of the workman for apparent indifference to safety. He possibly may be influenced by environment and be reflecting the attitude of his superiors to this important question. The problem, to my reasoning, should first be brought convincingly to the attention of the man higher up, the man directly in charge of the operation. If he meets it, as he should, in a spirit of serious interest and by precept and example sets the standard for his subordinates, lets it be known that he is keenly alive to any failure or disinterestedness on their part to shoulder their duty, the indifference, if any, of the foremen and sub-foremen will quickly vanish and those in positions of responsibility will, figuratively speaking, be standing on their toes and showing greater activity toward preventing accidents. The interest they show is bound to be reflected in the workmen and with the environment of good housekeeping, a place for everything and everything in its place, which must of necessity be part of the program, there will come a subconscious awakening of the prevention spirit in the workmen and that is the dominating factor in preventing accidents.

Team work as outlined means co-operation. When the force of co-operation is behind the punch for safety, the fight for accident prevention is soon won.

*Paper read before the Eighth Annual Safety Congress of the National Safety Council, Cleveland, Ohio, Oct. 3, 1919 (slightly abridged).

Safety Supervisor,
United Gas Imp. Co.,
Philadelphia, Pa.

Explosion Hazard in Steel Mills From Partly Consumed Coal Dust

FOR many years natural gas has been the principal fuel used in the heating furnaces in those mills located in the Pittsburgh district which manufacture bolts, nuts, rivets, picks, mattocks and small forgings. For a number of years the steady supply of this fuel has been more or less interrupted owing to the increased demand for domestic use and to the increasing difficulty in securing an adequate amount of natural gas.

This condition has led a number of the steel companies to substitute pulverized coal as a fuel for the furnaces. Elaborate installations have been made for pulverizing the coal and conveying it to the furnaces. Soon after the furnaces commenced to operate with pulverized coal, large quantities of fine dust began to accumulate on the platforms over the furnaces, the roof trusses, on the outside of the various pipe lines, electric cables and even on the roofs of the buildings.

Some of the companies, becoming alarmed, requested the Bureau of Mines to make an investigation to ascertain the liability of this dust to cause an explosion. While conducting this investigation, an explosion occurred in another mill which caused the death of one man and severely burned two others.

A report of this investigation by L. D. Tracy is included in the *Monthly Reports of Investigations* for December, 1919.

Eleven samples of the dust (which for convenience has been termed "mill dust") from various locations in the different mill buildings were taken and submitted to chemical analysis, microscopic examination and also to flame and explosion tests. Table I shows the range of the proximate analyses of these samples of mill dust, compared with analyses made upon five samples of the pure coal dust, before passing into the furnaces. The inference drawn from a study of these figures, namely,

TABLE I. PROXIMATE ANALYSES OF COAL DUST

	Mill Dust, per Cent	Pure Coal Dust, per Cent
Volatile matter	6.3 to 23.54	30.50 to 36.81
Fixed carbon	50.88 to 67.08	46.86 to 52.48
Ash	22.29 to 32.16	9.26 to 21.84

that for some reason the pulverized coal was being blown out of the combustion chambers of the furnaces before it had been thoroughly consumed, was further substantiated by microscopic examination.

Determination of Explosion Pressures

The several samples of dust were also subjected to tests to determine the pressure which might be exerted by the dust in a possible explosion, as compared with

TABLE II. EXPLOSION PRESSURES DEVELOPED BY COAL DUST IN CLEMENT-FRASER APPARATUS

Sample	Volatile Matter, per Cent	Explosion Pressure, Lb. per Sq.In.
Pure coal dust	.....	14.5
Mill dust	23.54	10.21
Mill dust	20.6	8.7
Mill dust	15.91	4.6

pure pulverized coal; this test was conducted in the Clement-Fraser apparatus (described in Technical Paper 141 of the Bureau of Mines). Briefly, this apparatus consists of a glass globe, possibly 6 in. in diameter, containing a small platinum coil which is electrically heated. A sample of dust is blown against the heated coil and the pressure of the resulting explosion is recorded by a pressure indicator. In these tests about 0.003 oz. of pure pulverized coal was blown by about 8 cu.in. of oxygen under a pressure of 5½ in. of mercury against the platinum coil, which had been heated to a temperature of 2,200 deg. F. The average pressure obtained was 14.5 lb. per sq.in. The results of several tests on mill dust are given in Table II.

Further experiments to determine the explosibility of the mill dust were carried on in the dust explosion gallery of the Bureau. Tests were also made to determine the inflammability of the dust, one of these being the heating of a clay roasting dish 6 in. in diameter, in a furnace to a temperature of 2,000 deg. F. When the dish had reached this temperature, about one-sixth of an ounce of "mill dust" was quickly dropped in a cloud upon it. Another test was made by blowing a small amount of the dust in a cloud across the flame of a Meker burner.

These methods of testing were valuable, as they were almost identical with the conditions in and around a steel mill where the red hot iron and steel are often in close proximity to clouds of dust. The results obtained are summarized in Table III.

TABLE III. INFLAMMABILITY TESTS ON MILL DUST

Per Cent Volatile Matter in Sample	Observations
23.54, 20.60	Burned readily with more or less explosive violence.
15.91, 13.45, 11.5	Burned readily but without violence.
11.25, 10.99	Slightly inflammable.
7.17	Would not burn at all.

From the above-described tests and from similar tests with dust from the steel mills of other companies, it has been fairly well demonstrated that the division point between mill dust which will explode and that which will not explode is reached when the dust contains about 11 per cent of volatile matter.

Example of Fire Hazard

A good example of the great danger from mill dust, caused by the use of pulverized coal, is the fire which occurred a few years ago in a plant in which there were a number of puddling furnaces, some of which used pulverized coal as a fuel. A draft of air blew some of the coal dust over some red hot iron or slag. The dust immediately ignited and communicated the flames to the roof trusses. These were covered with fine dust which caused the roof to burn so quickly that the men barely escaped in safety from the building.

Stopping Fans Too Soon a Dangerous Practice

Many of the systems distributing coal dust to the furnaces consist fundamentally of fans which drive the dust from the storage bins through large pipes, from which small feed lines lead to the burners. It is the practice in some mills, when the furnaces are shut down, to stop the fan before all the pulverized coal in the pipe line has been thoroughly blown out. This is a rather dangerous practice, for the reason that, when the pressure from the fan is stopped, there is liable to be a back draft from the furnace which may take live sparks into the feed line. These sparks will smoulder until the fan is started again and then will be fanned into a

flame, igniting the dust in the feed line with a consequent explosion. The fatal explosion mentioned in the first part of this article was evidently caused thus.

Other Precautions to Be Taken

The roof trusses, pipes, platforms and all other places upon which any considerable amount of dust might accumulate should be kept thoroughly cleaned. In cleaning these trusses, platforms, and so on, no flame torches or open lights should be used, because of the danger of igniting any dust cloud which might be raised.

In some of the furnaces in which natural gas has been used, it is customary to keep both the gas and pulverized coal connections ready for service. If coal is being used, the gas connection should be cut out, as there is a chance that a leaky valve may allow gas to accumulate in the main coal feed and become ignited by a back fire from the furnace.

All electric switches and motors should be kept from dust and all electric wiring should be kept away from any place where dust in large quantities is liable to accumulate. As far as possible the wiring should be carried in conduits.

Protection Against Static Discharges

Provision should be made to protect properly all pulverizing machinery from damage which might be caused by an explosion due to the ignition of coal dust from static electricity in the machinery. All conduits, grinders and other parts in which an electric spark is liable to be produced should be grounded. Care should be taken that there is no way in which the coal dust can come in contact with hot metal, especially where pulverized coal storage bins are close to hot metal or hot slag.

Conclusion

The substitution of powdered coal for natural gas in the heating furnaces of the steel mills is of comparatively recent date, and there is hardly any doubt that the practice will become more general in its application as an adequate supply of natural gas becomes more difficult to obtain. As the problem of mill dust and the consequent danger therefrom seems to be prevalent in some plants using pulverized coal, it would seem imperative that every mill official should take precautions to prevent loss of life and property by an explosion or fire from this dust.

American Glass in Canada

Prior to the World War Canada's principal source of supply for plate glass was Great Britain, with Belgium second, the imports from the two countries in 1914 being 2,307,670 and 1,976,563 sq.ft. respectively, whereas during the fiscal year 1919 Canada obtained but 152,558 sq.ft. from Great Britain and none from Belgium. At present over 99 per cent of the glass imported into Canada comes from the United States, the quantity in 1919 being 1,736,895 sq.ft., whereas in 1914 only 299,042 sq.ft. came from that source.

Canada has been unable to secure its pre-war supply of plate glass, its total imports last year being but 1,889,451 sq.ft., against 4,672,534 in 1914, the reason being that the United States has become the world's chief source of supply, and was not in a position to meet the demand which was so suddenly made upon its manufacturers.

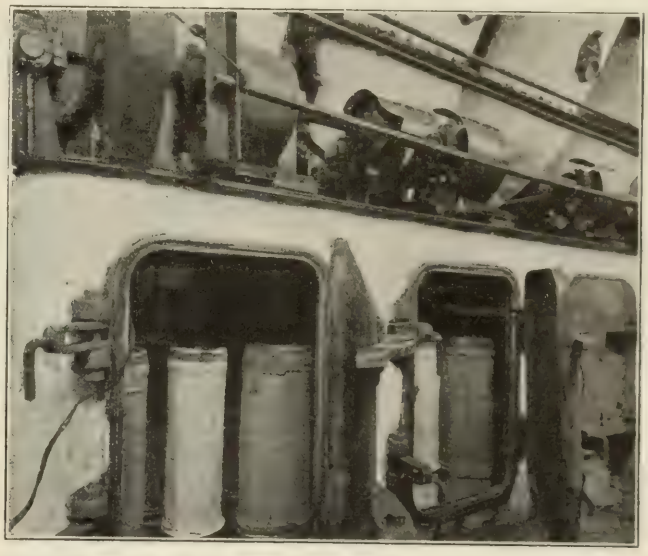
Canada has made some progress in the manufacture of plain window glass since the outbreak of the war.

Synopsis of Recent Chemical and Metallurgical Literature

Cleaning Blast-Furnace Gas.—A description of a dry method of cleaning iron blast-furnace gas previous to use in engines, stoves or boilers is given in *Iron and Coal Trades Review*, Dec. 19, 1919. Fifty-nine installations of this Halberg-Beth process are either in operation or under construction in Europe, with a total capacity of 174,000,000 cu.ft. per hr. (4,900,000 cu.m.), and it is claimed that the system overcomes the many difficulties in wet cleaning associated with providing and handling the very large amounts of water and power necessary.

Blast-furnace gas, after passing through an ordinary cyclone catcher for coarse dust, goes into a series of cooling towers, working like a surface condenser, and reducing its temperature to about 55 deg. C. From this it is taken to the filter bags by way of a preheater, where waste steam or gas superheats it about 10 deg. to prevent any moisture condensing during the next step.

The bag house is unique. One unit is divided into twelve sections, each containing twelve bags, fastened to a thimble floor as usual, and with closed tops suspended from a shaker frame. In operation, a suction fan draws clean gas through the fabric for about 7



TOP FLOOR OF FILTER HOUSE SHOWING SHAKING MECHANISM AND INSPECTION DOORS (OPEN) WITH FILTER BAGS IN POSITION

min., when the inlet and outlet valves for that section are reversed, placing pressure on the clean gas outside the bags. Hoops shown in the accompanying illustration prevent the bags from collapsing, the countercurrent of gas loosens dust in the fabric, and at the same time the upper suspension is vibrated up and down. In about 15 sec. the valves are reversed and a new cycle starts.

Gas at about 50 deg. C. is sent to burners or to gas engines. In the latter case it is cooled by sprays and then passes through a water separator. A content of 0.01 g. per cu.m. solid is easily attained in everyday working from dirty gas carrying 6 g., while 0.001 g. per cu.m. is often continuously attained. Filter bags last

at least six months, one year being a good average. One horse-power per 10,000 cu.ft. (280 cu.m.) gas per hr. is required to operate the fans, valves and shaking mechanism.

The Problem of Nitrogen.—The November-December issue of *Giornale di chimica Industriale* contains an important article by CARLO TONIOLO on the problem of nitrogen and its world and national importance. After describing the vital needs of nitrogen for the progress of civilized humanity, Mr. Toniolo dwells on the special need of Italy and gives comparative tables on capital required to produce nitrogen by the arc, cyanamide and synthesis of ammonia processes. These data, although specific to Italy, are of sufficient importance to be summarized in the accompanying Table IV.

Tables I and II show respectively the consumption of energy and of carbon in the nitrogen industries, and Table III shows the present status in Europe and North America of the potential and developed hydro-electric power.

TABLE I. CONSUMPTION OF ENERGY

Process	Kw.-Hr. per Kg. N	Kw.-Yr. per Ton N
Arc	70–75	8.4
Cyanamide	17–20	1.7–2.3
Synthesis of ammonia	1.5	0.17

TABLE II. CONSUMPTION OF CARBON

Process		Kg. per Kg. of N	Tons per Ton of N
Arc	For energy	51	51
Cyanamide	For reaction	3	3
	For energy	20	20
Total		23	23
Synthesis of ammonia	For reaction	3.6–3.8	3.6–3.8
	For energy	1.5	1.5
Total		5.2	5.2

TABLE III. POTENTIAL AND DEVELOPED HYDRO-ELECTRIC POWER

Country	Potential	Developed
United States	20,000,000	5,000,000
Canada	6,000,000	1,250,000
France	6,000,000	500,000
Norway	5,500,000	850,000
Spain	5,000,000	300,000
Italy	5,000,000	750,000
Sweden	5,000,000	600,000
Switzerland	1,500,000	400,000
Germany	1,000,000	500,000
Great Britain	700,000	60,000

He also describes the method developed by the Badische Anilin und Soda Fabrik at Oppau for the production of ammonium sulphate, ammonium chloride and urea based on the reactions:

$$CaSO_4 + CO_2 + H_2O + NH_3 = CaCO_3 + (NH_4)_2SO_4$$

$$2NaCl + CO_2 + H_2O + 2NH_3 = Na_2CO_3 + 2NH_4Cl$$

$$CO_2 + 2NH_3 = CO(NH_2)_2 + H_2O$$

Recent Chemical and Metallurgical Patents

British Patents

Complete specifications of any British patents may be obtained by remitting 25c. each to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Purifying Graphite.—Graphite reduced to a state of fine subdivision is treated with an aqueous solution of hydrofluoric acid, with a strength of between 30 and 50 per cent, sufficient in quantity to form a mud so as to obviate the employment of an undue bulk of liquid. The strength of the acid to be used depends on the percentage of carbon desired in the purified product, since, in some cases, a high percentage is not necessary. For example, in the manufacture of pencils and parts of electro-technical apparatus, to remove the whole of the silica, the remainder is converted during the process of purification into a gelatinous form, available for use as an agglomerating agent in subsequent operations. (Br. Pat. 134,894—1919. E. RIDONI TURIN and SOC. TALCOE GRAFITI VAL CHISONE, Pinerolo, Italy; Jan 14, 1920.)

Treatment of Tungsten Ores.—Tungsten ores are mixed with carbon and heated in dry chlorine at about 300 deg. C. Tungsten chloride or oxychloride is volatilized and condensed. The condensed chloride can be transformed easily into tungstic acid or other tungsten compound. Alternately the tungsten ore may be reduced by heating with carbon to a red heat, after which chlorine is passed over. (Br. Pat. 134,891. IMPERIAL TRUST FOR THE ENCOURAGEMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Westminster, and O. J. STANNARD, London; Jan. 14, 1920.)

Cementation.—Machined articles of soft iron and mild steel are coated with a metal such as nickel or cobalt and then subjected to a temperature of 1,000 to 1,200 deg. C. while protected from oxidation by a deposit or by a packing, until the nickel, etc., are absorbed by the iron or steel. Chromium and vanadium may also be used as the coating metal if the deposit thereof be protected by a deposit of iron or nickel. The packing material may be inert to the metal, or may act as a carburizer. (Br. Pat. 134,864—1919. E. H. JONES, London; Jan. 14, 1920.)

Recovering Lead and Tin.—Lead and tin are recovered from materials containing them, in the case of lead, with a treatment of hot ferric chloride solution, and in the case of tin, with hot ferric chloride or ferric sulphate solution. To the resulting solution, substan-

TABLE IV. CAPITAL INVESTMENT IN NITROGEN PLANTS

Process	Product	Required Capital Invested per Ton of Nitrogen		Cost of Production of 1 Kg. of Fixed Nitrogen with a Cost per Kw.-Yr. of		
		Thermo-electric Energy	Hydro-electric Energy	$20	$15	$10
Arc	Basic calcium nitrate with about 13 per cent N	$890	$1800	$0.32	$0.29	$0.25
Cyanamide	Calcium cyanamide with 18-20 per cent N	293	545	$0.16–$0.22	$0.15–$0.21	$0.14–$0.20
Synthesis of ammonia	Ammonium sulphate with 20-21 per cent N	$513		With a cost per ton of coal of $4, and per ton of lignite of $2.50. $0.15		
	Ammonium chloride with 20-24 per cent N	$400–$600		.12		

Ammonia from coal distillation, market price per kg, $0.33@$0.35.
Chilean nitrate, market price per kg., $0.32@$0.34.

tially free from acid, there is added about one-third of its volume of concentrated ferrous chloride or ferrous sulphate solution, and the lead or tin is then precipitated by means of scrap iron. The deposition is preferably carried out by adding from time to time successive portions of solution to be treated to solutions from which the metal has already been deposited. (Br. Pat. 135,052—1919. W. G. RUMBOLD, London; Jan. 14, 1920.)

Potassium Chloride.—Potassium salts are recovered from blast-furnace slag by the addition of calcium chloride to the slag, in a molten state, and by collecting the volatilized potassium chloride formed. The calcium chloride is introduced from a hopper into the stream of molten slag as this flows from the furnace to the ladle. Intimate mixing takes place by having the slag flow down a cascade into a chamber from which the potassium chloride fumes escape into a condenser, where they meet a spray of water and the potassium chloride solution is collected for further use. The treated slag is said to be improved for the making of slag cement. (Br. Pat. 134,665—1919. E. BURY, O. OLANDER, T. SMITH and F. BAMBRIDGE, all of Salturn-by-the-Sea, Yorkshire; Jan. 7, 1920.)

Magnesium Sulphate.—Magnesium sulphate is produced by heating to dull red a mixture of a magnesium-containing compound or mineral and calcium sulphide in a stream of air, water vapor and carbon dioxide. The separation of the resulting mixture of magnesium sulphate and calcium carbonate is effected by lixiviation. If the raw materials contain magnesium carbonate, the use of carbon dioxide can be dispensed with. (Br. Pat. 134,884. E. E. and P. C. DUTT, Jubbulpore, India; Jan. 14, 1920.)

Personal

Colonel WILDER D. BANCROFT, chairman of the division of chemistry, National Research Council, recently delivered a lecture at Oberlin College on colloid chemistry, and Mr. MARSH of the Hercules Powder Co. followed in the same alumni course with a lecture on high explosives.

Dr. ALLERTON S. CUSHMAN will deliver the 1920 course of lectures on "Chemistry and Civilization" under the Richard B. Westbrook Foundation at the Wagner Institute. Four lectures will be given on successive Saturday evenings, beginning March 13, at the hall of the Wagner Free Institute of Science, 17th Street and Montgomery Ave., Washington, D. C. Lectures are free to all.

J. R. DAWSON, formerly metallurgist with the American Steel & Wire Co., Worcester, Mass., has been appointed instructor in the department of metallurgy, Lehigh University, Bethlehem, Pa.

D. FRANKLIN FISHER, formerly of the U. S. Bureau of Chemistry, stationed at New York, has become research chemist for the Van Camp Packing Co., Indianapolis, Ind.

Prof. H. G. GREENISH, dean of the School of Pharmacy of the Pharmaceutical Society, London, has had conferred on him an honorary doctorate by the University of Paris.

FRANKLIN K. LANE, who retired as Secretary of the Interior on March 1, is now vice-president and legal adviser of the Mexican Petroleum Co. and the Pan-American Petroleum & Transport Co.

Dr. GRAHAM LUSK, professor of biological chemistry at Cornell Medical College, New York; Dr. LAFAYETTE B. MENDEL of Yale University, New Haven, Conn., and E. V. MCCOLLUM of Johns Hopkins University, Baltimore, Md., have been elected associate members of the Société Royale des Sciences Médicales et Naturelles de Bruxelles.

FRANK MERRICKS has been elected president of the London Institution of Mining and Metallurgy for 1920.

W. H. NICHOLS, president of the General Chemical Co., New York, has had conferred on him the degree of doctor of chemistry by the University of Pittsburgh.

Dr. A. A. NOYES has resigned from the Massachusetts Institute of Technology, to become director of chemical research at the California Institute of Technology, Pasadena, Cal.

W. A. NOYES, director of the department of chemistry of the University of Illinois, Urbana, Ill., has had conferred on him the degree of doctor of chemistry by the University of Pittsburgh.

F. K. OVITZ, superintendent of the Seattle Station, U. S. Bureau of Mines, has resigned to accept a position as fuel efficiency engineer with the Standard Oil Co. He will be located at Whiting, Ind.

G. A. RANKIN, who was with the Chemical Warfare Service at American University, has recently been made research chemist with the Geophysical Laboratory, Carnegie Institution, Washington, D. C.

F. H. RIDDLE, formerly with the Bureau of Standards at Pittsburgh, has accepted the position of director of research with the Jeffrey-Dewitt Co., Detroit, Mich.

Dr. R. E. RINDFUSZ, formerly assistant in chemistry at Oberlin College, has been appointed chief chemist to the American Writing Paper Co., at Holyoke, Mass.

Dr. WILLIAM T. SEDGWICK, head of the department of biology and public health at the Massachusetts Institute of Technology, will be the first exchange professor with the Universities of Cambridge and Leeds.

H. E. SKOUGOR has severed his connection with Guggenheim Bros., the Chile Exploration Co. and the Braden Copper Co. and has opened an office at 120 Broadway, as consulting industrial engineer.

EUGENE STEBINGER has been appointed chief of the foreign section of the Mineral Resources Branch of the U. S. Geological Survey. He has lately returned from private work in the Tampico oil fields of Mexico.

Dr. ALLEN E. STERN of the department of chemistry of the University of Illinois has resigned to become head of the division of physical chemistry at the University of West Virginia.

Dr. VICTOR C. VAUGHAN of the University of Michigan, Ann Arbor, presented a paper on Jan. 30 before the Institute of Medicine at Chicago on "The Chemistry of the Protein Molecule in Relation to Infection."

C. ERB WUENSCH, secretary of the Alumni Association of the Colorado School of Mines, has been in New York and other Eastern cities on professional business.

The American Physical Society elected the following officers at its St. Louis meeting: President, J. S. Ames; vice-president, Theodore Lyman; secretary, D. C. Miller; treasurer, G. B. Pegram; managing editor, F. Bedell; councillors, F. B. Jewett and Max Mason; members of the editorial board, E. L. Nichols, C. M. Sparrow and W. F. G. Swann.

The Southeast Texas Section of the American Chemical Society announces the election of the following officers for the year 1920: President, Dr. Felix Paquin, Galveston; vice-president, H. B. Weiser, Houston; councillor, Dr. F. W. Bushong, Port Arthur; treasurer, H. D. Draper, Houston; secretary, P. S. Tilson, Houston.

Obituary

WILLIAM J. DWYER, who established the Trade News Service, New York, died at his home in New Rochelle, N. Y., Feb. 19. Prior to entering the field on his own account, Mr. Dwyer was a member of the reportorial staff of the *Oil, Paint and Drug Reporter.*

JAMES GAYLEY, formerly vice-president of the United States Steel Corp., adviser of Andrew Carnegie in the creation of the Carnegie libraries and other Carnegie institutions presented to the public, died on Feb. 25 in his home, 555 Park Ave., New York City, after a brief illness. Mr. Gayley was sixty-five years old.

Perhaps no other individual in the world did more toward the perfection of the blast furnace than did Mr. Gayley. He had an international reputation as an inventor of steel- and iron-making apparatus; and especially did he achieve fame as the creator of the dry air blast, a refrigeration method of extracting the moisture from the blast-furnace atmosphere.

He also invented the auxiliary casting stand now used extensively in bessemer steel plants. He received the Elliot Cresson medal from Franklin Institute, Philadelphia, for inventing the dry air blast, and had been honored by many colleges and scientific institutions in the country for his achievements in the iron and steel industry.

Mr. Gayley was from his very entry into the steel-making business an intimate friend and adviser of Andrew Carnegie. He was one of the original Carnegie partners, "one of the boys who made the name Carnegie famous," as the Laird of Skibo used to say.

Mr. Gayley was born in Lock Haven, Pa., Oct. 11, 1855, a son of Rev. Dr. Samuel Alexander Gayley and Agnes G. Malcolm Gayley. After attending the public school at Lock Haven, he entered Lafayette College, where he was graduated with the engineering class of 1876, taking honors in mining and metallurgy. His first position was as chemist of the Crane Iron Co., the oldest iron-making concern in the Lehigh Valley. It was from the machine shops of the Crane Iron Co. that Captain William R. Jones, whose services to the steel industry while manager of the Edgar Thomson Steel Works ever will be remembered, graduated. Three years later Mr. Gayley became superintendent of the Missouri Furnace Co. of St. Louis. Shortly afterward he accepted the position as superintendent of furnaces at the E. & G. Brooks Iron Co., at Birdsboro, Pa.

In the fall of 1885, at the invitation of Captain Jones, Mr. Gayley accepted the position of furnace superintendent of the Edgar Thomson Steel Works at Braddock. This was the beginning of his association with Andrew Carnegie.

When Charles M. Schwab was transferred to the Homestead Steel Works Mr. Gayley was appointed general superintendent of the Edgar Thomson works, and in 1895 was transferred to the general offices in Pittsburgh to assist the late Henry M. Curry in the increasing business of the ore department. Upon the retirement of Mr. Curry from active business Mr. Gayley succeeded to the management of the ore department and also as a member of the board of managers of the Carnegie Steel Company, Ltd.

He continued with the Carnegie interests until the formation of the United States Steel Corp. in 1901, when he was made first vice-president of the Steel Corp., and had since made his headquarters in New York City. He retired from the Steel Corp. about eight years ago to devote his undivided attention to his personal interests. He was succeeded in the corporation by D. G. Kerr.

Mr. Gayley was generous toward Lafayette College. He had given approximately $100,000 to that institution, among his gifts being a splendid chemical and metallurgical laboratory.

Mr. Gayley for many years was president and director of the American Ore Reclamation Co. He was a trustee of Lafayette College, Tome Institute, was at one time president of the board of directors of the American Institute of Mining Engineers, and was a member of the Iron and Steel Institute of Great Britain. He was a member of the following clubs: Duquesne, Metropolitan, University, Engineers, Oakland, Golf, Bankers, Automobile of America and the Society of St. Andrew's and the Pilgrims of the United States.

Dr. S. MACKAY, professor of chemistry at Dalhouse University, died of pneumonia at Halifax, N. S., on Jan. 6. He was born in Nova Scotia in 1864.

JAMES P. REILLY of The Barrett Co., New York, died recently at his home at Germantown, Pa. Death was caused from hemorrhage of the brain from an attack which occurred two weeks before his death and which, it is believed, is traceable to overwork during the war when he was chairman of a chemical board, with headquarters in Washington. Prior to his last illness, Mr. Reilly had never known a sick day in his life. He was born in Ireland forty-three years ago, and was educated in England. As a youth he came to Philadelphia. He had been connected with The Barrett Co. for many years. He leaves a widow, Mrs. Minnie McKey Reilly, a daughter and three sons.

Dr. EDWIN A. STRONG, professor emeritus of physics at the Michigan State Normal College, died Feb. 4 at the age of eighty-six.

RALSTON C. WARE, president of Ware Bros. Co., Philadelphia, publishers of *American Fertilizer* and other trade journals, was stricken with pneumonia and died Wednesday, Feb. 4, at the age of sixty.

HERBERT SPENCER WOODS, professor of biological chemistry at the University of Texas, died at Dallas on Jan. 4, following an operation. He was thirty-six years of age.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 1.—There has been little change since last week's report. Tin, lead and mercury advanced, while zinc and silver declined slightly.

		Cents per Lb.
Copper, electrolytic		19.00
Aluminum, 98 to 99 per cent		33.00
Antimony, wholesale lots		12.00
Nickel, ordinary		43.00
Nickel, electrolytic		45.00
Tin, Straits, spot		64.50
Lead, New York, spot		9.00
Lead, E. St. Louis, spot		8.37½
Zinc, spot, New York		9.30
Zinc, spot, E. St. Louis		9.00
Silver	oz.	$1.29½
Cadmium	lb.	1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	90@92

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	26.50
High brass rods	23.75
Low brass wire and sheets	28.50
Low brass rods	29.25
Brazed brass tubing	38.25
Brazed bronze tubing	43.00
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	32.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap	23½@24½
Aluminum, sheet scrap	22½@23½
Aluminum clippings	25½@27
Copper, heavy machinery comp	14½@14¾
Copper, heavy and wire	13¾@14
Copper, light and bottoms	12½@12¾
Copper, heavy cut and crucible	16½@17
Brass, heavy	11½@12
Brass, casting	10½@10⅝
Brass, light	9 @ 9⅛
No. 1 clean brass turnings	9¾@10
No. 1 comp. turnings	12 @12½
Lead, tea	5½@ 5⅝
Lead, heavy	6 @ 6¼
Zinc, scrap	6 @ 6¼

Chemical and Allied Industrial Markets

New York, February 27, 1920.

Continued firmness characterized the chemical market during the past week, there being but few changes of importance. Demand in the spot market is still brisk and small supplies are the only drawback. Unfavorable rate of exchange has slightly affected exporting in some lines, but *caustic soda* still tops the list and is under heavy foreign inquiry.

HEAVY CHEMICALS

White salammoniac remains steady, with a slight upward tendency, 15@16c. per lb. being the listing on carlots, while in less than carlots it is quoted at 16@18c. *Barium chloride* has been very active and quotations vary greatly, $100 per ton being the lowest and $130 the highest. There is very little of this material on the spot market and producers

are pushed to the limit to meet their contracts. The export demand has fallen off slightly on *caustic potash*, while domestic demand continues firm. The last price of 28@32c. is still maintained.

Soda ash is practically off the spot market. Sales have been reported on the light at $2.50@$2.60 per cwt., while $2.70@$2.75 is being asked for the dense. Foreign demand remains unaltered despite the low rate of exchange. *Cobalt oxide* has been advanced from $1.50@$1.55 per lb. to $2@$2.05. This change went into effect the early part of last week. *Niter cake* is very scarce and the price still remains firm at $7.@$7.50 per ton. There has been a tightening in *sal soda* during the past week, with the price of $1.35@$1.40 per cwt. remaining firm. *Oxalic*, crystals, has advanced during the past week and as high as 46c. per lb. is being asked for spot material, but the average price ranges from 40@42c. per lb. A slight tightening of supplies has been felt in *sulphuric*, 66 deg., which remains firm at $22 per ton.

Coal-Tar Products

The coal-tar products market remains practically unchanged, although it is reported that producers are not being pushed as hard as they were a few weeks ago, but as yet this has not affected the spot market. *Dimethylaniline* continues scarce owing to the lack of methyl alcohol. Quotations range from 95c.@$1.20 per lb. *H acid* is practically unobtainable either on spot or contracts. The price of $1.60@$1.75 per lb. remains firm. *Pthalic anhydride* has picked up slightly and is now being offered at 60@70c. per lb. The spot market on *benzol* is rather tight. Producers are supplying contract orders at 25c. per gal. *Alpha naphthol* continues scarce, there being very little material available on spot. Crude is quoted at $1@$1.10 per lb., while refined is listed at $1.40@$1.60 per lb.

Naval Stores

There has been a gradual decline in this market lately, due principally to the unfavorable rate of exchange. England has fallen below her previous large buying business in this country. The coming spring painting campaign is expected to put *turpentine* back in its recently high position. Present quotation on spirits of turpentine is about $1.93 per gal., as compared with $2.05 a few weeks ago. *Rosins* have dropped in all grades due to a falling off of foreign inquiry.

Crude Rubber

Evidently the bottom has not been reached in the crude rubber market, as prices continue steadily on the decline. Buyers are anticipating a still lower level and are not very active beyond their actual present needs. The continued low rate of exchange is responsible for the low price level now existing in this market.

Oils

An easier market in practically all lines in oils is the report of the past week. *Cottonseed* continues on the decline and is quoted as low as 18¼c. per lb. *Soya bean* remains quiet with a slight drop from 17¾c. to 16¾c. per lb. *Linseed* has been firmly maintained and it is pointed out by some that a drop in this item will occur before the spring buying season opens.

Miscellaneous Materials

The future market in *barytes* is still indefinite as to price. Producers' quotations are from month to month. Demand on this item remains brisk and plants are being worked to their limit in order to meet contracts. The present quotation holds firm at $35@$40 per ton. Quotations on *feldspar* are still nominal at $13.50@$18 per ton with great difficulty in locating any material even at the latter price.

Chicago, February 25, 1920.

Strong markets in all lines prevail, with production apparently not able to keep up with demand. Pressure of export business continues on alkilis, and prices in these items have been forced up another notch. Actual trading is light in all lines except alkalis, apparently because consumers refuse to buy anything beyond current needs.

Heavy Chemicals

Methyl alcohol is almost unobtainable, offers ranging from $2.25@$2.50 per gal. for 95 per cent grade. Owing to scarcity of the product, actual sales are few and for small quantities. *Ethyl* grade seems to be a little freer, some business being done at $5.35@$5.70 for 190 proof, in bbl. Production is so far behind spot demand that no orders for later delivery are being taken. *Formaldehyde* remains firm at 48@50c., with the severe shortage formerly noted still effective, with practically no future delivery contracts being placed.

On continued Eastern demand for export shipment *caustic soda* is again up, price for the solid being around $4.25 per cwt. in cars, f.o.b. works, and for the granulated $4.50@$4.75, with the latter figure ruling today. These figures represent an advance of from 35@50c. per cwt. since last reported. *Bleaching powder* remains stationary at $3 per cwt., f.o.b. works, in carload lots. Similar conditions have pushed the price of *soda ash* up 15c., with today's quotation $2.25 per cwt. Accurate quotations on *sodium bichromate* are impossible, transactions in small quantities having been closed during the past two weeks at 35@45c. per lb. It is offered today at 40c.

Acids show no important change. Demand is light, but production is so nearly completely under contract as to preclude any drop in prices. Current quotations are: *Sulphuric*, 66 deg., $22 per ton in cars; *muriatic*, 22 deg., $2.50@$2.62½ per cwt.; *nitric*, 42 deg., $7.25 per cwt., and *oxalic*, 40@42c. per lb. in bbl.

Coal-Tar Products

This market remains firm in all lines, producers holding the current high figures and buyers reluctant to do much trading. As production is gradually getting better, it seems that somewhat lower prices may soon prevail. *Benzol* and *toluol* stand at 27c. and 28c. respectively in large quantities from refiners. Spot business is very light and is at a slight advance over these quotations. In the acids no change is noted, *picric* being quoted at 25c. per lb., *benzoic* at 75c. for technical grade and *salicylic* at 44c. for technical grade. *Aniline oil* at 34c. and *aniline salts* at 44c. show no change, supply being very light and but little demand being felt at these high prices.

Vegetable Oils

Quietness prevails throughout this line, no changes of moment having occurred for some time. Current quotations for *linseed oil* in bbl. are $1.98 per gal., in cars, $1.75@$1.80 per gal.; *cocoanut oil*, miller grade, in bbl., 19c. per lb.; *soya bean oil*, 18@19c. in bbl.; *corn oil*, prime, in tanks, 19@20c.; *cottonseed oil*, crude, in bbl., 18¾c., prime summer yellow, in bbl., 23@23½c. These quotations are all f.o.b. Chicago.

Flotation Oils; Naval Stores

Foreign demand for *turpentine* has ceased for the present, and the domestic trade seems unwilling to pay such high prices, hence price is off from a quotation of $2.16 per gal. a few days ago to $1.96 per gal. today. With the new crop an unknown quantity, trading is apt to remain light. Acute shortage keeps pine oil up to its previous high mark of $1.50 for both pure and destructively distilled. Conditions affecting *turpentine* also prevail in trading in *rosin* as a result of which prices have receded. Present quotation on *F* grade is $18.80 and on *WW* is $22@$22.50.

Fertilizers

There is no change in prices in this market. As buyers seem to feel that conditions justify their expectation of lower prices soon, but little actual trading is being done. Last quotations were: *Ground blood*, $8; *unground blood*, $7.80; high-grade *ground tankage*, $7.65; *bone meal*, in carloads, f.o.b. Chicago, $46.50 per ton.

The Iron and Steel Market

Pittsburgh, February 28, 1920.

The iron and steel market has been the subject of conflicting emotions. While it may be the case sometimes that the market is controlled by actual physical conditions as to supplies and requirements, it has not infrequently been the case that the actual market has been dictated largely by men's feelings or emotions. In times of relatively slack demand for steel the consumer has underrated his prospective requirements and has had an undue feeling of security about the certainty of prompt deliveries in future, while in times of slight scarcity he has frequently been unduly alarmed and has sought to buy in excess of his real requirements.

Set in juxtaposition, two incidents of the past week are illustrative of the psychological aspect of the market just referred to. About three weeks ago sheet bars sold at the new record high price of $65, the buyers being automobile interests intending to have the bars converted into sheets under conversion contracts at sheet mills. Such conversion contracts have been easy to make with some sheet mills, on account of their being short of steel and thus having idle rolling-mill capacity. Even the Steel Corporation subsidiary has been quite ready to make such contracts in some cases, at quite moderate charge for the conversion. Last week sheet bars similarly brought $70. This week there were two sales, one of 1,000 tons of open-hearth at $80, and another of 1,500 tons of bessemer at $75. The item to be set in opposition to this feverish buying at sharply advancing prices is that a pig-iron producer has just sold a round tonnage of basic pig iron for early delivery on the basis of $41.50, valley, when previously the market had been pushed up by actual purchases to $43 and for a time had been well established at that figure as minimum for any delivery.

Market Abandoning Runaway Disposition

Further illustrating the market's tendency to abandon its disposition toward a runaway, either through discovery of an inability in the market to run very fast or far, or from an accretion of conservatism dictated by sober second thought on the part of producers, it is to be related that several large independents, hitherto practically out of the market, have set relatively moderate prices at which they will cover their customers for second quarter delivery, these prices being 3c. and 3.10c. for bars and shapes respectively, $2 a ton above the war control prices and $13 a ton above the March 21 or Industrial Board prices, still rigidly adhered to by the Steel Corporation, and 3.25c. to 3.50c. for plates, comparing with 3.25c. under the war control price and 2.65c. by the March 21 schedule.

It should be particularly noted that these prices are set for settlement of second quarter deliveries, because curious statements have been appearing in the financial press to the effect that the independent steel producers are sold up far ahead, hence "rumors from Pittsburgh" that the steel market is less strong than had been imagined do not mean anything. Nothing could be further from the truth than to assert that the independents at this time are unusually well sold up. On the contrary, they have unusually light order books, for a period of apparently heavy demand. This arises from the fact that the class of mills that have been seeking fancy prices could obtain them only for early deliveries while those who pursued the pseudo-conservative policy of staying out of the market and not naming prices at all have naturally not been making sales. They have by promise to customers reserved large tonnages to be furnished at prices to be named later, some of these prices having been named in the past few days, as related above, but such operations constitute an obligation on the part of sellers, not an obligation on the part of buyers.

Revolt Against Automobile Steel Price Dictation

A feature of the general steel market situation is the growing revolt among steel consumers against automobile trade dictation of prices. The automobile trade has been bidding fancier and fancier prices for prompt lots of steel products, as well as for various other materials, including lumber, plate glass, etc., and buyers of such commodities find that the pace set is one that simply cannot be followed by the manufacturers of such commonplace articles as agricultural implements, hardware, freight cars and locomotives. There is a growing disposition to reflect that the automobile trade, no matter how much money it may perhaps have at its disposal, does not and cannot consume the bulk of the production in any important commodity. In steel, for instance, while its consumption has not been estimated closely, the quantity can hardly be a quarter million gross tons of finished rolled steel a month, while the steel industry's capacity is in excess of three million gross tons a month.

Transportation Conditions Unimproved

On the whole transportation conditions as affecting the iron and steel industry have not improved. Coal operators claim their car shortage is greater than ever. Car supplies in the Connellsville region have been better this week than last, but were poorer last week than the average of several weeks preceding. On a general average the supply of cars for moving finished steel from mill may have improved somewhat. One very favorable item is that the Carnegie Steel Co., which four weeks ago had between 150,000 and 160,000 tons piled at its various plants awaiting shipment, has now cut the accumulation in half. On the other hand, the American Sheet & Tin Plate Co.'s accumulation has grown until it amounts to about 50,000 tons, or approximately ten days of normal production. A third aspect is presented by another subsidiary of the Steel Corporation, the National Tube Co., which has operated at fully 90 per cent of capacity since the first of the year, and has been able to ship its product as fast as made.

From these and other considerations a generalization may be hazarded that car shortages are a local matter, depending chiefly upon the terminal and other facilities in various districts. From this, furthermore, it may be inferred, as many railroad men have asserted, that what the railroads need is not so much cars and locomotives as additional terminal and siding facilities, and probably more block signalling. There is, however, a moderate volume of freight car inquiry in the market, and buying in the next few months may aggregate several tens of thousands of cars. Assertions sometimes encountered setting immediate railroad needs in terms of hundreds of thousands of cars may well be ignored.

Pig Iron

As noted above, basic pig iron has sold at $41.50, valley basis, against a previously established market of $43. Bessemer remains at $42, valley, and can easily be had for prompt shipment at this figure. Foundry remains at $42, valley, for extended delivery, with doubt whether much premium would have to be paid for prompt. Throughout the local market inquiry is very light, and some recent purchases were of smaller tonnages than the buyers originally contemplated.

Steel

Sheet bars have sold at up to $80, as reported above, and it is uncertain at what prices mills will cover regular customers for additional tonnages. Billets have been in light demand and correspondingly light supply, being quotable perhaps at $55 to $60.

Ferro-Alloys

There seems to be a scarcity of prompt ferromanganese, with sales of small lots reported at over $200. Furnaces continue to quote $160, delivered, for second half, but it is possible this might be shaded to $150. English is about $150, c.i.f. Spiegeleisen is held at $57 to $60, furnace, for futures.

Electrolytic ferrosilicon, 50 per cent, remains at $80, delivered, but one or two makers have just advanced to $85, while 75 per cent remains at $140, delivered. Bessemer ferrosilicon remains at last week's price of $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. Jackson, Ohio.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 – .....
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	5.25 – 5.75	6.00 – 6.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	..... –	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09½
Oxalic, crystals	lb.	.35 – .40	.40 – .46
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	..... – .....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	..... – .....
Sulphuric, 60 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	..... – .....
Sulphuric, 66 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., carboys	ton	..... –	..... – .....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 – .....
Tannic, U. S. P	lb.	..... –	1.35 – 1.45
Tannic (tech.)	lb.	..... –	.42 – .55
Tartaric, crystals	lb.	..... –	.69 – .74
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	..... –	.65 – .78
*Alcohol, denatured, 190 proof	gal.	..... –	.67 – .74
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¼ – .10¼	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.15 – .16	.16 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	..... – .....
Ammonium sulphate	lb.	.05 –	.06 – .....
Amylacetate	gal.	..... –	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..... – .....
Barium chloride	ton	100.00 – 105.00	110.00 – 130.00
Barium dioxide (peroxide)	lb.	.26 – .27	.28 – .30
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.90 – .95	..... – .....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	..... –	.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	..... – 3.50	4.00 – 4.50
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .80
Calcium sulphate, pure	lb.	..... –	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..... –	.80 – 1.05
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 – .....
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	..... –	2.00 – 2.05
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	..... –	.65 – .70
Copper sulphate, crystals	lb.	.08¾ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	3.00 – 3.25
Formaldehyde, 40 per cent	lb.	..... –	.45 – .65
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.24½ – .26
Iodine, resublimed	lb.	..... –	4.10 – 4.30
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	..... –	.13 – .17
Lead nitrate, crystals	lb.	..... –	.70 – .80
Litharge	lb.	11½ – 12½	12½ – .13
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	..... –	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	2.15 – 2.63	2.75 – 3.25
Magnesium sulphate, commercial	100 lb.	1.75 –	2.00 – 2.50
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.12½ – .13	.17 – .....
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	..... –	.60 – .65
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .37
Potassium bitartrate (cream of Tartar)	lb.	..... –	.56 – .60
Potassium bromide, granular	lb.	..... –	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 – .....
Potassium hydroxide (caustic potash)	lb.	.28 – .32	.35 – .42
Potassium iodide	lb.	..... –	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	..... –	$0.65 – $0.95

Nominal quotations.

		Carlots	Less Carlots
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	..... –	.40 – .70
Potassium sulphate	ton	$225.00 –	..... – .....
Rochelle salts (see sodium potas. tartrate)		..... –	..... – .....
Salammoniac (see ammonium chloride)		..... –	..... – .....
Salsoda (see sodium carbonate)		..... –	..... – .....
Salt cake (sodium sulphate)	ton	18.00 – 21.00	..... – .....
Silver cyanide	oz.	..... –	1.25 – .....
Silver nitrate	oz.	..... –	81½ – .82½
Soda ash, light	100 lb.	2.50 – 2.60	..... – .....
Soda ash, dense	100 lb.	2.70 – 2.75	..... – .....
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite	cwt.	5.00 – 6.00	6.50 – 7.00
Sodium borate (borax)	lb.	.08½ – .08¾	..... – .09
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.40	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.30 –	.31 – .34
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..... –	4.85 – 5.25
Sodium hyposulphite	lb.	..... –	.03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	..... – .18
Sodium peroxide, powdered	lb.	..... –	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	..... –	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – .....
Zinc carbonate, precipitate	lb.	..... –	.20 – .....
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .....
Zinc dust	lb.	.11½ – .12½	.13 – .15
Zinc oxide, dry American	lb.	..... –	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.42 — .50
Anthracine, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.05 — 1.25
Benzidine, sulphate	lb.	.90 — 1.00
Benzoic acid, U.S.P.	lb.	.90 — 1.10
Benzoate of soda, U.S.P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .29
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .55
Beta naphthol, sublimed	lb.	.65 — .80
Beta naphthol, tech	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal	.85 — 1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 — .70
Dichlorbenzol	lb.	.07 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline	lb.	.95 — 1.20
Dinitrobenzol	lb	.26 — .37
Dinitroclorbenzol	lb	.25 — .30
Dinitronaphthaline	lb	.45 — .55
Dinitrophenol	lb.	.32 — .36
Dinitrotoluol	lb.	.38 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal	.38 — .40
Diphenylamine	lb.	.55 — .65
H-acid	lb	1.60 — 1.75
Metaphenylenediamine	lb	1.15 — 1.80
Monochlorbenzol	lb	.12 — .15
Monoethylaniline	lb	1.50 — 1.75
Naphthaline crushed, in bbls. (250 lb.)	lb	.06 — .08
Naphthaline, flake	lb.	.07 — .08
Naphthaline, balls	lb	.08½ — .10
Naphthionic acid, crude	lb	.75 — 1.25
Nitrobenzol	lb	.14 — .19
Nitro-naphthaline	lb	.30 — .35
Nitro-toluol	lb	.20 — .30
Ortho-amidophenol	lb	3.75 — 4.25
Ortho-dichlor-benzol	lb	.15 — .20
Ortho-nitro-phenol	lb	.80 — 1.25
Ortho-nitro-toluol	lb	.25 — .40
Ortho-tolnidine	lb	.25 — .45
Para-amidophenol, base	lb	2.50 — 3.50
Para-amidophenol, HCl	lb	2.50 — 3.25
Para-dichlor-benzol	lb	.12 — .18
Paranitraniline	lb	1.00 — 1.35
Para-nitro-toluol	lb	1.35 — 1.50
Paraphenylenediamine	lb	2.15 — 3.00
Paratoluidine	lb	1.75 — 2.50
Phthalic anhydride	lb	.60 — .70
Phenol, U. S. P., drums (dest.), (240 lb.)	lb	.12 — .25
Pyridin	gal	2.00 — 2.50
Resorcin, technical	lb	3.75 — 4.50
Resorcin, pure	lb	6.50 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb	.43 — .45
Salicylic acid, U. S. P.	lb.	.55 — .60
Salol	lb	.90 — .95

Solvent naphtha, water-white, in drums, 100 gal..	gal.	$0.22	—	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	....
Xylol, commercial, in drums, 100 gal	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	—	$0.45
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1	lb.	.80	—	.88
Carnauba, No. 2, regular	lb.	.65	—	.78
Carnauba, No. 3, North Country	lb.	.46	—	.48
Japan	lb.	.18½	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.07½
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½	—	.10½
Paraffine waxes, refined, 133-135 m.p.	lb.	.....	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.....	—	.14
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$17.00	—	$18.50
Rosin E-I	280 lb.	18.05	—	18.75
Rosin K-N	280 lb.	18.50	—	21.50
Rosin W. G.-W. W	280 lb.	21.50	—	24.25
Wood rosin, bbl	280 lb.	15.50	—	17.50
Spirits of turpentine	gal.	.....	—	1.93
Wood turpentine, steam dist	gal.	.....	—	1.93
Wood turpentine, dest. dist	gal.	.....	—	1.85
Pine tar pitch, bbl	200 lb.	8.50	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.75
Retort tar, bbl	500 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.93	—	.95
Rosin oil, second run	gal.	.96	—	.97
Rosin oil, third run	gal.	1.10	—	1.15
Rosin oil, fourth run	gal.	.....	—	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.42½	—	$0.44
Upriver coarse	lb.	.31½	—	.35
Upriver caucho ball	lb.	.31½	—	.34½
Plantation—First latex crepe	lb.	.46½	—	.49
Ribbed smoked sheets	lb.	.46	—	.48
Brown crepe, thin, clean	lb.	.41	—	.43
Amber crepe No. 1	lb.	.45	—	....

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.18	—	$0.19
Castor oil, AA, in bbls	lb.	.21¼	—	.23
China wood oil, in bbls	lb.	.23½	—	.25¼
Cocoanut oil, Ceylon grade, in bbls	lb.	.18½	—	.19½
Cocoanut oil, Cochin grade, in bbls	lb.	.20½	—	.23
Corn oil, crude, in bbls	lb.	.19	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.18¼	—	.20
Cottonseed oil, summer yellow	lb.	.22	—	.27
Cottonseed oil, winter yellow	lb.	.24½	—	.25½
Linseed oil, raw, car lots	gal.	1.65	—	1.68
Linseed oil, raw, tank cars	gal.	1.60	—	1.62
Linseed oil, boiled, car lots	gal.	1.70	—	1.75
Olive oil, commercial	gal.	2.50	—	3.00
Palm, Lagos	lb.	.16½	—	.16½
Palm, bright red	lb.	.15½	—	.17½
Palm, Niger	lb.	.16	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22½	—	.24
Peanut oil, refined, in bbls	lb.	.27	—	.28
Rapeseed oil, refined in bbls	gal	1.45	—	1.68
Rapeseed oil, blown, in bbls	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½	—	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16½	—	.20

FISH

Winter pressed Menhaden	gal.	$1.20	—	....
Yellow bleached Menhaden	gal.	1.18	—	....
White bleached Menhaden	gal.	1.20	—	....
Blown Menhaden	gal.	1.26	—	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.04½	—	.05½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	13.50	—	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00	—	52.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	07½
Graphite, crucible, 86% carbon content	lb.	.....	—	07
Graphite, crucible, 87% carbon content	lb.	.....	—	.07
Graphite, crucible, 88% carbon content	lb.	.....	—	.08
Graphite, crucible, 89% carbon content	lb.	.....	—	.08½
Graphite, crucible, 90% carbon content	lb.	.....	—	.08½
Graphite, crucible, 91% carbon content	lb.	.....	—	.08½
Graphite, crucible, 92% carbon content	lb.	.....	—	.09
Graphite, crucible, plus 92%	lb.	.....	—	.12
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, orange, fine	nominal lb.	1.55	—	1.60
Shellac, orange, superfine	lb.	1.65	—	1.70
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn
Chrome cement	net ton	45-50 at Chester, Penn
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.50
Ferro-manganese, 70-80% Mn	gross ton	160.00	—	170.00
Spiegeleisen, 16-20% Mn	gross ton	50.00	—	60.00
Ferro-molybdenum, per lb. of Mo	lb	2.50	—	2.75
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.25	—	1.40
Ferro-uranium, 35-50% of U	lb	7.00	—	....
Ferro-vanadium, 30-40% per lb. of contained V	lb	5.50	—	7.00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60	—	$0.85
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	7.50
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	6.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..	—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.80
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50	—	10.00
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	....
Pyrites, foreign, lump	unit	.17	—	
Pyrites, foreign, fine	unit	.17	—	
Pyrites, domestic, fine	unit	.16	—	.17
Ilmenite, 52% TiO_2	lb.	.02	—	
Rutile, 95% TiO_2	lb.	.11	—	
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb	.10	—	
Monazite, per unit of ThO_2	unit	42.00	—	....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb	$2.15
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.15
Tees, 3-in. and larger	100 lb.	2.15
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conchead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. fo 19 to 24 gage; for galvanized corrugated sheets, add 15c. all gages

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

GADSDEN — The Lehigh Portland Cement Co., Allentown, Pa., will build 2 large mills near here, one at Legarde and the other at Read's Mill. Estimated cost, $5,000,000.

California

OAKLAND—The Palmolive Co., 42 4th St., Milwaukee, Wis., plans to build a soap factory, here. Estimated cost, $400,000.

PASADENA—The Throop College of Technology will receive bids until March 10 for the construction of a laboratory. Estimated cost, $150,000. B. Goodhue, 2 West 47th St., New York City, archt. and engr. Noted Feb. 4.

Connecticut

DANBURY—The Danbury Roller Bearing Co., c/o Sunderland & Watson, archts., 248 Main St., has awarded the contract for the construction of a 2-story, 55x85-ft. manufacturing plant, to L. F. Sweeney, Montgomery St. Estimated cost, $25,000.

HARTFORD—The City School Bd. plans to build a 3-story high school on Maple Ave. and Benton St. Physical and chemical laboratories will be installed in same. Estimated cost, $1,250,000. Whiton & McMahon, 36 Pearl St., archts.

MERIDEN—The International Silver Co., 48 State St., has awarded the contract for the construction of a 1-story, 42x130-ft. manufacturing plant on Brooks St., to J. H. Grozier Co., 756 Main St., Hartford. Estimated cost, $25,000.

PLAINVILLE—The Standard Steel & Roller Bearing Co. is having preliminary plans prepared for the construction of a 1-story factory at the present factory site. Estimated cost, $75,000.

WINDSOR—The General Electric Co., Lynn, Mass., has awarded the contract for the construction of a 3-story, 60x200-ft. factory on its plant here, to W. M. Bailey Co., 88 Broad St., Boston, Mass. Estimated cost, $80,000.

Georgia

ATLANTA—The Corrugated Paper Products, Inc., has awarded the contract for the construction of a 2-story, 150x185-ft. factory on Stephens St., to the Massell Constr. Co., 305 Healy Bldg. Estimated cost, $60,000.

Idaho

ASHTON—The village will receive bids until March 23 for the construction of a sewage disposal plant, etc. Estimated cost, $120,000. Cotton & Wilson, Post Bldg., Idaho Falls, engrs.

Illinois

CHICAGO—The Koppers Co. is building a plant consisting of 100 byproduct ovens and a 20,000,000 cu.ft. water gas plant for supplying gas to the city mains on the drainage canal near the city limits.

CHICAGO—The Matchless Metal Polish Co., 840 West 49th Pl., will soon award the contract for the construction of a 2-story, 100x125-ft. factory on 49th Pl. and Halsted St. Estimated cost, $75,000. A. G. Lund, 453 West 63rd St., archt.

Indiana

EVANSVILLE — The Liquid Carbonic Co., Heidelback Ave. and Indiana St., is having plans prepared for the construction of a 2-story, 80 x 150 ft. factory. Estimated cost, $50,000. Clifford Shapbell & Co., archts.

Kansas

BLUE MOUND—Meese & Co. plans to move its old mill from St. Louis, Okla., here, and is in the market for rock drills, rolls and tables. George Meese, supt.

Louisiana

MANSFIELD — The Associated Producing & Refining Corp., Shreveport, plans to build a 5,000-bbl. refinery unit, here, ultimate capacity, 10,000 bbl. Malcolm Burns, pres.

RUSTON—The Russell Petroleum Co., of Ruston, plans to build a 1,200-bbl. refinery. Estimated cost, $120,000.

Maryland

CURTIS BAY (Baltimore P. O.)—The Sterno Corp. is having plans prepared for the construction of a plant for the manufacture of heating devices for automobiles and boats, on a 37-acre site along the waterfront, here. Estimated cost, $1,500,000. Carl Hauer, Jr., c/o U. S. Industrial Alcohol Co., resident dir.

Massachusetts

DORCHESTER—The Mason Regulator Co., 1190 Adams St., has awarded the contract for the construction of a 2-story addition to its manufacturing plant on Adams St., to the J. T. Scully Foundation Co., 1st St., East Cambridge. Estimated cost, $30,000.

LYNN—The General Electric Co. has awarded the contract for the construction of a 3-story, 60x100-ft. addition to its plant, to C. W. Wright, 23 Central Ave. Estimated cost, $50,000.

Missouri

CHITWOOD—Pearl Bros. plan to remove the old Hero tailing mill and erect same on the St. Regis lease to run St. Regis tailings. The owners are in the market for 1 hoist and 2 tables.

DUENWEG—The Clear-Peacher Mining Co. is building a new mill at its lead and zinc mine, here. The company is in the market for 1 compressor, 1 crusher, 2 sets rolls and 4 tables. Fletcher Clear, genl. mgr.

ST. LOUIS—The Mississippi Glass Co., 4070 North 1st St., has awarded the contract for the construction of a 1-story, 83x104-ft. glass factory at 83-91 Angelica St., to the Unit Constr. Co., Title Guarantee Bldg. Estimated cost, $26,000.

Montana

FORSYTH—The city plans to construct a complete sewage disposal plant, etc. A $40,000 bond issue has been voted upon for this project. W. C. Record, engr.

Nebraska

BROKEN BOW — F. M. Skillman, city clk., has awarded the contract for the construction of a sewerage system, including a disposal plant, to Smith & Chambers, Scotts Bluff. Estimated cost, $167,000. Noted Sept. 14.

New Jersey

TRENTON—The National Porcelain Co., Southard St., plans to build a 2-story, 50x72-ft. porcelain plant. Estimated cost, $20,000. R. G. Consolloy, 211 Commonwealth Bldg., archt.

New York

OGDENSBURG — Cooper's Brass Wks., Inc., is in the market for brass furnaces, etc. Address Robert J. Donahue.

ROCHESTER — The Virginia-Carolina Chemical Co. plans to construct a fertilizer factory on Lyell Ave. and the Barge Canal. Estimated cost, $500,000.

North Carolina

BURLINGTON—The Mayor will soon award the contract for furnishing filter apparatus, etc., in connection with the proposed waterworks system. The Ludlow Engrs., Winston-Salem, engrs.

North Dakota

COOPERSTOWN—The City Council will soon award the contract for the construction of a water softening plant in connection with the proposed waterworks improvements. Estimated cost, $79,000. Dakota Eng. & Constr. Co., Valley City, engrs.

COOPERSTOWN—The City Council will receive bids until March 8 for the installation of a septic tank, etc. Estimated cost, $56,000. Dakota Eng. & Constr. Co., Valley City, engrs.

LEEDS—The City Council will soon award the contract for the construction of a septic tank for the sewerage system. Estimated cost, $25,000. T. R. Atkinson, Bismarck, engr.

MAYVILLE—The City Council will soon award the contract for the construction of a filtration and water softening plant. Estimated cost, $25,000. T. R. Atkinson, Bismarck, engr. Noted Feb. 25.

Ohio

CINCINNATI—The Davis Welding Co., 1543 Queen City Ave., plans to build a factory on Borden St. Estimated cost, $150,000.

CLEVELAND—The Cleveland Automobile Co., East 131st St., is having plans prepared for the construction of a 1-story, 80x80-ft. heat-treating plant on London Rd. Estimated cost, $60,000. Ernest McGeorge, 1900 Euclid Ave., archt. and engr.

COLUMBUS—The Climax Rubber Co., Citizens Bank Bldg., has purchased a 7½-acre site on Northwest Blvd. and plans to construct a 3-story, 100x300-ft. rubber factory on same.

Oklahoma

ADA—The city has awarded the contract for the construction of a sewage disposal plant, to Yates & Gallamore, Ada, at $46,936. Noted Oct. 15.

CLAREMORE—The E. B. Rankin Oil & Refining Co. plans to build a 1,500-bbl. refinery, here. Estimated cost, $150,000. Address E. B. Rankin, Sapulpa.

PICHER—The Hunt Mining Co. is building a new 250-ton mill to replace the one recently destroyed by fire, and is in the market for new machinery. C. C. Whittier, supt.

PICHER—Moses & Marcum are moving the old Grayston mill from Tanyard Hollow to this city, and are in the market for gas engines, rolls and 6 tables. J. G. Marcum, supt.

ST. LOUIS—The Aztec Mining Co. plans to build a 250-ton mill at its lead and zinc mine, here, and is in the market for entire new equipment. Harry Larsh, supt.

TULSA—The Robinson Packer Co., 226 East 3rd St., plans to build a 2-story, 90x130-ft. factory at 209-17 North Main St., for the manufacture of oil well supplies. Estimated cost, $100,000. O. K. Eysenbach, pres.

Pennsylvania

LEMOYNE—The Pennsylvania Concrete Tile Roofing & Cement Products Co. will build a 1-story, 40x100-ft. factory for the manufacture of cement products. Estimated cost, $6,000. Work will be done by day labor.

PITTSBURGH—The Philadelphia Co., 435 6th Ave., has awarded the contract for the construction of a large blue gas plant near here, to the Bartlett Hayward Co., Scott and McHenry Sts., Baltimore, Md. The company has been compelled to build this plant owing to the shortage of natural gas.

West Virginia

SISTERSVILLE — The John B. Scohy Glass Co. is building a glass factory.

Ontario

NIAGARA FALLS—W. J. Seymour, City Clk., will receive bids until March 15 for furnishing a 35 gal. capacity chemical tank, etc. D. T. Black, Erie Ave., engr.

PETERBORO — The Canadian Aladdin Co., Canadian Pacific Ry. Bldg., has awarded the contract for the construction of a 3-story, 60x80-ft. factory for the manufacture of electric bulbs, etc., to the Dickie Constr. Co., Pyrie Bldg., Toronto. Estimated cost, $125,000.

TORONTO — The Keystone Products, Ltd., 133 Eastern Ave., is in the market for 1 second-hand electric furnace, etc.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CANADIAN MINING INSTITUTE will hold its annual meeting at the King Edward Hotel, Toronto, March 8 to 10.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 p.m., Dr. R. B. Moore, chief chemist, U. S. Bureau of Mines (*Lantern*); "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern*).

THE FARADAY SOCIETY (London) will hold a meeting on March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institute of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning October 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE BLAW-KNOX CO., Pittsburgh, Pa., has purchased the C. D. Pruden Co. of Baltimore, Md., manufacturer of standardized steel buildings for industrial plants, warehouses, cottages and garages. The Blaw-Knox Co. also announces that J. Grier Campbell, purchasing agent of the company, has resigned to become assistant treasurer of the C. D. Pruden Co. and that W. S. Boyd, formerly assistant purchasing agent of the Crucible Steel Co. and purchasing agent of the Page Steel & Wire Co., has been appointed purchasing agent of the Blaw-Knox Co. to succeed Mr. Campbell.

THE PHILADELPHIA TEXTILE MACHINERY Co., Philadelphia, Pa., manufacturer of drying machinery, has opened an office in the East River Bank Bldg., 291 Broadway, New York, of which H. S. Landell will be in charge.

THE EASTON CAR & CONSTRUCTION Co., New York, has opened a branch office in Room 400, Penobscot Bldg., Detroit, Mich., in charge of H. H. Siff, the district sales engineer. This company announces that this branch office will carry a stock of spare parts as soon as the demand for such service makes it advisable.

THE EASTERN PRODUCTS Co., of Putnam, Conn., has been incorporated to deal in chemicals, dyes, etc. The company will start with a capital of $25,000, and the organizers are as follows: Samuel Smith, 64 Ring St., Putnam; George F. Bidwell and G. A. Bidwell, both of Putnam, Conn. Address all matters to Samuel Smith, president.

THE NATIONAL CHEMICAL PRODUCTS Co., of 59 Elm street, Stamford, Conn., has been organized to make and deal in chemicals, etc. The officers of the new company are as follows: Philip Sewdosh, president; B. Troupin, vice-president; Eli S. Troupin, secretary and treasurer. Mr. Sewdosh is an experienced chemical man, and both B. Troupin and Eli S. Troupin are in the drug business in Stamford. The new company is now in operation.

THE MAHER ENGINEERING Co. of 30 North Michigan Ave., Chicago, announces the opening of a branch office under the direction of Lincoln E. Maher at 708 Scofield Bldg., Cleveland, Ohio. This office will distribute Erie Engine Works engines, Dayton-Dowd Co. centrifugal pumps and Galland-Henning hydraulic presses.

THE INTERNATIONAL ACETYLENE ASSOCIATION is making a census of schools where the art of oxy-acetylene welding is taught. The purpose of this census is to assist the association in answering inquiries from persons desiring to secure competent artisans in this kind of work. A blank form will be sent to any institution desiring to be registered with the association.

FREYN, BRASSERT & Co., Peoples Gas Bldg., Chicago, has made arrangements with the Gellert Engineering Co. of Philadelphia, Pa., for the mutual handling of Cottrell electrical blast-furnace gas cleaners for the entire world. Freyn, Bassert & Co. will have exclusive charge of sales and will co-operate with the Gellert Engineering Co. which is the exclusive builder of the Cottrell cleaner in the United States in the installation and practical adaptation of this apparatus to the particular requirements of blast-furnace practice.

Creditors of the METALS PRODUCTION EQUIPMENT Co. (bankrupt), Springfield, Mass., are notified that a second dividend of 10 per cent has been declared on all claims which have been proved and allowed but not entitled to priority. The trustee has been ordered to pay in full all claims which have been approved and allowed and are entitled to priority. The dividend is payable by Trustee Harry C. Dodge, Boston, Mass.

SIR RALPH FORSTER, Bart., has given £34,500 to the fund for building and equipping the chemical laboratory of University College, London. The department of organic chemistry will be called the Forster Laboratory.

Manufacturers' Catalogs

THE HAUCK MANUFACTURING Co., Brooklyn, N. Y., has issued a new bulletin, No. 119, illustrating and describing in detail its different types of oil burners. The catalog contains results of tests which are of particular value.

THE WELLMAN-SEAVER-MORGAN Co., Cleveland, Ohio, has just issued Bull. No. 49, giving views of a number of types of car dumpers together with blue prints of these machines. Copies will be sent upon request to any one interested.

PYROLECTRIC INSTRUMENT Co., Trenton, N. J., is issuing its January, 1920, bulletin, No. 10, the subject of which is "Secondary Standards of Inductance," by E. F. Northrup. This bulletin formerly came out once a month but now comes out bi-monthly, starting with this issue.

ELECTRO BLEACHING GAS Co., Niagara Falls, N. Y., announces a new publication entitled "Liquid Chlorine," which contains illustrations and descriptive matter.

N. B. PAYNE & Co., New York City, has just issued a new bulletin entitled "Lane Electric Cranes." This company is the sole agent for Lane electric cranes, manufactured in Montpelier, Vt., by the Lane Mfg. Co. The bulletin fully illustrates and describes several styles of cranes in which steel girders or heavy timbers of long leaf yellow pine are used. It contains a complete set of specifications and a list of users. A questionnaire is inserted in the bulletin for the use of the prospective purchaser on which can be written all information needed by the manufacturers. A free copy will be mailed upon request.

THE AMERICAN PULVERIZER Co., East St. Louis, Ill., announces Cat. No. 53 on the pulverizer that solves your problem. Illustrations and descriptive matter are given, including the standard pulverizers, coal crushers, shredder and disintegrator, and chemical machines.

THE ELECTRIC FURNACE Co., Alliance, Ohio, is distributing Booklet 8-B, entitled "Some Installations of Baily Electric Furnaces," melting non-ferrous metals. This booklet is profusely illustrated, with some descriptive matter, together with a list of the sizes built.

WESTINGHOUSE, CHURCH, KERR & Co., INC., New York, has issued a leaflet entitled "W. C. K. City." A large photograph is given showing many buildings erected by this company, which include manufacturing plants, shops, foundries, power plants, railroad terminals, hotels, etc., together with descriptive matter.

THE DELAVAL SEPARATOR Co., New York, has published Bull. No. 200, on the De-Laval method of centrifugal clarification of varnishes, japans and pigment goods, illustrating and describing multiple clarifiers, centrifugal filters, belt-driven machines, also the mechanical construction of the centrifugal machines, how the multiple clarifier bowl works and how the centrifugal filter bowl works.

THE KOPPERS Co., Pittsburgh, Pa., has issued a booklet on "Coal and Byproducts."

THE NORTHERN EQUIPMENT Co., Erie, Pa., calls attention to a 24-page booklet, entitled "Saving Fuel Automatically and Scientifically in the Boiler Room," based upon matter that was prepared for the United States Fuel Administration during the war. In the preface of the booklet the manufacturers say: "When the war ended we thought we had done our duty, and that the fuel situation would ease up a bit. However, we find the fuel problem now becoming serious. Prices will not come down because wages will evidently stay up or will go higher." The booklet compares hand and mechanical feeding with mechanical regulation, as performed by the Copes Regulator. It shows what is to be desired in the way of scientific boiler feed regulation. Many charts and diagrams are shown to emphasize the value of scientific control, together with a list of the users of Copes Regulators.

THE MEAD-MORRISON MFG. Co., East Boston, Mass., has issued a very attractive catalog, No. 21, on hoisting machinery. The catalog contains 166 pages illustrating and describing the different types of hoisting machinery for coal, ash and ore handling machinery, steam hoists, electric hoists, belt and gasoline hoists and grab buckets.

PORTABLE MACHINERY Co., INC., Passaic, N. J.: A bulletin has just been issued on portable belt conveyors for handling material horizontally or at a slight incline which are described and illustrated. It contains prices of these machines which are made with 16-in. wide belt and in standard stock sizes as follows: 12 ft. 6 in.; 16 ft.; 19 ft. 6 in.; 23 ft.; 26 ft. 6 in.; 30 ft.; 33 ft. 6 in., and 37 ft. These machines in addition to being used for handling coal, sand, crushed stone, fertilizer, etc., can be used for conveying many manufactured products, bagged material such as cement, etc.

THE INDUSTRIAL GLOVES CORP., Chicago, Ill., is issuing a booklet on industrial gloves and mittens. Illustrations and descriptive matter are given on gloves, mittens, arm protectors, hand pads, leggings and aprons, together with the prices.

THE GRISCOM-RUSSELL Co., New York, desires to announce Bull. No. 231, on the G-R instantaneous heater.

THE INDUSTRIAL PRODUCTS Co., Mutual Life Bldg., Philadelphia, has published a folder illustrating and describing industrial acid hoods and suits. These are products of acid-proof rubberized cloth designed to protect those who have to deal with acid lines, storage tanks and processes in which acids are used.

W. S. ROCKWELL Co., New York City, has issued Bull. 208, "The Function of Oil Burners in the Operation of Furnaces." This bulletin is being distributed with the idea of correcting the erroneous impression held by some regarding the real function of oil burners in the operation of furnaces.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
Assistant Editor

ALAN G. WIKOFF
Assistant Editor
L. W. CHAPMAN
Western Editor
CHESTER H. JONES
Industrial Editor
J. S. NEGRU
Managing Editor

Volume 22 — New York, March 10, 1920 — *Number* 10

Food Drafts for Relief of Europe

SUPPORTING an appeal from HOOVER is becoming almost a habit with engineers. Beginning with Belgian Kiddies, Ltd., and running through the whole list of plans for the relief of the war-stricken peoples of Europe, members of the engineering profession have gladly lent their support to projects which they knew were worthy. The latest plan devised for the relief of Europe's hunger is the sale of "food drafts" which can be bought at banks in the United States, mailed abroad and exchanged for the equivalent value in food at any one of five central warehouses in Europe. Mr. HOOVER appeals to engineers who are employers of foreign-born labor to bring to the notice of these workmen the easy possibility of assisting their friends and relatives in Europe who may be without sufficient food. As outlined in a letter from Mr. HOOVER, printed elsewhere in this issue, the plan is very simple. Bankers throughout the United States will sell food drafts authorizing the American Relief Administration warehouses at Hamburg, Warsaw, Vienna, Prague or Budapest to deliver to a named individual food to the value of the draft, $10 or $50. Hungry Europe needs food and not money; and under the arrangement between the American Bankers Association and the American Relief Administration, it is possible to supply food in addition to that which is available under the rationing system. The plan is highly practicable and we bespeak for it wide publicity and adoption.

Co-ordinating Scientific And Industrial Effort

IF THE war demonstrated one thing more than another to industry in this country, it was the inefficiency of rule-of-thumb methods and the necessity of scientific control. In many cases industrial executives made their first acquaintance with technically-trained men, and while the gap between the educational institutions and the industrial interests of the country cannot be said to have been completely bridged in all instances, it was materially narrowed. Following closely upon our war experience came the Massachusetts Institute of Technology with a plan for co-ordinating its interests with those of our industries in such a way as to promote the welfare of both education and business. Originally evolved as part of Tech's plan to secure endowment funds, the idea is full of promise for the recognition of science and those who apply it. For the next five years the Institute will introduce science to industry through co-operation between its own faculty, students and graduates and those concerns which have contributed to the endowment fund. This will mean five years of accustoming industry to the habit of seeking advice at the hands of scientists and technologists, at the end of which time a foundation will have been laid for the recognition of chemical and industrial engineers in a greater degree than would otherwise be possible. It should mean five years of the most rapid industrial progress ever made in this country. Details of the Technology Plan, outlined in this issue by Professor WALKER, reveal an idea which can be adapted to other institutions of learning. Indeed we are informed that Cornell already has adopted the plan, and we are assured by the Institute that other colleges and universities are welcome to do so. It was highly successful with its originators, over 190 contracts being made, having a money value in excess of $1,200,000.

Sewage Disposal And Physical Chemistry

SOME of us who have arrived at years which we hold to be those of discretion, but which are not generally considered to indicate the peak of man's productivity, are likely to grow a little testy about physical chemistry. This is especially the case if we have been lazy in our reading, or if we have let our mathematics and physics drift into those cloudy regions of memory where we keep our Latin grammar and our Greek verbs. We are apt to forget the available fields of research which should precede the methods of trial and error. We wonder if this has not been the case in regard to sewage disposal.

We have considered oxidation in many aspects, chlorination of effluents, the SO_2 reaction and a few other indefinite chemical phenomena, and thereupon we have addressed ourselves to the engineering problems. So we wonder if we have not begun with engineering a little too soon. If there is anything that the conscientious engineer needs to know, no matter of what particular kind he may be, it is the nature of his materials. Now, sewage and its disposal is largely a problem in colloid chemistry, and it may be that the subject has not been adequately studied from the colloid point of view. The chemical behavior of solid substances is largely dependent upon the surface of their particles, and this in turn is determined by the size of them. In such a miscellaneous mess as sewage we have presented a vast field for colloidal study, and the treatment is bound to be chemical if we would change its nature so as to rid it of offensiveness.

It may be that talent and scholarship of the first order in physical chemistry have been addressed to this subject, but if this be true the fact has escaped us. What we should like to see would be a comprehensive study undertaken of the physical chemistry of sewage in a laboratory where modern physicochemical methods of research prevail. It would give the engineers a better show—a better opportunity to design apparatus to meet existing conditions. It may be possible to

coagulate sludge and to separate it from the effluent in a much more effective manner than we now know. With an improved method of separation established it might open the road to a real solution of this perplexing problem. The record of chemistry in regard to sewage is not complete. The case is not closed. Our rivers are still canals of filth, while they carry off to the sea a wealth of nitrogenous material of which we are still in such need that we are at our wits' end to produce it.

An Engineer At the Shrine

These are predestined: if a man love the labour of any trade, apart from any question of success or fame, the gods have called him.

STIMULATED by the vision of a glass maker in his old apron and battered hat, H. L. DIXON recalled the days of twoscore years ago to the enlivenment of the ceramists at their meeting in Philadelphia. One who has thus been associated with an industry from its infancy, who has seen it become a giant in production, is to be envied indeed. All the best in life is not found in things intellectual. There is a call in the heart of every engineer to the handicraft of his business.

Ridiculous Substitute For the Metric System

OPPOSITION to the proposal to make the metric system compulsory in the United States has produced many foolish arguments, but up to date we have observed nothing quite so inane as the proposal contained in Senate Bill 3,943, the purpose of which is "to establish the standard and decimal divisions of weights and measures and coins of the United States." The bill was introduced "by request" by Senator KING of Utah, who is probably the willing or the unwilling victim of a zealous fanatic.

The bill proposes that after January 1, 1921, the standard for the measure of length and distance shall be the foot, as heretofore. One-tenth of a foot shall be a "decimal inch," one one-hundredth shall be a "line" and one one-thousandth of a foot shall be a "point." One-twelfth of a foot shall also be denominated a "common inch." The multiples of the foot shall be the "double foot, the yard, the quad, the fathom, the decad, the rod, the hundred, the furlong and the mile," whereby, under the grand old Arabic rule of decimal computation, 16½ ft. make one rod and 320 rods make a mile. (Why discriminate against the ancient "cubit," which was standard when NOAH built the Ark?) In measuring plane surfaces a square foot shall be called a "square," and the acre remains, as before, composed of 160 square rods. For volume we are to take a great leap forward by calling a cubic foot a "cube," and the cube of the "decimal inch" shall be called a "decimal cube."

For the measurement of weight we shall have a kind of an ounce which shall be "the weight of the decimal cube of water at maximum density." The decimal divisions of the ounce shall be the dram and the grain, "of which one hundred grains equal one dram and ten drams equal one ounce." Here the zealot's sub-conscious mind evidently referred to fluid measure in the dram, but as our memory serves us one-tenth of an ounce would make a very small pony. A more popular conception of a dram would be a jigger.

Ten ounces are to constitute one decimal pound, and one hundred decimal pounds one "weight unit," while eight "weight units" equal one "quarter" and ten quarters equal one ton. We shall also have the "common pound" of sixteen ounces. The liquid ounce is to be one decimal cube, and ten liquid ounces will be one decimal pint, while a thousand liquid ounces will be one "liquid cube." For dry measure we are to have "the quart, the pot, the gallon, the peck and the half cube." The mechanical power unit shall be that required to raise one "weight unit" one foot in one second. "The thermal unit shall be the quantity of heat required to raise one ounce of water one degree of the scale of the Fahrenheit thermometer," and we don't know what kind of an ounce it is. For coinage we are to have the dollar, the two-franc piece, the franc and the dime; the nickel, the penny and the cent; and in gold the pound, the eagle and the double eagle.

When we first heard of this bill we presumed it to be a joke, but on receiving a copy from Senator KING we found it to be a fact. We protest against the folly and waste involved in the legislative process of introducing such a bill. The cost of printing and the time of the Senators in session and of the Committee on Weights and Measures to consider and throw out such a fool bill mount into the thousands of dollars, all paid for in taxes by the people of the United States. Besides this we have to consider the far more important interruption of business of world-wide importance, all of which is wasted to meet a fanatic's pleasure. We wonder if there is any possible way of bringing to the consciousness of Congressmen the fact that neither their pleasure nor their political advantage in such matters is worth the price? Compared with this measure the proposal to make the metric system obligatory is the height of sanity; but this sort of a thing, with its different kinds of ounces and inches, its "drams," its "weight units," its "lines," "points," "pots," and so forth, would make confusion worse confounded, as everybody knows. We suggest that if the gifted gentleman who proposed the plan wants to be original. he substitute his ear as the standard of length, thus insuring good measure.

Speaking of Standard Weights and Measures

BROWSING around in ancient literature is usually entertaining, sometimes instructive and occasionally profitable. In an old work on metallurgy and assaying, published in 1799, under the title "Nueva Teórica y Práctica del Beneficio de los Metales de Oro y Plata por Fundición y Amalgamación," JOSEPH GARCES Y EQUIA describes a progenitor of our modern system of assay-ton weights.

Our author and inventor (if, indeed, the idea be original with him) proceeds somewhat as follows:

> For fine work, requiring a scorification assay, take one adarme [a Spanish weight equivalent to about one-sixteenth of an ounce troy] and call that a quintal ["assay quintal" being inferred] and divide the adarme into one hundred equal parts, or units, which we will call an [assay] pound. This unit divide again into sixteen parts, which we will call an [assay] ounce. Then by taking an adarme of the sample and using our system of weights we get a figure which corresponds to the pounds and [or] ounces of metal per quintal of ore.

There is also developed a similar system for the calculation of silver expressed in marcos per carga.

Thus we have further proof, if there be need of such, that there is nothing new under the sun.

Political and Commercial Nitrogen

UNBIASED views are particularly valuable at this time in attempting to get a clear-cut view of the situation relative to nitrogen and its compounds. As CHESTER G. GILBERT states elsewhere in this issue, "The discordant grinding of many axes makes a noise from which it is impossible to gather an adequate comprehension" of the facts. The comment is pertinent and is also indicative of the freedom from prejudice with which the author approaches his subject. We commend a careful study of Mr. GILBERT'S views to all who would comprehend the political and commercial activities relative to nitrogen.

The article will also be enlightening to members of Congress and other laymen who have in the past failed to distinguish the terms nitrogen, air nitrates, nitrification, fixation, etc., one from the other. Mr. GILBERT'S discourse is quite within the comprehension of the uninformed.

Nitrogen in tangible and usable form is important to our welfare at all times. The demand for fertilizers is increasing at a rate exceeding the supply, in spite of increased production caused by the war. Consequently, the future policy of the Government and of private industry cannot be decided without serious study, nor can final action be passed on personal or political prejudices. The price of nitrogen in fertilizer has been determined by the cost of the Chilean product, and there is little reason to infer that this condition will be altered for some time to come, even if the Government should operate its own plants.

Steel Corporation Does Not Violate the Sherman Law

IN NEARLY all circles there is an overwhelming feeling of satisfaction that the United States Supreme Court has declared that the United States Steel Corporation is not a violation of the Sherman law. The competitors of the Steel Corporation are well satisfied, its customers are well satisfied and its employees have great grounds for satisfaction. A few doctrinaires and lawyers may be dissatisfied.

It is of interest to note that the law under which the Government instituted its suit October 26, 1911, ten and a half years after the Steel Corporation came into existence, the act approved July 2, 1890, is officially entitled "An act to protect trade and commerce against unlawful restraints and monopolies." The text of the law does not so state, but the circumstances attending its passage have been regarded as indicating that the object was to clarify the existing common law into a definitely worded statute, rather than to prohibit things previously regarded as clearly lawful. To the ordinary observer the evidence has been plain that the corporation's conduct, at least in recent years, has not been such that trade and commerce needed to be protected against it. There are few, undoubtedly, who would deny that the existence of the corporation actually encouraged the growth of independent production.

Nevertheless, the record of the case is that the decision in favor of the Steel Corporation was by a four to three division in the Supreme Court, and that two Justices whom circumstances prevented from participating in the case are commonly assumed to feel unfavorably toward the corporation. It is also to be noted that the majority opinion cites that it would be injurious to the public interest for the corporation to be dissolved and that the Government omitted to outline a definite method by which dissolution could be effected, giving the dissenting Justices opportunity to assert, in essence, that the law should not be ignored because its execution presents difficulties. It can hardly be said, therefore, that the corporation secures anything at all beyond a mere termination of the suit in its favor, from the legal viewpoint.

Neither the majority nor the dissenting opinion can be found to add anything important to the interpretation of the Sherman law, yet the divergence of the opinions rendered is a definite indication that further clarification of the law is very desirable.

There were many defendants in this suit, all of whom won through the decision, but the really great victory was won by ex-Judge ELBERT H. GARY, chairman of the Steel Corporation since its formation nineteen years ago. Beyond peradventure of doubt it was Judge GARY'S policies that saved the United States Steel Corporation from defeat in the Supreme Court. Judge GARY did vastly more than keep the Steel Corporation from doing things that would have invited an adverse decision in the court. He helped the corporation, directly and in great measure, to succeed in a business way.

The case was really decided upon the conduct of the Steel Corporation. If the decision had been based upon the expectations and intentions of those who brought about the prior consolidations and the formation of the Steel Corporation itself, it requires little reflection to reach a conclusion that the decision would have been different, but the decision plainly writes such expectations out of the case.

This suit of more than eight years' standing being decided, the natural question is, What next? At various times a consolidation of a number of the larger independents has been discussed. It seems fairly clear that no large consolidation could be safe from legal attack. With a four to three decision in favor of the Steel Corporation, which is approximately a 44 per cent interest in point of finished steel-producing capacity, the spectacle of the steel industry's capacity being very largely in the control of two companies would hardly be viewed approvingly.

There is absolutely no reason to assume that the Steel Corporation's price and sales policies will be altered at all by the settlement of the suit. The Steel Corporation's steadfast adherence to March 21 or Industrial Board prices for steel, even beyond the calendar year for which they were formulated, rests upon important business considerations, rather than legal considerations, and undoubtedly has the strong approval of financial interests that are so well represented in the corporation's counsels.

As to investments in plant facilities, on the other hand, there is good reason now for the Steel Corporation to modify its policy. When there was hanging over it the threat of a dissolution, it was imperative that the corporation maintain as large liquid reserves as possible, against the arrangements that would be forced by a decree of dissolution. The occasion for the maintenance of these large liquid reserves has now passed, and the corporation may well address itself, when business conditions warrant, to the investment of a large part of these reserves in property account. In several of its important finished products the corporation now produces somewhat less than 40 per cent of the total produced in this country.

Readers' Views and Comments

Food Drafts for European Relief

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am sure that my fellow engineers will welcome an opportunity to assist in practical support of the relief measure for the civil population of the larger cities in Eastern and Central Europe. We have inaugurated a simple method by which it is possible

(1) For an individual in America to supply a relative or friend in Europe with a food package on payment in dollars at any one of several thousand banks in America.

(2) For anyone desirous of helping to give to the unfortunate without naming a particular relative or friend.

This is made possible by a "food draft" which can be bought at banks, mailed abroad, and is good for the equivalent in food when presented at any one of our five central warehouses in Europe. About four millions of our people are foreign-born or have close foreign affiliations. A large proportion of these people are operatives in our mines and large technical industries.

This is not a "charity" in the ordinary sense of the term, because we give much more than the same number of dollars could possibly buy in Europe if remitted in money at the present rate of exchange. Further, if the transaction is not completed in ninety days, the purchaser of the draft is entitled to a refund, less a small charge for handling. Profits which may be derived from these operations will be credited to the European Children's Fund for child-feeding in the country where the draft is presented.

I earnestly hope you can devote some space to an appeal to the engineers to make these facts known concerning this food draft system and interest the foreign-born in their employ in its possibilities and value. We want their indorsement and their support.

115 Broadway,
New York City. HERBERT HOOVER.

The Phonograph as an Adjunct to a Research Laboratory

To the Editor of Chemical & Metallurgical Engineering

SIR:—I desire to call attention to the fact that as an aid to scientific research, dictation machines such as the Ediphone or the Dictaphone bid fair to play a prominent part. This is particularly true in so far as the dictation of descriptive data is concerned.

For instance, it is quite feasible for the metallographist to enlist the service of such a help when he has occasion to observe the structure of a specimen under the microscope. His power of description is enhanced, while the field of vision is focused upon the retina. Furthermore, he is in a position to portray vividly the image in its minutest detail.

The prevalent method of recording microscopic data in most research laboratories is to explore the specimen and then write a description of such details as remain fresh in the mind. Much valuable information is lost in this manner; the investigator is later often desirous of writing a more detailed report, but he finds it difficult to depict exactly what he saw.

It is true that microphotographs are a valuable adjunct to scientific research, but their value generally lies in the phrases that describe them. Moreover, microstructures can be more sharply resolved under the eye piece than on photographic paper, except when the exposure, development and printing are done in the most expert manner.

Briefly stated, the investigator should find it to his advantage to dictate his observations the moment he sees them, and not rely upon memory.

The use of the phonograph may obviously be extended to kindred sciences, such as chemistry, biology, bacteriology and microscopic analysis. V. E. HILLMAN.

Worcester, Mass.

A Rapid Method for the Analysis of Monel Metal

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have been very much interested in an article appearing in your magazine of Jan. 7, 1920, written by Philip Covitz, entitled, "A Rapid Method for the Analysis of Monel Metal."

To make the method still more rapid, I would suggest the following:

Starting from the filtrate taken from the silicon determination; the filtrate should not consist of more than 125 c.c. Make this solution ammoniacal, which precipitates the iron and aluminum as hydroxides. If much copper is present, a double precipitation is necessary. Dissolve the precipitate in hydrochloric acid, dilute and add about 25 c.c. of a 10 per cent solution of sodium phosphate. Then make ammoniacal, then neutralize with hydrochloric acid, adding not more than 3 c.c. in excess. To this solution add 25 c.c. of a 40 per cent boiling solution of sodium thiosulphate. Boil for at least 10 min. and filter off the precipitate of aluminum phosphate. Wash the precipitate at least five times with boiling hot water and ignite in a porcelain crucible and weigh. Make the filtrate ammoniacal, boil and filter. Dissolve the precipitate of iron, which is in the form of iron hydroxide, in hydrochloric acid, reduce with stannous chloride and continue the determination for iron as given by Mr. Covitz.

I think this method is more simple and will require less amount of time for the determination than the one as outlined by Mr. Covitz because a separate weighing is not necessary for the iron and aluminum determination, as these two elements can be taken from the filtrate of the silicon determination, and because less time is consumed in the method that I have outlined above. H. A. HORNER.

American Metallurgical Corp.,
Philadelphia, Pa.

Potash From Lakes in Nebraska

To the Editor of Chemical & Metallurgical Engineering

SIR:—Through an unintentional oversight a section of the article on Potassium Salts in vol. 27 of *Mineral Industry* entitled "Potash From Lakes in Nebraska" on pages 584 and following does not give credit in the text to the source from which this material was copied, namely, an article by the same name, written by E. E. Thum and published in MET. & CHEM. ENG., Dec. 15, 1917. J. W. BECKMAN.
G. A. ROUSH.

Industrial Safety Codes

On Dec. 8 there was held at the Bureau of Standards in Washington a notable conference on industrial safety codes, at which there were representatives of practically all organizations of a national scope interested in any of these wide phases of industrial safety. The conference grew out of an earlier one held on Jan. 15, 1919.

There was a thorough discussion of the whole situation, the consensus of opinion being that there should be a large number of industrial safety codes—perhaps fifty or even one hundred—developed during the next few years.

The conference unanimously voted that the preparation of all such safety codes should be under the auspices and rules of procedure of the American Engineering Standards Committee.* In accordance with the recommendation of the conference, the American Engineering Standards Committee requested the International Association of Industrial Accidents Board and Commissions, the Bureau of Standards, and the National Safety Council to organize a Joint Committee on Safety Codes, this committee to include representatives of these bodies, and such others as they may consider advisable.

In compliance with this request the three bodies have organized such committee, the personnel of which is: D. S. Beyer, Boston, Mass.; Edward F. Boyle, Albany, N. Y.; C. B. Connelley, Harrisburg, Pa.; L. A. de Blois, Wilmington, Del.; W. C. L. Eglin, Philadelphia; George P. Hambrecht, Madison, Wis., represented by R. McA. Keown, Madison, Wis.; M. G. Lloyd, Washington, D. C.; Royal Meeker, Washington, D. C.; Dana Pierce, New York, N. Y.; C. C. Rausch, New York, N. Y.; Calvin W. Rice, New York, N. Y.; John Roach, Trenton, N. J.; E. B. Rosa, Washington, D. C.; A. W. Whitney, New York, N. Y., and S. J. Williams, Chicago, Ill.

It is planned to add two more members to the committee, one each from the Ohio and the California commissions.

The committee held its first meeting in Washington on Jan. 9, at which time tentative recommendations were formulated for about thirty safety codes. This committee, which represents in its own personnel a large range of interests, is actively at work. It is consulting a large number of other interests involved. Rapid progress is being made and it is expected that the committee will soon render an important preliminary report.

Regulation Affecting Transportation of Denatured Alcohol in Texas

Under the Dean law in Texas, no carrier can deliver denatured alcohol to the consignee without the permit required by this law. The United States Railroad Administration failed to take out such a permit for 1920. The attention of the Texas Chamber of Commerce was called to this situation by the First Texas Chemical Co., of Dallas, its plant having been forced to shut down for lack of denatured alcohol.

Upon telegraphic representations made by the Chamber of Commerce that failure to take out this permit promptly had prevented carriers from delivering denatured alcohol, thereby handicapping the chemical industry in Texas, the regional director ordered that a permit under the Dean law be taken out for Texas railroads then under Government control.

*See CHEM & MET. ENG., Feb. 18, 1920, p. 294.

Civil Service Examinations

The following examinations are announced by the Civil Service Commission:

Petroleum engineer, $3,000 to $4,500 a year; assistant petroleum engineer, $2,100 to $3,000 a year. Vacancies in Bureau of Mines for duty in Washington, D. C., or in the field will be filled from these examinations. Apply on Form 2,118 before March 16.

Geologic aid and assistant geologist for duty with United States Geological Survey at salaries ranging from $100 a month when actually employed to $1,800 a year. Apply at once for Form 1,312. Examination will be held March 17 and 18.

Automatic scale expert for duty in the Customs Service, New Orleans, La., at $1,600 a year. Applicant must be familiar with construction, operation and care of automatic and electric scales. Form 1,312 is to be used in applying for examination, which will be held March 17.

Foreman, heat treatment for armor plate, $10 to $14.40 a day; foreman, heat treatment of large guns, $8 to $12.56 a day. Vacancies at U. S. Naval Ordnance Plant, South Charleston, W. Va. Apply on Form 1,371 before March 23.

Valuation aid, $1,200 to $2,500 a year; assistant valuation engineer, $2,500 to $3,600 a year; valuation engineer, $3,600 to $4,800 a year. Vacancies in technical staff of Income-Tax Unit of Bureau of Internal Revenue, Treasury Department. The duties of these positions will involve estimation of: (1) The quantity of mineral or oil and gas or timber; (2) theoretical and market values of mineral or oil and gas in place or standing timber, and their products; (3) value of equipment used in developing these natural resources; (4) cost of development, exploitation and utilization of these natural resources. Applications will be received on Form 1,312 until further notice.

Meeting of California Section, A. C. S.

The monthly meeting of the California Section of the American Chemical Society was held in the rooms of the Engineers' Club of San Francisco Thursday evening, Feb. 26. Two papers were presented. The first, by Dr. W. C. Bray of the University of California, on "The Practical Application of Catalysis," dealt with the successful development of catalysis for use in gas masks to bring about the oxidization of small amounts of carbon monoxide. The second paper was by Dr. E. D. Eastman, of the University of California, on the subject of "The Reduction of Iron Oxides by Fuel Gases." Dr. Eastman discussed the theoretical aspects of the subject, which was studied with the object of determining the practicability of the production of iron from the calcines resulting from roasting sulphide copper ores containing pyrites, the iron produced by this process to be used for the precipitation of copper from sulphate solutions.

Land Leasing Bill

Friends of the oil land leasing bill were kept on the anxious seat until the eleventh hour by the President, who signed the bill on the afternoon of the day on which the bill would become a law automatically. It had been rumored that the President intended to veto the measure. In addition to oil, the act provides for the leasing of coal, phosphate, gas, and oil shale.

BANQUET OF AMERICAN CERAMIC SOCIETY, PHILADELPHIA

The Philadelphia Meeting of the American Ceramic Society

Report of the Twenty-second Annual Meeting—Addresses of the General Session—Selection of the Papers Read Before the Enamels, Glass, Refractories, Terra Cotta and Porcelain Divisions

THE twenty-second annual meeting of the American Ceramic Society opened at the Bellevue-Stratford Hotel in Philadelphia Feb. 23, 1920, with an address by President R. T. Stull, who outlined the need of technical research in the clay industries. There is now manufactured in the United States about $500,000,000 in ceramic products per annum, one-half of which are clay, the remainder enamels, etc. Every state is engaged in the industry. Brick is the largest in tonnage and value.

Seventy per cent of the cost of production is labor and fuel. There is great room for reduction of these costs through the adaptation of mechanical devices and automatic machinery. The price of brick has trebled in the last ten years.

The tunnel kiln will play a large part in fuel economies. The time will come when brick will be produced automatically throughout the process; but no company has the capital to undertake this development at present. Secretiveness and patent conflicts choke the progress. Either a brave corporation must enter the development or a central corporation must be organized with large research laboratory and mechanical plant.

Business Meeting

Reports of the committees showed the business affairs of the society to be in good condition. The total membership is 1,228 with an average increase of twenty-five new members per month. The committee on ceramic research, co-operating with the National Research Council, has proposed establishment of fellowships as a means of solving the fundamental problems. It is necessary to know not only the how but the why. Every works problem is a fundamental one.

These fellowships should be established by the manufacturing companies and there are two classes, as follows:

Class A: The stipend for this class of fellowships shall be $800 for the first year and $1,000 for the second and each subsequent year. A holder of this class of fellowships shall carry out his research work at a university and shall have the privilege of becoming a candidate for an advanced degree at that university, and of taking such advanced courses as may be necessary thereto.

Class B: The stipend for this class of fellowships shall be $1,600 for the first year, $1,800 for the second year and $2,000 or more for subsequent years. The holder of one of this class of fellowships shall be a trained research worker and shall devote all of his time to the research work.

The special committee on definition of the word "ceramics" delivered a long report giving the complete etymology of the term and concluding with the statement that there is no barbarism when the word is applied to the present field of the American Ceramic

Society. Ceramic industries are those which manufacture products by the application of heat to earthy materials, and ceramic engineering is that branch of engineering which deals with the ceramic industries.

Election of Officers

The election of the following officers was announced for 1920: R. H. Minton, president; E. T. Montgomery, vice-president; R. K. Hursch, treasurer; Charles F. Binns, secretary; F. H. Riddle, member of board of trustees; Homer F. Staley, editor of the *Journal*.

Papers Presented

A total of 139 papers read and a symposium on tunnel kilns compared favorably with the fifty-eight offerings of last year. Monday was devoted to the

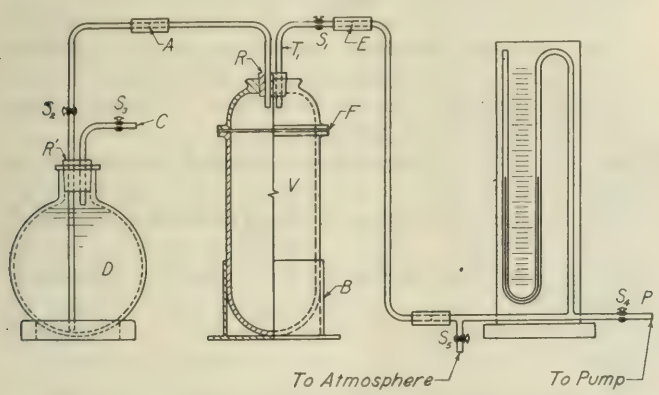


FIG. 1. APPARATUS FOR TESTING POROSITY

presentation of general papers, while the following days were occupied in divisional meetings.

Classification of Clays

A. S. Watts proposed a classification of clays on a ceramic basis. At present there is much confusion as to the definition of kaolin. This is true of ball clay, and the specification regarding fire clay is even more vague. Fire clay is now understood to refer to "coal-measure clay." It should be based on refractoriness, say above cone 27. General classification should be made according to ceramic properties as evidenced by color, shrinkage, bonding strength, vitrification and fusion.

Testing of Clay for Light-Weight Concrete Aggregate

D. H. Fuller, of the Bureau of Standards, spoke on testing of clay for light-weight concrete aggregate. Tests have been made on clays intended to produce, when fired, a light vesicular mass, suitable for concrete work. Such clays must be hard but not overfired, containing a large volume of pore space so that fresh specimens will float in water. The density of clay structure, the amount and character of carbon and the presence of sulphates and sulphides seem to affect the requirements. Materials which fail to float in salt solution of specific gravity 1.1 or which contain large cavities are unsuitable.

Determining Porosity of Clays

Edward W. Washburn and Frank Footit gave the results of experiments on the source of error in the methods of determining porosity of clays using the apparatus shown in Fig. 1.

(1) Place the cold test piece in a desiccator over 95 deg. sulphuric acid and allow it to remain till it reaches constant weight. This process may be hastened, if desired, by evacuating the desiccator.

(2) Place the weighed test piece in a vacuum vessel and evacuate the air until the manometer reads less than $P = \frac{AB}{100}$. Here B is the barometric reading and A is the percentage accuracy desired in the result. Then admit to the vacuum vessel enough air-free cold (the colder the better) distilled water to cover the test piece. Break the vacuum immediately, bring the water to room temperature, remove the test piece, wipe with a very damp towel and weigh. If the pump is not good enough to give the degree of vacuum indicated by the above equation, the vacuum vessel should be warmed until the water will boil under the vacuum obtained, and this boiling should be continued for about one hour.

A series of comparative experiments with water and paraffine, using the same test pieces, was carried out and the results were found to check within close range. Fig. 2 shows gain in weight with porosity test. A perfectly burned piece of dry clay is a better drying agent than calcium chloride or sulphuric acid.

Storing and Handling Raw Clays

T. W. Garve, in outlining a plant for the storing and handling of raw clays, emphasized the need of mechanical equipment in all such operations. Shales should be crushed before storing. Flat conveyors wear longest

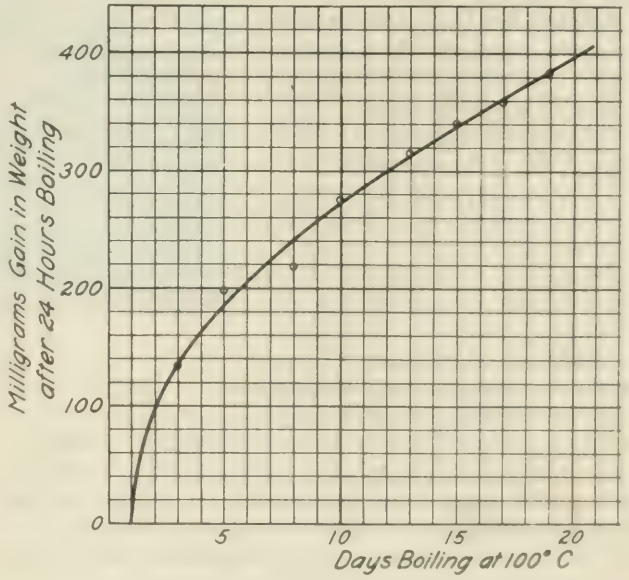


FIG. 2. GAIN IN WEIGHT—POROSITY TEST

and belt speed should be about 125 ft. per min. Details of machinery layout and buildings must conform to good mechanical and architectural practice.

Cobalt Oxide

N. B. Davis read a paper on cobalt oxide. Its use as a coloring matter in ceramics dates back to the early Chinese. The world supply for many years came from the cobalt-silver deposits of Saxony, and later from Missouri and Canada. Annual consumption in the United States amounts to 240,000 lb., most of which was used for ceramic ware. This is now being shared with the steel industry and chemical processes for drying the soya bean.

Other papers given were:

"Theory and Practice of Fractional Calcination of the Dolomites," by G. A. Bole and George Blumenthal.

"Experiments in Dead Burning Dolomite and Magnesite," H. G. Schurecht.

"Combustible Matter in the Chicago Clay," A. Malinovsky.

"A Direct Reading Overflow Volumeter," H. G. Schurecht.

"The Grain Sizes of Clays and the Relationship of the Grain Sizes of Certain Clays to Plasticity and Service," R. Thiessen and R. B. Gilmore.

"Fused Artificial Sillimanite," A. Malinovsky.

"Effect of Oxidation and Reduction on the Fusibility of Iron Oxide-Silica Mixtures," W. H. Reid.

"Further Study of MgO-Al_2O_3-SiO_2 Mixture, A. S. Watts.

"Methods of Testing Sagger Mixtures," S. C. Linbarger and C. F. Geiger.

"Waste Heat Drier Construction," E. Roddewig.

"Experiments With Aventurine Glazes," H. G. Schurecht.

"Some Luster Pottery Decorations," R. T. Watkins.

"Cost of Materials vs. Final Cost of Fired Pottery and Glass," George F. Hasslacher.

"Drying," William W. Wilkins.

Enamels Division

Papers in this division were accompanied by interesting discussions which evidenced the fact that the development has been slow owing to research being carried on by independent investigators. Considerable difference of opinion exists on important phases. The new subjects taken up were:

"Electric Cleaning of Metals for Enameling Purposes," W. C. Lindemann.

"Fish-scaling," J. B. Shaw.

"Fish-scaling of Gray Ware Enamels," R. R. Danielson.

"Cause of Fish-scaling in Enamels," R. C. Charron.

"Relative Action of Acids on Enamel—IV," E. P. Poste.

"Notes on Mottling of Enamels," R. C. Charron.

"Some Relation of Composition to Solubility of Enamels in Acid," H. F. Staley.

"Acid-Proof of Cast-Iron Enamel," H. F. Staley.

The last paper, covering a series of tests which are still under way, showed that the best oxides for acid-proof enamel as tested in a 20 per cent solution of HCl are SiO_2, BaO, PbO and Al_2O_3. The poorest results were obtained with ZnO, CaO, MgO, B_2O_3 and Na_2O.

Glass Division

H. L. Dixon, an old-time glass maker of forty-three years' service in the industry, delivered an inspiring address before this division under the subject, "Ancient and Modern Methods of Glass Manufacture. He told how the business, starting in Pennsylvania in 1843, migrated through Ohio, Indiana and Kansas following the development of natural gas properties. There have been losses extending over many years because there were no chemists on the job. Expensive materials were imported and glass makers produced their own refractories. Every factory should have a chemist. Science means so much to the business. A chemical education is necessary to the glass manufacturer's success at the present time. But the graduate must not make the mistake of analyzing everyone he meets by chemical equation. He should put on the undershirt, overalls and old hat and, going into the factory, win the confidence of the practical man, exchanging ideas with him. Colleges should teach the equality of the two types.

The word "can't" has been stricken from the vocabulary of the glass industry. Large things are ahead. The electric furnace in glass melting is the next step.

Other unpublished papers were given and discussed as follows:

"Glass Sand Resources of Pennsylvania," Charles R. Fettke.

"The Present Glass Situation," S. W. Stratton.

"Producer Gas as Fuel for the Glass Industry."

"The Art of Pot Making," Charles O. Grafton.

"Study of Some Glass Pot Clays," D. H. Fuller.

"Note on Porcelain Glass Pot Mixtures," D. H. Fuller.

"The Relation Between Refractivity and Chemical Composition in Optical Glasses," F. E. Wright.

"A Practical Test for the Resistance of Optical Glass to Weathering," F. R. Bichowsky.

"A Method of Determining Thermal Expansion of Glass," C. C. Rand.

"Note on the Mechanics of the Weathering of Glass," F. R. Bichowsky.

"The Annealing of Glass," L. H. Adams and E. D. Williamson.

"The Composition of Lead Glasses," R. J. Montgomery.

Measuring Viscosity of Pot-Made Glass

E. W. Washburn submitted a factory method for measuring the viscosity of pot-made glass during the process of manufacture. This includes the introduction of thermocouple into stirrer as shown in Fig. 3.

Refractories Division

D. W. Ross offered notes on silica brick. Not many careful studies have been made on the combined effects of thermal expansion as it occurs in the crowns of industrial furnaces. Study made on a bottle-glass

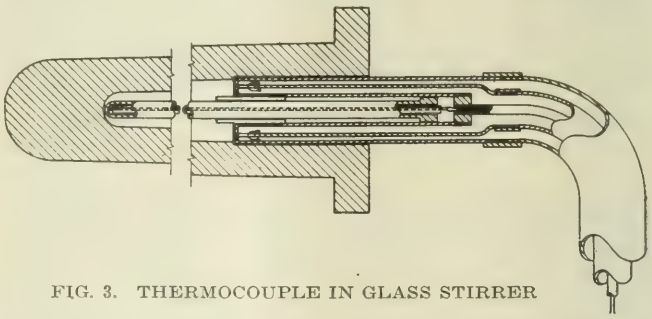


FIG. 3. THERMOCOUPLE IN GLASS STIRRER

furnace over a period of years led to the conclusions that (1) great care is necessary in heating up a new crown; (2) after eighteen months a crown can be slowly cooled without disruption; (3) a reheating of the cooled furnace gives less trouble, as the expansion is about one-half as great as during the initial heat; and (4) when crown is cooled after eighteen months' service the zone of weakness is found midway between the inside and outside of the crown.

Design of a Firebrick Plant

R. H. Minton's paper on the design of a firebrick plant was of especial interest to the manufacturers of refractories. In designing the process it should be

made as automatic as possible, compactly arranged and involve efficient burning. Complete layout was given, showing three wet pans, three rotary driers and three dry pans.

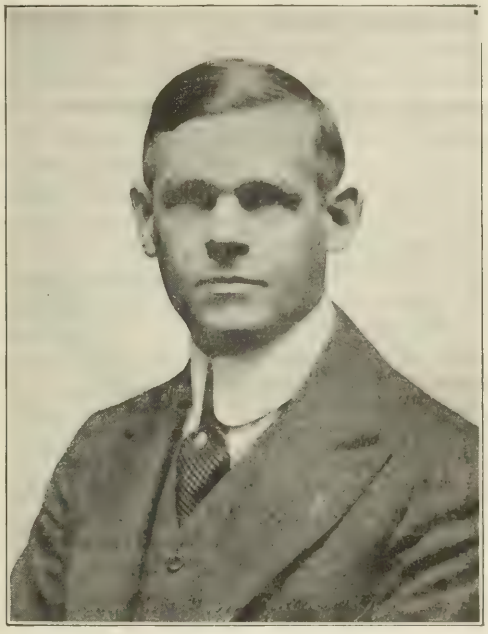
Sillimanite Development

A. S. Watts offered a possible explanation of failure under load at high temperatures as displayed by fireclay refractories. A peculiar combination of facts discovered over a period of years points to sillimanite development in the following points:

(1) Sillimanite is known to develop at about the temperature of observed failure.

(2) The sillimanite development through molecular rearrangement and not by crystallization out of solution would occur during the heating up process and does not require any definite period of exposure to the elevated temperature.

(3) The hard burning of the refractory prior to test could cause the sillimanite rearrangement in the mass and thus reduce the amount of strain due to sillimanite development at the time of test. This explanation of the improvement due to hard burning is at least as logical as that the advanced solution of the flint clay gave it strength under high temperatures.



R. H. MINTON
President, 1920, American Ceramic Society

(4) The increase of SiO_2 as a means of improving strength at elevated temperature can be explained as also reducing the Al_2O_3 content to a point at which the development of sillimanite is very small or nil, and thus its weakening influence is not displayed.

(5) The low sillimanite development in ball clays may explain their freedom from weakness at temperatures where fireclays and pure kaolins fail, and as they have no associated material of greater refractoriness which they can absorb, the explanation of their superior behavior must lie within themselves.

Other papers under this division were as follows:

"Mica Schists as Refractories," J. S. Hibbs.

"Conductivity of Refractories and Methods of Testing Conductivity," by S. F. Walton and F. H. Riddle.

"Magnesite Refractories," J. S. McDowell and R. M. Howe.

"Tests on a California Refractory Clay," H. W. Douda.

"Testing Refractories," F. A. Harvey.

"Refractory Clays of Missouri," I. A. Krusen.

"Behavior of Firebrick in Malleable Furnace Bungs," H. G. Schurecht.

"Note on the Load Behavior of Aluminous Refractories," A. V. Bleininger.

"An Industrial Laboratory for Research in Ceramics With Note on the Construction of a Novel Testing Furnace," S. F. Walton.

"Siliceous Sagger Mixtures," M. R. Hornung.

"Behavior of Bond Clays in Graphitic Crucibles Under Brass and Steel Melting Practices," R. T. Stull.

"Use of the Microscope in Crucible Making," R. Thiessen and R. B. Gilmore.

"The Fusibility of Mixtures of Graphite Ash and Bond Clays," R. N. Long.

"A Rapid and Approximate Method for Determining the Melting Point of a System Composed of Highly Refractory Materials," E. W. Washburn.

Terra Cotta Division

R. L. Clare and D. F. Albery have investigated the effect of variation in the size of the grog in terra cotta bodies, and results showed clearly that if the terra cotta is to be kept uniform in its physical properties the grog size must be controlled. To accomplish this the grog must be specially prepared and ground under stated conditions. It must be selected and burned under specifications. A central plant operating for several companies was suggested. The extra cost would be more than offset by advantages resulting.

R. H. Minton in searching for a substitute for tin oxide found that little work has been done outside the enameled ware field. Results showed that tin oxide is the best opacifier, although "terrar" and zirconium oxide offer possibilities. Zinc oxide is of great assistance in producing capacity when used with tin oxide. Barium also exerts a marked influence, while a combination of barium and zinc has more effect than the clay content, giving more favorable opacity. Antimony oxide and "leukonin" are cheaper than tin where applicable. Zirconium has proved to be the best substitute, but it is too expensive.

Research on Vermilion Colors

Charles F. Binns and Frobisher Lyttle in research on vermilion colors made two glazes, one with 20 per cent commercial yellow oxide of uranium content and the other using 37 per cent. The first gave a bright vermilion color. Some difficulty has been experienced in protecting uranium oxide from reducing influences in firing, but with complete oxidation these colors seem to be commercially possible.

J. D. Whitmer presented the results of a glaze study involving some interesting colors produced by nickel oxide which demonstrated that grays are obtained from nickel oxide in the presence of magnesium oxide.

Other papers presented and discussed were:

"The Effect of the Size of Grog Particle in a Terra Cotta Body," H. E. Davis.

"Discussion of Humidity Drying of Terra Cotta," B. S. Radcliffe.

"Satisfactory Method of Using Barium Hydrate in Place of Barium Carbonate to Take Care of Soluble Salts in Terra Cotta Bodies," M. E. Gates.

"Some Data on the Composition of Kiln Gases and Their Effect on Terra Cotta Glaze and Colors," F. B. Ortman.

"Discussion of Spalling of Enamel Terra Cotta After Erection in Building," F. B. Ortman.

"The Effect of Glaze Composition on the Crazing of Terra Cotta," E. C. Hill.

White Ware, Porcelain, Etc.

A. S. Watts presented the draft of a complete set of specifications for flint and another for feldspar under the following headings:

1. Sampling.
2. Chemical composition.
3. Physical properties and tests.
   (a) Color.
   (b) Fineness of grain.
   (c) Moisture content.
   (d) Fusion behavior.
4. Rejection.

Substitute for German Clays

Jerome Alexander outlined preliminary ultramicroscopic examinations of clays during the war in determining the proper American substitutes for German clays, which showed that a thorough study of clays along the lines of colloid-chemical principles and analysis will throw much light upon many obscure phenomena met with by clay users. These factors extend their influence not only to the formative part of the ceramic processes, but to the subsequent drying, baking and firing, and the effects are traceable to the zone of actual fusion.

Tests on Rate of Vitrification

R. F. Sherwood gave the results of tests on the rate of vitrification of porcelain molded under different conditions. The initial structure of a clay body governs the rate of contraction and vitrification. A comparison was made to show the difference in the rate of vitrification of one and the same body molded by hand pressing in the plastic state, by casting and by dry pressing at different pressures and finally firing simultaneously in the same kiln, giving identical heat treatment. The cast gave the most dense body and the plastically molded body had the most rapid rate of vitrification.

Other offerings were as follows:

"The Use of Domestic Kaolins in the Manufacture of White Ware Pottery," A. V. Bleininger and W. W. McDanel.

"A Possible Explanation of the Differences in the Behavior of Potter's Flint and Ground Quartz in Pottery Bodies and Glazes," E. W. Washburn.

"Tests of Commercial Samples of Feldspar and Flint," B. E. Sockman.

"The Effect of Wet Grinding, Screening, and Electrolytes on Clays of Low Plasticity," H. W. Douda.

"Elutriation Tests on American Kaolins," H. G. Schurecht.

"The Effect of Aluminum Chloride Upon the Plasticity of Kaolins," H. P. Reinecker and J. S. George.

"The Effect of the Method of Preparation on the Viscosity of a Casting Slip," V. S. Schory.

"Some Problems in the Manufacture of Sanitary Porcelain," Samuel Bedson.

"Structure of Porcelains," H. Spurrier.

"Note on Zirconia Porcelain," A. V. Bleininger.

"The Solubility of Some White Ware Glaze Fritts," George Blumenthal, Jr.

Kilns

The symposium on tunnel kilns developed little criticism of the tunnel kiln by the users of periodic kilns, but rather resulted in an argument between tunnel kiln manufacturers as to the relative merits of the direct-fired and the muffle-fired types. The chief advantages of the latter are the economy of fuel effected, better control in firing, convenient handling of materials, elimination of saggers, and smaller maintenance cost due to continuous heat. On the other hand, there is a question of less capacity and more floor space. The coming year should develop some real data for comparative figures.

Entertainment Features

The smoker held on Monday evening proved a marked success due to the feature event, a farce presented by the New York Student Section, entitled, "A Day in the Secretary's Office." The adaption of new lines to well known tunes was welcomed enthusiastically by the audience. The Ceramic Engineers' Song was especially applauded as to the last verse, which runs:

> Oh, we're Ceramic Engineers,
> We're not so very neat,
> We never change our underwear,
> We never wash our feet,
> We wear our collars and cuffs for months,
> With grime and dirt they're smeared,
> Oh, we're the very scum of the earth,
> Ceramic Engineers.

The banquet under the skillful direction of Francis Walker, Sr., was most pleasurable. Mr. Cattell, the Philadelphia statistician, was there with his usual greetings to which everyone looks forward at these conventions. He said "au revoir" meant "goodby" in France, but "carbolic acid" meant "goodby" in every country. He finished with a truly Cattell appeal for "Americanism." The applause continued with everyone standing for many minutes. Calvin O. Althaus delivered an eloquent address.

The whole affair was just informal enough to carry the right appeal.

The Philadelphia Section

The work of the local section in providing everything necessary for convenience and comfort of the visitors received a unanimous vote of thanks at the business meeting. Trips were made to places of interest and industrial plants on Thursday.

Electrochemists and Electrical Engineers to Meet Jointly in Boston

Plans for the joint session of the American Electrochemical Society and the American Institute of Electrical Engineers at Boston, April 8, 9 and 10, are progressing so favorably that there is every promise of an unusually good meeting. The symposium on electrically-produced alloys will be opened by H. E. Howe, with a paper on "Fundamental Problems in Alloys Research." The manufacture of ferro-alloys in general will be discussed in two papers by R. J. Anderson and C. B. Gibson. Other special alloys on which papers have been prepared are ferrovanadium by B. D. Saklatwalla; ferrosilicon by F. A. Raven; nickelchrome by W. B. Driver, Jr.; cobaltchrome by Ellwood Haynes; ferromanganese by E. S. Bardwell and high-speed steel in the electric furnace by R. C. McKenna.

The session on power requirements for electrochemical industries will be addressed by H. A. Winne, C. A. Winder and John A. Seede. Other papers of technical importance are "Nitrogen Fixation by the Silent Electric Discharge," by C. F. Harding, and "Magnetic Properties of Iron-Nickel Alloys," by T. D. Yensen. There will also be a symposium on colloids.

Political and Commercial Control of the Nitrogen Resources of the World—I

A General Review of the Sources of Nitrogen: Atmospheric, Nitrate Ore, Organic and in Carboniferous Deposits, With a Description of the General Aspects of the Control of Nitrogen Resources in Normal and War Times

By CHESTER G. GILBERT*

PLANT life requires nitrogen, and gets it in the normal cycle of events. But when the occasion calls for stimulating the growth of plant life by feeding —by soil fertilization, in other words—nitrogen in available form is indispensable. Further down along the channels of food supply it exercises another and equally important function in providing the chemical around which the modern practice of refrigeration is built. Likewise, the chemistry of explosives is basically the chemistry of nitrogen compounds. Nor is this all, for chemical operations in general, hence research and industrial chemistry in general, involve the employment of nitrogen compounds. Such, in brief, is its social status. On each of three major counts—the interests of food production, of food distribution, and of national defense—it is indispensable; and of no less consequence is the retinue of less conspicuous agencies serving the interest of chemistry at every turn.

The development of fixed nitrogen sources is conditioned by three simple chemical facts. With these three simple facts in mind the rest follows largely as a matter of inference. They are:

1. That under all ordinary conditions of temperature and pressure, free nitrogen is a gas.
2. That it is extremely inert and indisposed to participate with other elements in the formation of chemical compounds.
3. That such combinations, when they do occur, are characteristically soluble.

In consequence of these three governing principles, along with its relationship to organic matter as alluded to above, nitrogen has four habits of occurrence worth considering as at least potential sources of supply; namely, atmospheric nitrogen, nitrate ore deposits, organic nitrogen and nitrogen in carboniferous deposits.

Atmospheric Nitrogen

Being indisposed to participate in chemical combinations, nitrogen in the course of world evolution was left largely to itself; and since in the free state it is normally gaseous, it established its home in the atmosphere. Thus it comes about that the atmosphere today is approximately four-fifths nitrogen gas, and after all is said and done the atmosphere is bound to constitute the great source to which we must turn for our supplies. With a source so boundlessly ever-present, the question of supply at first glance looks simple enough. But atmospheric nitrogen, it must be remembered, is nitrogen uncombined, and the demand is not for nitrogen itself but for nitrogen-bearing compounds. Once in a state of combination, it may remain so indefinitely, and the form of combination may be changed more or less readily to suit the demand. Before it can be put to use, however, it must be induced to surrender its gaseous freedom and affix itself in some such state of combination. The free nitrogen must become fixed nitrogen—hence the terms fixed nitrogen, nitrogen fixation and the like in common use. Toward this end it must be induced to do what it has not seen fit to do of its own accord, and the very trait of aloofness responsible for the inexhaustible resources of atmospheric nitrogen stands as an obstacle opposing their utilization. The obstacle has not proved insuperable, as will appear later; but it is sufficiently a source of trouble even to this day, so that the fixed-nitrogen situation may with peculiar appropriateness be characterized as distinctly in the air.

Nitrate Ore Deposits

The disposition on the part of nitrogen to take up its abode in the atmosphere has an obvious result in minimizing the development of mineral nitrates. Atmospheric nitrogen is not entirely stagnant, however. Natural processes are constantly at work effecting substantial fixation. The processes are not obtrusively energetic, as in the case of atmospheric oxygen, whose fixation processes constitute the ever-present phenomena of oxidation. Still in various ways, the most prominent among which is undoubtedly a form of bacterial action, nitrification and the building up of nitrate minerals everywhere in the soil goes quietly forward, and their concentration in ore deposits of more or less plentiful occurrence is thus to be looked for in the natural course of geologic events.

Development of Nitrate Ore Deposits

In attempting to trace their further course, however, we are confronted at the outset by the principle of solubility. The nitrate minerals are in the nature of soluble salts. They leach from the immediate environment in which they form, just as do the soluble minerals in general. Mostly these latter are carried in solution to the ocean, adding themselves to its salinity; but under exceptional conditions of topography where the drainage feeds into land-locked basins, the water finds itself entrapped with no avenue of escape except through evaporation. Here the salts accumulate, become concentrated, and finally give rise to deposits. This, in outline, is the course set for the soluble mineral salts as a class, and it is along this course that we must expect to trace the development of nitrate ore deposits.

Dissociation of Nitrogen Compounds

But the ocean with its 3½ per cent of salinity has only traces of nitrate minerals; and the same is true for the waters of land-locked basins, in all the various stages of concentration. Their solubility is such that they cannot

---

The basis of this article by Mr. Gilbert was issued in mimeographed form for Government use only as one of the Political and Commercial Geology Series prepared under the direction of J. E. Spurr, to whom book rights are reserved.

*Curator of Mineral Technology, U. S. National Museum.

TABLE I. STATISTICS OF NITROGEN PRODUCTION

Year	Organic Nitrogen	Chemical Nitrogen										
		Sodium Nitrate			Fixation Compounds					Byproduct Ammonium Sulphate		
					World's Production							
	Dried Blood, Tankage, Guano, Fish Scrap, Cottonseed Cake and Meal, etc.	World's Production, Tons	Domestic Production, Tons	Imports, Tons	Ammon. Sulph. (Haber) Tons	Calcium Nitrate (Arc), Tons	Cyanamide, Tons	Domestic Production, Tons	Imports, Tons	World's Production, Tons	Domestic Production, Tons	Imports, Tons
1900	Data for organic nitrogen indefinite, but probably about equal to the total for chemical nitrogen	.....	.....	.....	.....	.....	.....	.....	.....	540,000	27,600	8,411
1901		1,328,664	.....	203,960	.....	.....	.....	.....	.....	580,000	29,279	14,486
1902		1,349,300	.....	205,245	.....	.....	.....	.....	.....	600,000	36,124	18,146
1903		1,485,279	.....	272,947	.....	.....	.....	.....	.....	640,000	41,873	16,777
1904		1,559,091	.....	228,012	.....	.....	.....	.....	.....	650,000	54,664	16,667
1905		1,754,605	.....	321,231	.....	.....	.....	.....	.....	694,575	65,296	15,288
1906		1,800,500	.....	372,222	.....	.....	386	.....	.....	778,365	75,000	9,182
1907		1,846,036	.....	364,610	.....	.....	1,874	.....	.....	906,255	99,300	30,114
1908		1,970,974	.....	310,713	.....	.....	2,767	.....	.....	970,200	83,400	38,238
1909		2,110,961	.....	428,429	.....	45,450	12,734	.....	.....	987,840	106,500	42,914
1910		2,465,415	.....	529,172	.....	.....	22,596	.....	764	1,104,705	116,000	92,342
1911		2,521,023	.....	544,878	.....	.....	59,479	.....	5,617	1,206,135	127,000	94,633
1912		2,585,850	.....	486,352	.....	.....	115,688	.....	7,134	1,356,075	165,000	59,542
1913		2,772,254	.....	625,862	20,000	181,800	173,026	.....	14,656	1,532,475	195,000	65,775
1914		2,463,356	.....	541,715	60,000	.....	208,070	.....	29,536	1,320,000	183,000	75,010
1915		1,755,291	.....	772,190	150,000	.....	845,388	.....	20,564	1,690,000	249,000	36,370
1916		2,912,893	.....	1,218,423	300,000	.....	1,053,439	.....	38,023	2,000,000	285,000	12,962
1917		2,950,000	.....	1,555,839	500,000	300,000	954,765	.....	44,146	.....	325,000	.....
1918		2,900,000	.....	1,845,192	.....	.....	.....	.....	43,070	.....	.....	.....

have escaped in substantial form along the way. There is only one inference to be drawn. Evidently the inherent trait of aloofness is not lost to nitrogen when it does combine. The compounds do not survive for any length of time, but suffer dissociation, releasing their nitrogen and returning it to the atmosphere even as other processes are slowly withdrawing it therefrom.

With this the eternal cycle is closed for nitrogen, and closed without apparent provision for any considerable sidetracking such as would be required in the building up of ore deposits.

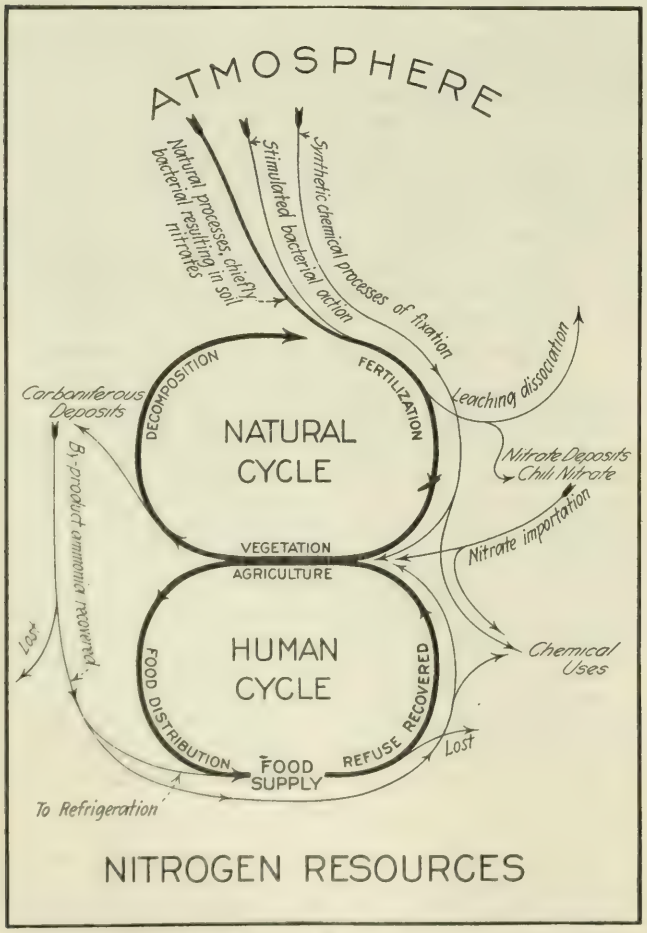


FIG. 1. GRAPH OF THE NITROGEN SITUATION

So much for the rule; now as to the exceptions. Mostly they are of minor consequence. Pockety enrichments in the soil are common. Accumulations tend to build up in caves and may even grow to be of consequence in a small way, as during the Civil War when they helped materially toward relieving the nitrogen troubles of the blockaded Confederacy. In arid country, too, they not infrequently assume sufficient prominence to be of interest especially at the hands of the promoter. Finally, there are the Chilean nitrate fields, which far from being of minor consequence, go to the other extreme in catering to the needs of the entire world. These occurrences, especially the last named, have served to keep alive the hope that others of economic importance await discovery. The Chilean deposits alone among them all deserve more than passing notice.

Origin of the Chilean Nitrate Deposits

The origin of these deposits is veiled in uncertainty. Just why or how the natural forces, which elsewhere as a matter of universal observation have been seen to oppose both the formation of nitrogen salts and the accumulation of such as do manage to form, should have failed in this particular instance remains wholly conjectural. A conclusive explanation would be of the utmost value in determining the likelihood of similar occurrences elsewhere. But none has been forthcoming, and nothing is to be gained to the present purpose from stopping to inquire into the plausibility of the various attempts that have been made.

Confronting us on the one hand are the evidences of a nitrogen cycle established, seemingly, without affording any visible loophole of opportunity for the accumulation of extensive deposits; on the other hand stands the bare fact of enormous deposition. This fact of existence unquestionably carries with it the possibility of duplication elsewhere. However, the fact of occurrence merely suggests the possibility, but does not determine the chances of recurrence. These are recorded in the prevalence of the conditions requisite to extensive deposition. In the case of nitrogen they are unique beyond comprehension, and the prospect of recurrence is to precisely the same degree unlikely. Accordingly, to all practical purposes, a review of the world's nitrate ore deposits, both real and potential, resolves itself down to a review of the Chilean occurrence.

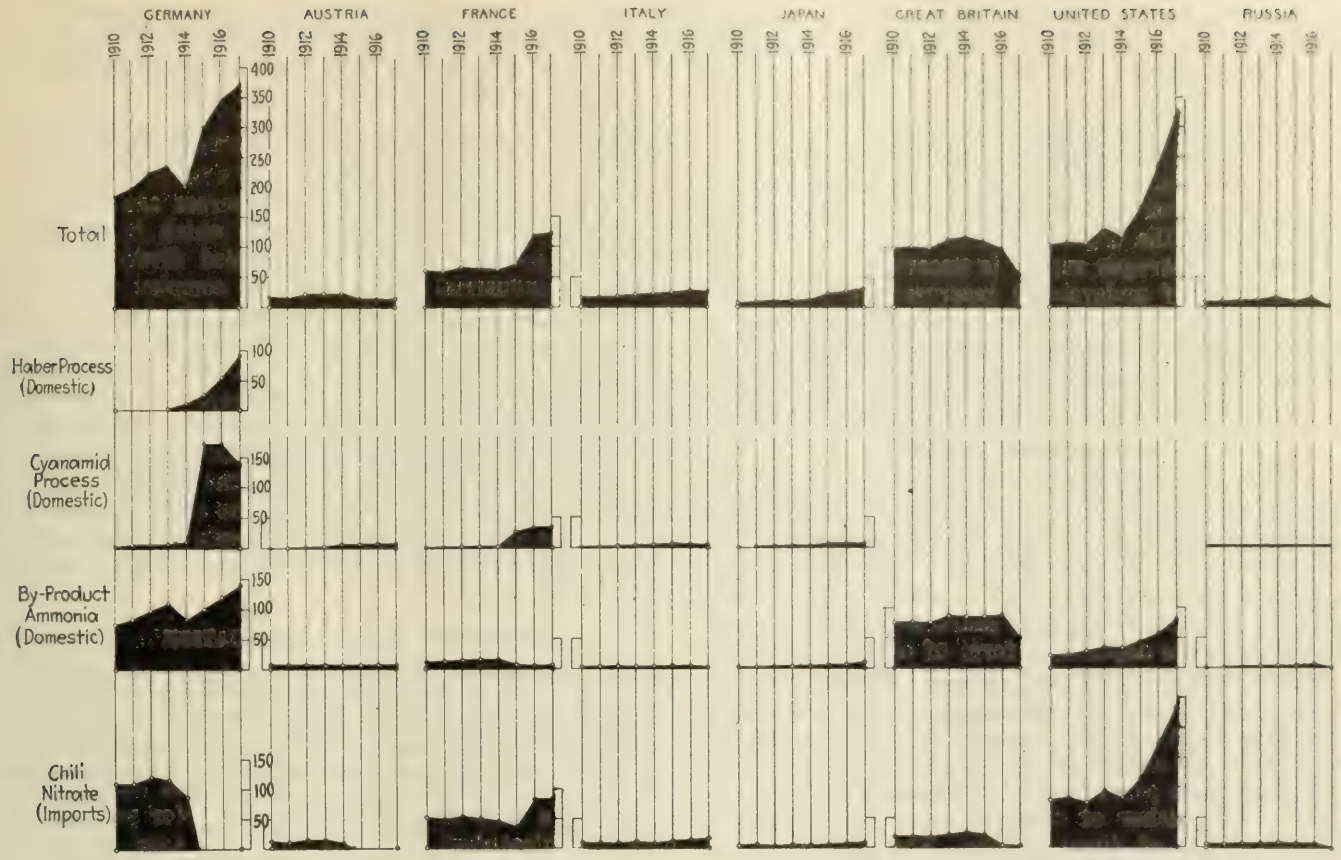


FIG. 2. WAR-TIME DEVELOPMENTS IN THE PRODUCTION OF NITROGEN—FIGURES IN THOUSAND TONS

The Chilean nitrate fields lie in the arid valley basin to the east of the lofty coast range and just south of the present Peruvian boundary line. They do not occur as a single expansive area of deposition, but as deposits scattered here and there along the desert land at the bases of the mountain slopes. The formation consists of a conglomerate or breccia of rock material from the adjacent slopes cemented with a mixture of soluble salts in which sodium chloride, common salt, is the dominant member, with sodium nitrate ranking second. The formation is called caliche. It lies for the most part just below the surface of the ground and varies from a few feet to many feet in thickness. Only in scattered patches is the caliche high enough in content of sodium nitrate to warrant treatment. These patches are sought out and excavated, and the picked ore is loaded in carts which haul it to the extraction plant for treatment. Here the soluble salts as a whole are extracted in solution, and the nitrate in turn is segregated from the other salts by crystallization. Aside from haulage, hand labor is used throughout.

The caliche regarded as worth treating contains not less than 10 per cent and ranges up to 25 per cent and over, with an average of around 18 per cent. The product marketed is of two general grades—the ordinary, listed as 95 per cent nitrate, and the refined, a guaranteed 96 per cent nitrate low in sodium chloride. The deposits have been worked more or less consistently and with steadily increasing output since about 1830. Their importance in the scheme of nitrogen supply may be gathered from Table I and Figs. 2, 3 and 4.

Organic Nitrogen

Another source of fixed nitrogen grows out of its relationship to life processes, and is consequent on the very requirements of organized society which earlier it is called upon to assist in meeting. In other words, fixed nitrogen participates in the material cycle of life. It enters into the material demands of life for food, and it is yielded up among the material discards available to absorption. All manner of residuum, animal and vegetable alike, affords at least a potential source of fixed-nitrogen supply. Some of these are in service; others for one reason or another are not. Prominent among those in the former class are animal excreta, the so-called tankage from animal-rendering plants, slaughter-house refuse, fish scrap, and vegetable product refinery refuse. Most prominent among those still largely potential are sewage and garbage disposal.

Importance of Organic Nitrogen

The nitrogen from these organic sources does not appear on the market as such. Instead, the products enter in bulk into the make-up of fertilizer. They are of miscellaneous character, and only part of what is contributed collects to pass through industrial channels where its flow may be measured. The industrial flow goes on record and the records are available, but even here the nitrogen content has never been systematically computed, so the record is inadequate. For the rest, the portion that does not reach the channels of industry, there is nothing whatever in the way of data to go by.

Taken all in all, then, the significance of the organic nitrogen resources is largely conjectural. This is unfortunate. The production is so diversified and distributive that anything like exactitude of statistical data would be impossible of compilation, but there is no justification in this for the assumption that nothing is to be gained. Approximate figures covering the use of organic nitrogen would be of value in various connections, as in the interests of intelligent allocation in times of nitrogen shortage, as helping to determine the

extent to which the growing demands of agriculture incident to the growth of population may be discounted from the consequent expansion of scavenging opportunity, or as affording a basis for estimating the very considerable influence of motorization toward increasing the demand for chemically prepared fertilizers.

As things stand, all such questions of relationship lead only to profitless speculation. Even the relative importance of the organic sources as a whole in the economics of nitrogen supply is uncertain. What they have to offer of undeveloped reserves now taking the form of wasteful sanitation procedure will be taken up later. Under existing conditions, it is probably fair to assume that 40 to 50 per cent of the nitrogen normally put to use in the United States is organically associated.

Carboniferous Deposits

Nitrogen in its organic relationships is bound up with carbon, of which organic matter is largely composed, and the bond between the two is entirely disestablished only as the carbon itself loses its substantial form through oxidation. In consequence of this enduring alliance, nitrogen is characteristically present in carboniferous deposits, a form of occurrence giving rise to still another, a fourth type of nitrogen resource. Coal and oil shale loom up as the outstanding representatives of this class. In each, the nitrogen content is variable, but amounts to 1 per cent or over.

With so low a percentage of nitrogen, it goes without saying that neither of these is to be regarded as a possible source of direct supply. The cost would be prohibitive, even under the stress of the most extreme emergency. The nitrogen in a coal bed or an oil-shale formation is as worthless as the iron in any ordinary rock. But coal has other uses, and so has oil shale, or at least will shortly. The nitrogen does not have to be extracted; it gets released incidentally, and when its release is effected under conditions that prevent its escape, the result is a productive nitrogen resource. The nitrogen from this type of resource is in the form of ammonia, the relative importance of which is shown in Table I and Figs. 2, 3 and 4.

General Aspects of Control of Nitrogen Resources

The nitrogen resource situation as a whole is represented graphically in Fig. 1. Its sources are animal, vegetable, mineral and atmospheric, which is to say, universal, and out of this unparalleled diversity has grown an industrial development as complex as it is diversified, and, incidentally, in view of its bearing on food and munitions supply, as important as it is complex. The situation at best can be but imperfectly grasped, for it has been but inadequately studied. In transgressing all set rules of resource occurrence, it transgresses the limits set for organized investigation. Geologists have studied one phase of the situation, electrochemists another, sanitation experts another, and so on; and the various commercial interests involved have seen to the giving of publicity where publicity would do the most good.

Composite Economic Situation

An investigation working on the basis of geology alone cannot cope with the situation; neither can one on the basis of technology alone; nor one on the basis of organic chemistry, or bacteriology alone; nor yet one prepared to employ any or all of these means but only with a view to some special end. Nor yet again does the discordant grinding of many axes make a noise from which it is possible to gather an adequate comprehension. The nitrogen situation has been inadequately treated because it has been inadequately studied. It has been studied piecemeal, always through the medium of limited means or with some special end in view.

It is not a series of technical problems in geology, in

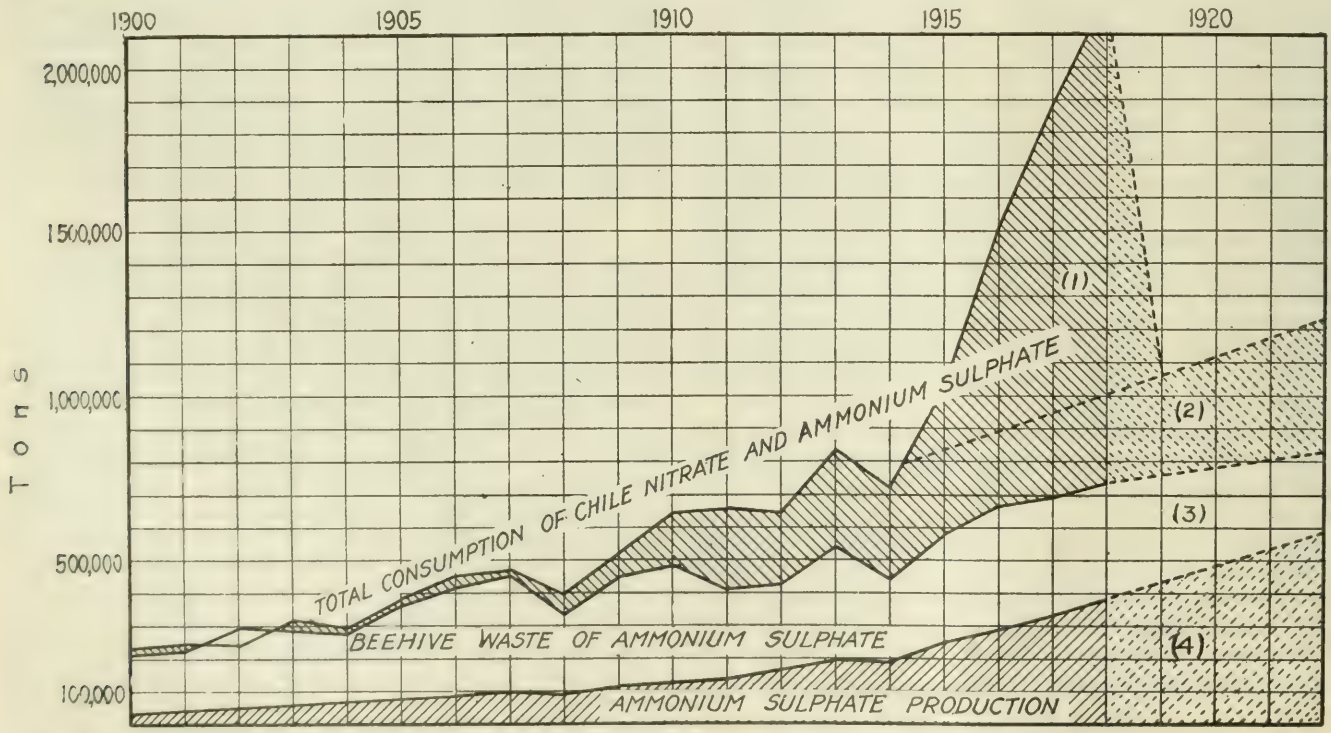


FIG. 3. NITROGEN DEVELOPMENTS IN THE UNITED STATES

(1) War-time expansion for munitions manufacture. (2) Field of competitive opportunity indicated for Chilean nitrate, air nitrate fixation, improved coal fuel practice, shale-oil ammonia, bacterial fixation, imposed sanitation, etc. (3) Field of opportunity reserved to coke-oven recovery. (4) Developments indicated for coke-oven recovery.

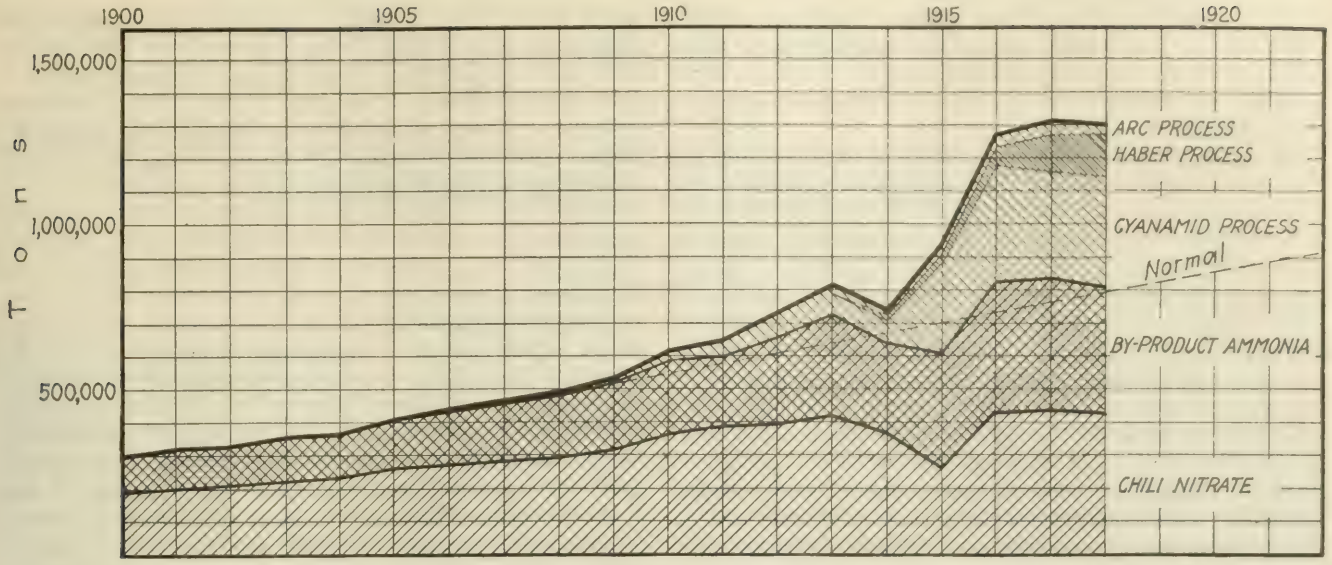


FIG. 4. NITROGEN DEVELOPMENTS FOR THE WORLD, 1900-1918

bacteriology, in fixation, in munitions supply, and the like. It has to do with a composite economic structure building for the dependence of society in peace and war alike. Until treated as such, the needs of the situation are bound to be inadequately met and its control a matter of perilous uncertainty. The present discussion makes no pretense of supplying this deficiency or of doing much of anything more than to show the extent to which it exists.

Control of Nitrogen Resources

Fig. 1 is designed to show not so much the scope of the resources as their composite functioning in the system of nitrogen supply. The influence of geography in the control of resources so universally available is bound to be subordinate. True, it enables Chile to exercise monopolistic control over the mineral nitrate supply, but it leaves the way open for the development of others; and while acknowledging the fullness of our dependence as shown in Table I and Figs. 2 and 3, we must not lose sight of the fact that it is so not of necessity but because we have been content to leave it so rather than undertake to develop supplies of our own.

So, too, with political control; what is gained in one direction is, potentially at least, offset by the possibilities opening up in others. Control of the sea gives a control over the mineral nitrate supply as absolute as that in Chile's territorial monopoly. Yet in the recent great war Germany, with her shipping obliterated at the outset, was not made to suffer materially from a nitrogen shortage. Britain's supremacy of the sea went for naught. In the years before the war the force due in season to exercise control over the nitrate supply served only to stimulate the development of domestic potentialities, with the result that when the test came Germany's proved actually to be the more advantageous equipment.

Control over the nitrogen resources themselves is impossible. They are too universally available. Their only susceptibility to control is in the shaping of their development. This is too important a matter to be disregarded with impunity and left to develop without guidance. The modern nation that does so courts the irrepressible disaster of a nation at war but bereft of the means not only of waging war but of maintaining a food supply as well.

From Fig. 2 may be gathered the quality of attention given the matter of domestic supply by the different nations immediately before and during the war.

Germany, it will be observed, heeded the call to give the matter special attention well before the war and had an independent system of supply developed in readiness drawing upon the atmosphere and coal product nitrogen, with the results already chronicled.

Great Britain did not ignore the importance of nitrogen, but placed reliance on her supremacy of the sea and paid little or no attention to shaping the course of developments. Nor did its importance go unheeded elsewhere abroad, and the foothold gained for fixation in France, Italy, Austria, Russia and Japan was, it is safe to say, not wholly automatic.

The United States alone among the great nations up to the outbreak of hostilities in Europe in 1914 neglected to take any special precautions whatever.

War's Special Requirements for Nitrogen

The war, when it came, far exceeded all expectations as to magnitude, and so in consequence did the demand for specially developed nitrogen supplies. To meet the emergency some could be deflected from agricultural channels, but nothing like what was required, for food was just as important as munitions. The organic sources offered no help. Rather they were a hindrance; for organic nitrogen, broadly speaking, comes as a by-product of sanitation, and as such develops as the outgrowth of civilization's refinements. There was a measurable response from the carboniferous sources, but these could not be made to meet the emergency, for, being of byproduct order, the supply is determined not in response to the demand for nitrogen but for the major products. Dependence on the native mineral source in Chile was out of the question, or at least precarious for any country except Great Britain. Accordingly, of the four great sources it remained for atmospheric nitrogen to meet the emergency. Thus, the war, in bringing the nitrogen situation emphatically to the fore, communicated practically the whole weight of its tremendous impetus to development in the one direction of fixation. The result is shown in Fig. 4.

Roused by the nightmare of war in 1914, even the United States awoke to the perils if not to the real needs of the domestic situation. It is a striking and

highly significant fact that despite the fundamental importance of nitrogen, the awakening found us absolutely without any formulated program of action, even military or agricultural, let alone anything of comprehensive economic scope.

A hysterical effort at improvizing a program ensued. We were not yet in the war, and public interest was just roused to the gullible stage. The opportunity for private pickings from public favors was too promising to go by the board. The only prospect opening up lay in the direction of fixation developments, and fixation in the hands of the promoter is one of the most appealing propositions imaginable. Its major requirements are nitrogen and power. With the former inexhaustibly present in the air and the latter inexhaustibly available in the wasting water powers of the country, nothing, it would seem, could offer greater promise. Add to this the reflection that cheap nitrogen means cheap fertilizer, and cheap fertilizer means lowered cost of foodstuffs, and the proposition broadcasted over the country is complete.

Out of the confusion of interests, public, political, and private, a program was finally evolved following our entry into the war calling for the erection of a series of fixation plants with an aggregate producing capacity of around 85,000 tons of fixed nitrogen annually. For a detailed description of these plants the reader must be referred in the interests of brevity to the Bibligraphy. For the present it must suffice that the war ended before any of these had reached the producing stage, and the United States, like Great Britain, depended on imports.

Influence of War on the Development of a Nitrogen Industry

Fig. 2 shows the influence of the war in the development of nitrogen distributively among the countries concerned. The Scandinavian developments, while actuated from wholly commercial motives, were so largely influenced by the politically stimulated market that they may well enough be included in that general class of politically controlled developments. The same is true for the neutral countries in general.

Fig. 4, based on the best information obtainable, is designed to show the collective influence of the war in contributing to the world's supply. Organic nitrogen is disregarded both because it involves too many uncertanties and because the war-time emphasis was all in the direction of chemical nitrogen. The data in Fig. 2 take into consideration only the actual production and leave out what was in process of construction when the war ended. Accordingly, while in one respect Fig. 2 overrates the effect of the war by including strictly commercial operations that very possibly might have transpired anyway, in another it underrates the situation by disregarding developments like those in this country. The best that can be done is to consider these as balancing each other, which, all things considered, is probably fair enough for all practical purposes. Taken on this basis, the net effect of the war, it will be observed, was to swell the production of fixed nitrogen about 40 or 50 per cent above the figures indicated for the normal rate of expansion.

Peace-Time Needs of Nitrogen

Thus the war-time shortage was made up; but all this is history. Now that the war is over, the question arises as to whether the world is due to face the situation in reverse. In making ready for war, and finally in meeting its demands, has the world been building up a 50 per cent overproduction beyond the needs of peace? Offhand, the answer would seem to be in the affirmative, but the question is not one that can be answered offhand. Agriculture is capable of absorbing an indefinite amount of nitrogen, and the war has wrought a lasting change in the agricultural situation. The changed agricultural conditions make room for much, perhaps for all, of the increment to nitrogen production. The development cannot be sustained, however, on its present arbitrary preferential basis of political expediency. Least of all can it be sustained on that basis in this country. Normally, we do not and cannot be made to think in terms of war. The reason is evident enough, and its recurrent force is already apparent. Distasteful as the fact may be in some of its extremes of application, the only rational procedure is to accept it and fashion our measures of economic preparedness so that the normal activities of peace will keep our economic forces exercised and in trim for the test of war. It was recognized all along before the war that without an assured source of nitrogen supply, our system of defense was hollow; but we succeeded in building up no means of supply in direct response to political needs. We managed to get comfortably started during the war, but it remains to be seen to what extent this artificially nourished development is fitted to withstand the bitter strife of competition ahead.

Part II, dealing with the commercial aspects of nitrogen control and recent developments and changes in practice will be published in our next issue.

Ample Supply of Chilean Nitrate Assured

Sufficient tonnage has been placed in the nitrate trade by the Shipping Board to insure an ample supply of Chilean nitrate to meet fertilizer demands during the coming season. Few deliveries will be made during March, but a sufficient number of ships has been allocated to insure large deliveries during April, May and June. The allocation of ships was arranged after a careful study of the situation by representatives of the Shipping Board and of the Bureau of Soils.

Bureau of Chemistry Appropriation

The total appropriation allowed the Bureau of Chemistry in the agricultural appropriation bill, as it passed the House, was $1,321,591., The general salary account totals $426,190. Other items forming a part of the appropriation are as follows: Biological investigation of food, $66,400; chemical investigations for other departments, $14,000; to carry into effect the provisions of the food and drug act, $579,361; naval stores investigation, $10,000; insecticide investigation, $20,000.

Metric System Bill

Hearings are to begin in the near future before the Committee on Coinage, Weights and Measures of the House of Representatives on a bill making the use of the metric system compulsory by the Government departments. The exact provisions of the bill have not been announced. Representative Vestal of Indiana, chairman of the committee, has been assisting in the drafting of the bill, but as yet the draft has not been perfected. Mr. Vestal states, however, that the bill will be introduced shortly.

The Requirements of Refined Copper

A Discussion of the Market Requirements of Refined Copper as to Electrical Conductivity, Pitch, Ductility, Casting and Dimension, Together With Notes as to the Effect of Analysis, Manipulation and Metallurgical Practice on These Characteristics

By LAWRENCE ADDICKS*

IN ORDER to satisfy market requirements, prime electrolytic copper wirebars and cakes must possess high electrical conductivity, sufficient ductility and physical soundness. From the refiner's point of view the product must also be free from commercial quantities of precious metals. Ingots are given a little more leeway in conductivity and relieved of restrictions as to soundness, inasmuch as they are intended for remelting.

This general subject may advantageously be discussed under the headings of conductivity, pitch, ductility, casting and dimensions.

Electrical Conductivity

It has come to be generally assumed that if a wirebar is a sound casting and a sample of the copper drawn into wire shows a satisfactory conductivity, the product may be accepted as prime electrolytic (or lake) copper. This assumption is not strictly true, as will be shown later, but inasmuch as the preparation of the sample of wire for testing in itself demonstrates within certain limits the ductility of the copper, as the test may be easily and quickly made and as no other test appears to be of general application, conductivity will probably remain as the chief criterion of commercial copper.

Impurities in copper may be divided into three groups as regards their effect upon conductivity: Those which are insoluble in copper, those which are partially soluble and those which are completely soluble—remembering that we are interested only in mixtures where copper enormously predominates.

The elements which are insoluble can evidently have but little effect upon the conductivity, inasmuch as the total quantity of any one impurity is always far below 0.1 per cent and the impurity itself has a certain specific conductivity.

The class which is partially soluble exerts a very marked depression on the conductivity, as such elements form low melting point alloys with copper which crystallize out as eutectics, forming a matrix surrounding crystals of copper like the mortar joints of a mosaic. This matrix may be quite bulky, as part of the copper is added to the quantity of impurity present.

The few elements, such as silver, that form solid solutions with copper have a relatively mild effect upon the conductivity, which is quite negligible in view of the small quantities present.

About fifteen years ago the writer conducted a systematic investigation into the relation between impurities and copper (*Transactions*, American Institute of Mining Engineers, vol. 36, p. 18). Each element in question was added in varying amounts to crucible melts of high-grade copper wire and the conductivity of an annealed sample of wire drawn from the cast compared with the assay of the same wire for the impurity added. The results of this work are grouped together in Fig. 1.

It will be noted at once that the elements which are known to make copper brittle, such as lead, bismuth and tellurium, have but slight effect upon the conductivity, while those which make excellent bronzes, such as phosphorus, aluminum and silicon, have caused a marked depression. It is difficult, however, to make any practical application of these results, because the presence of one impurity often neutralizes the effect of another, and copper which would be expected to be of indifferent quality based upon these figures may prove to be excellent. This is the reason that chemical analysis, apart from the difficulties attending the accurate determination of traces of impurities, has proved of little value in judging copper as compared with the more practical test of forging and drawing followed by a measurement of conductivity.

By common consent conductivity has come to be expressed in percentage of the value of 0.141729 international ohm at 0 deg. C. found by Matthiessen for a meter-gram of supposedly pure copper over fifty years

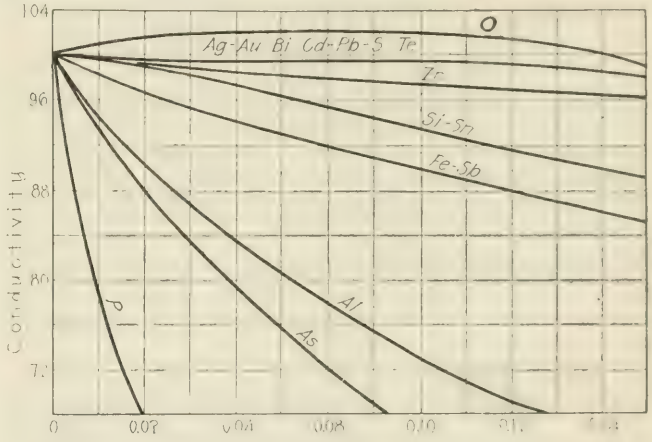


FIG. 1. EFFECT OF IMPURITIES ON CONDUCTIVITY

ago. The specifications of the American Society for Testing Materials have established a minimum requirement equivalent to 98.5 per cent for wirebars and cakes and 97.5 per cent for ingots, determinations being made upon annealed samples. Average copper on the market runs considerably higher than these figures, much of it being over 100 per cent as compared with the imperfectly purified standard copper of Matthiessen. The purest cathode copper—that is, an annealed sample of wire drawn directly from a cathode without melting—may run over 102 per cent; it is unusual, however, for copper that has been melted to run over 101 per cent. The lowering of conductivity by melting is due chiefly to the fact that much of the impurity content of the cathode is present merely as mechanical contamination,

*All book rights reserved by the author.

a certain proportion of which a melting will incorporate chemically. Then there is always the smaller opportunity for the copper to absorb impurities from outside sources during furnace refining.

In drawing copper into wire the coarse crystalline structure of cast copper is broken down into a fibrous structure much harder and stronger but of a lower electrical conductivity, due perhaps to a rearrangement of the system of series-parallel circuits made by copper crystals and matrix. The depression of conductivity bears a direct relation to the degree of hardness attained, as shown in Figs. 2, 3 and 4. (See Addicks, *Transactions*, American Institute of Electrical Engineers, vol. 22, p. 695.) It will be seen from Figs. 3 and 4 that the softening of a wire by annealing has a progressive character in the exact reverse direction from the hardening by working the metal.

In order to arrive at a definite standard for comparing conductivities, therefore, wire is annealed in order to obliterate the somewhat uncertain effect of hard drawing before a determination is made. On the other hand, either a partial annealing or an overheating or "burning" of the wire will give results below the truth.

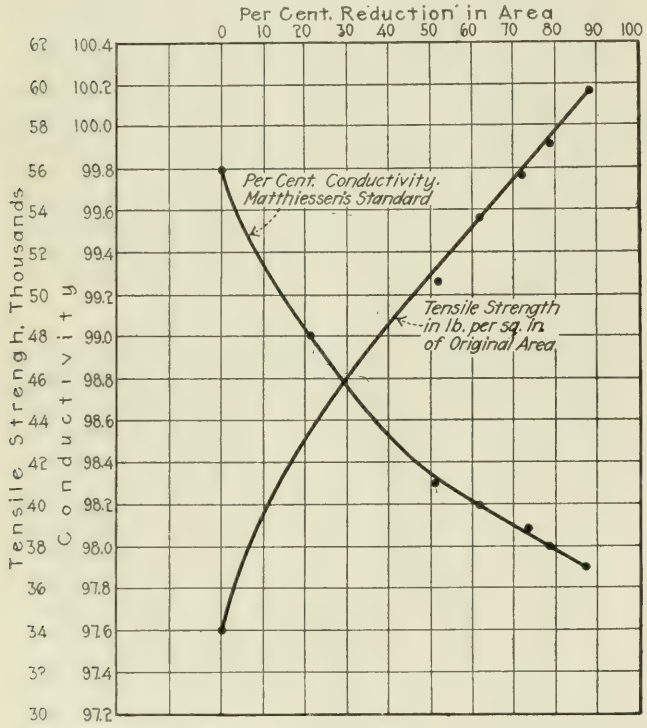

Per Cent. Reduction in Area
0 10 20 30 40 50 60 70 80 90 100
Tensile Strength, Thousands
Conductivity
Per Cent. Conductivity. Matthiessen's Standard
Tensile Strength in lb. per sq. in. of Original Area

FIG. 2. ANNEALED COPPER ROD OF DIFFERENT SIZES DRAWN TO NO. 12 B. & S.

It is therefore necessary to bring the wire to incipient red heat (about 900 deg. F., or 480 deg. C.) for a brief time in order to get consistent results. All errors, however, are on the safe side, as it is impossible to get unduly high conductivity figures by faulty manipulation.

Pitch or Set

The pitch, or set, of copper is an expression used to define the appearance of the free surface of a cast copper bar; that is, the bar may be of high, normal or low pitch or it may be "in set" or "out of set."

Molten copper readily dissolves the various gases with which it is brought in contact in the refining furnace, such as oxygen, carbon monoxide and dioxide, and sulphur dioxide. As the copper cools and sets in the mold excess gas is given off, and the proper control of this phenomenon is the secret of good furnace refining. As has been outlined in a previous article ("The Furnace Refining of Copper," Metallurgical & Chemical Engineering, vol. 17, p. 579), the bath after melting is allowed to oxidize and the resulting cuprous oxide dissolves and acts as a scorifying agent, the scoria is

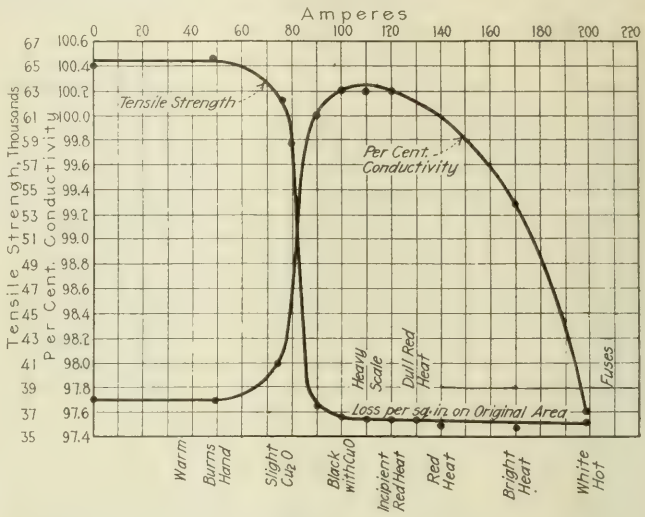


FIG. 3. ELECTRICAL ANNEALING OF NO. 12 B. & S. COPPER WIRE

skimmed off and the excess cuprous oxide reduced by poling. A button of copper cast in a "say-ladle" gives a characteristic set surface and fracture for each stage, the finished product showing a slightly swelling surface without deep wrinkles and a rose-red silken fracture. Should the poling not be carried far enough, the set surface will show a depression and the metal will be hard and somewhat sonorous. Metallographic examination will show thick veins of cuprous oxide eutectic, and careful inspection of the depressed set will reveal "niggerheads," or minute entrances to considerable cavities within. Fig. 5 shows a low set bar which has been planed to show a longitudinal cross-section, and one or two of these cavities are plainly shown. Such a bar may show red shortness in rolling or merely a slight hardness, but the cavities will roll out into small "cold sets" and are probably the main cause of splinters and slivers frequently met with in wire drawing. This phenomenon is identical with "piping" in steel and brass, which are always cast on end, the set surface being sheared off and rejected. Casting of copper on end has been advocated but never generally adopted except in the case of wedge cakes used for purposes where a special mirror polish is required in the rolled article and certain special shapes such as round billets.

If, on the other hand, poling is pushed too far, a reverse condition sets in. The surface bulges on setting and finally "spews over," throwing out worm-like excrescences; some excellent photographs of this condition are given by Hofman, Hayden and Hallowell, *Transactions*, American Institute of Mining Engineers, vol. 38, p. 175. This is analogous to the well-known "spitting" of silver. Such a bar shows perfect softness and malleability in rolling, but the worms have to be chipped off, and overpoled copper is not a satisfactory product. In general, however, the best pitch is one as high as consistent with the avoidance of overpoling.

Overpoled copper shows a slight depression in conductivity, as may be seen from the curve marked oxy-

gen in Fig. 1. The microscope shows the formation of some compound, presumably involving the gases of reduction or possibly sulphur. The latter element is present as included electrolyte in the cathode and in the products of furnace combustion, and until the sulphur has been worked out a charge of blister copper in an anode furnace will give a test button which will "throw a worm" quite similar to that of overpoled copper. Cases of mysterious aging and season cracking in brass have been traced to traces of sulphur, and it must be remembered that lake copper, which had at one time a special reputation in the manufacture of cartridge brass, did not enter the refining furnace with the possibility of faulty separation from a sulphate electrolyte in its past history.

An overpoled charge of copper exhibits instability of pitch, and the mere exposure to the air long enough to restore its depleted oxygen content is not sufficient

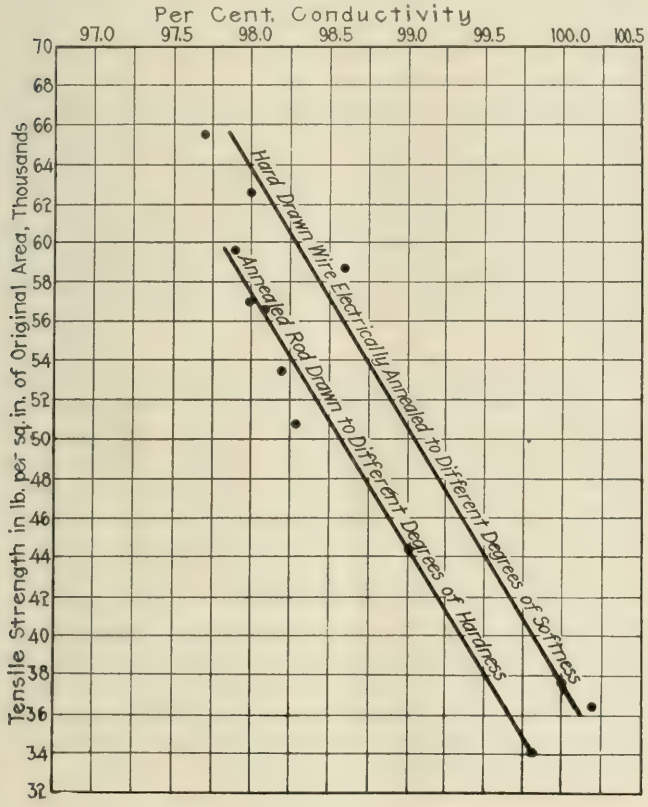


FIG. 4. RELATION BETWEEN CONDUCTIVITY AND TENSILE STRENGTH IN COPPER WIRE

to stabilize this wabbly pitch. It is, therefore, necessary to rescorify the entire charge, another indication that a new compound is formed in overpoling. Curiously enough, the addition of a minute proportion of metallic lead to an overpoled charge will stabilize it, but there is great danger of making the copper brittle. This corrective influence might also point to the presence of sulphur, inasmuch as while lead is insoluble in copper, leady copper matte is readily formed, and under special conditions lead and copper can be made to unite as they do in Allan's metal and in many Oriental bronzes.

The reason that foundries have such difficulty in making sound, high-conductivity castings of pure copper is that they get the copper badly below pitch in melting, so that they find it necessary to add various deoxidizing agents. Much phosphor bronze is nearly pure copper,

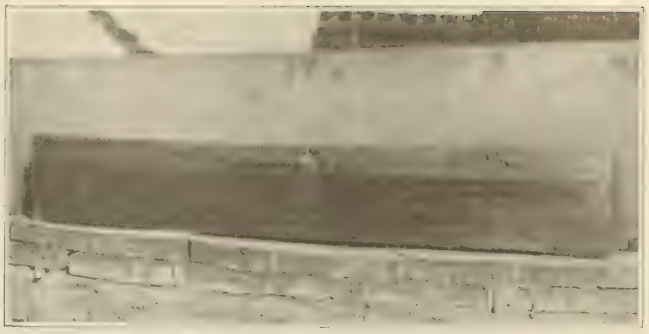


FIG. 5. GAS CAVITIES IN IMPROPERLY REFINED BARS

the phosphorus having vanished as volatile phosphorus pentoxide and merely served as a substitute for poling.

Copper which contains a considerable proportion of some other element—as in the case of arsenical lake running 0.5 per cent arsenic—will show a much coarser wrinkling of the set surface and to the practiced eye has quite a different appearance from pure copper. In the same way copper which has been poled with oil presents a peculiar appearance. Low set copper has heavy wrinkles and may cause cold sets in rolling.

Bars which break in the rolls are frequently found to possess a large cavity near the upper center as shown in Fig. 6, due to a lowness of set. A perfect set should be high and rounding like a mercury meniscus and not show a low level center and a high edge close to the sides where the mold chilled the copper. The wrinkles should be fine and the surface solid.

The set surface carries somewhat more dissolved oxide than the body of the bar. In Europe it was at one time the custom to plane this surface off before rolling when difficult specifications had to be met.

Ductility

While it is known that the addition of exceedingly small quantities of certain elements, such as lead, bismuth or tellurium, will make copper so red-short as to fall to pieces in rolling, it is quite impossible to state permissible limits of such elements on account of the neutralizing effects or various other impurities which may or may not be present. In general it is safe to say that nearly all troubles from brittleness may be traced to low pitch.

Well-refined high-grade copper can be hot rolled into quarter-inch rod which after pickling free of scale can be cold drawn into the finest wire without any intermediate annealing. In practice, however, there is always a certain percentage of "breaks" in the wire-drawing machines, and this percentage has been found to bear a direct relation to the copper contents of the lot of wirebars under test. It is, therefore, customary

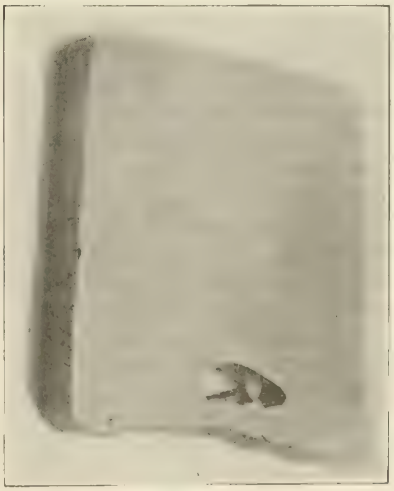


FIG. 6. GAS CAVITY IN LOW SET BAR

to impose, in addition to the conductivity specification, a requirement that the copper content (including silver) shall not be less than 99.88 per cent, a figure intended to represent a limit of 99.90 per cent after allowing a margin for assay precision.

The determination of traces of impurities in copper requires long experience. This is particularly true in the case of sulphur, where even the atmosphere of the laboratory must be free from sulphur compounds.

Mechanical tests on samples of wire as checks upon the character of the raw copper have been abandoned because the fabrication of the wire introduces so many variables. The former tests, as a rule, consisted of measurements of tensile strength and torsion.

Tensile Strength and Torsion

The tensile strength of copper wire depends upon the percentage of reduction in area after annealing, the speed and the temperature of drawing. With proper regard to these factors, almost any copper not too brittle to draw can be made to fulfill standard telephone wire specifications as to strength.

The usual torsion test was to determine the number of twists a No. 12 B. & S. (2.05 mm. diameter) hard-drawn wire would stand before snapping. This test is perfectly worthless, because it depends entirely upon the property of the thin skin which forms on wire in drawing. A wire as it comes from the drawbench when put in the testing machine will twist uniformly throughout its length for a few turns and then twist tightly at one point and snap. If the wire is scoured with emery paper or dipped for a moment in nitric acid before twisting, the skin is broken down and before snapping the entire length will coil tightly, giving several times the number of total twists formerly obtainable. This skin is at least in part due to imperfect pickling after rolling, as by the use of a nitric acid instead of sulphuric acid pickle on the rod the number of twists that the wire will stand is greatly increased. Particles of oxide scale are probably rolled into the metal, and sulphuric acid, while it will dissolve oxide, cannot cut metallic copper to reach it.

Sometimes bars are badly overheated in the heating furnace before rolling, and this probably causes absorption of gases and consequent brittleness. Altogether, mechanical tests have been entirely dropped as a check on the quality of the copper as distinguished from the finished wire.

Castings

In order to get a perfect casting from a physical point of view, the first requisite is that the copper should be in correct pitch, a subject which has already been discussed at some length. Small adjustments in pitch are made by adding or removing charcoal at the casting machine ladle. Next, the temperature of the copper must be high enough to insure good fluidity without burning the mold. The mold itself must be warm—that is, slightly above the boiling point of water—in order to avoid any condensation of moisture or too sudden chilling of the copper first striking it. There must be a fine film of a suitable mold wash to prevent sticking and the material used must be free of any volatile matter. The mold must be solid and free of pores which would entrap water; otherwise a spongy casting would result. The copper must flow in quickly but evenly and the casting machine must operate so smoothly that a partially set bar will be subject to no vibration or jars. The bars must be quenched in water soon after setting and this water must be warm. Finally, the molds must be free of warp and set truly level and filled to a given mark without any attempt at adjustment.

These many small points require very careful supervision at the casting wheel and carelessness in any one detail will give more or less defective product. Bars may be out of size, out of set, porous or contain splashes, fins, cold sets or "fish."

Out-of-size bars result from out-of-level or warped molds, or from careless filling to a wrong level. Too large a bar may result in the production of fins in the rolls, due to crowding. Molds suspended at the ends tend to drop in the middle and pinch at the top center.

Porosity may come from low set or may be due to moisture. It generally follows cold or porous molds or too high a casting temperature. In this connection it may be stated that copper molds turn out superior castings to iron ones, although the latter are more or less in use.

Splashes occur when the copper first strikes the mold, being thin sheets of metal which splash on the sides and freeze. Unless they are knocked off with a suitable tool before they are submerged, they are likely to leave a cold set or unwelded lamination in the bar.

Fins are sharp high edges due to filling the mold too rapidly or to vibration of the casting machine giving a wash to the bar before setting. They must be chiseled off the finished bar or they will be rolled in later.

Cold sets occur in various ways whenever molten copper is allowed to enfold cold splashes, etc. They must be chiseled out or, if extensive, the bar rejected.

Fish are bits of charcoal, nails or other foreign bodies allowed to become incorporated in the casting. They are supposed to be removed by a "fisher" during pouring much as a fly is rescued from a glass of milk.

The color of cast copper depends chiefly upon the time allowed to elapse between pouring and quenching and the temperature of the bosh water. The beautiful ruby shades are due to thin films of the lower oxides, and a slight change from the proper conditions will make bars either brassy or black. Twenty years ago good color was given great importance at the rolling mill, but it has nothing to do with the quality.

Dimensions

Each refinery issues a metal schedule giving the weights and dimensions of the market shapes it produces. This covers wirebars, cakes, ingots, ingotbars and billets. Very large wirebars, very heavy cakes and very large billets cast on end are poured by hand from a crane ladle and the additional cost over machine casting is reflected in a premium charged. Ingotbars are merely three ingots cast end to end in order to bring the weight up to a figure where steamships will accept them without demanding that they be barreled.

No rigid requirement as to regularity of size and weight is required of ingots and ingotbars which are to be remelted. In the case of wirebars, however, the American Society for Testing Materials specifications give a tolerance of 5 per cent in weight and ¼ in. in any dimension except that wirebars may vary 1 per cent in length and cakes 3 per cent in any dimension greater than 8 in.

For wirebars, each refinery has its own design and

proportions of point. Different rolling-mill men have such contradictory opinions regarding the relative advantages of slight changes in these matters that it is probable that one design is about as good as another. A long point enters the roll more easily at the first pass, but is apt to leave more scrap. A square cross-section is desirable, because a flat bar is apt to turn over in the rolls when part way through. The first pass is often a box roll and after that diamond and oval alternately.

American Wirebar Sizes

A refinery carries about six sets of standard molds and raises the weight of the bars cast from each set by suitably changing the depth to which the molds are filled within the limits imposed by the necessity of keeping a bar reasonably square in cross-section. An example from practice is shown in Table I.

Bars of 135 lb. and under are commonly used in Europe, but practically not at all in the United States, where the usual demand is between 175 and 225 lb. Very heavy bars, running around 800 lb., are in moderate demand on the Continent for making great lengths of trolley wire without reverting to the American practice of brazing.

Inasmuch as the great demand for power in a rolling mill is in the first two or three passes, the roller would prefer a long bar of small cross-section. This, however, would increase the difficulties in casting and in obtaining sound bars, and developments in this direction are improbable unless it be in connection with castings made on end.

TABLE I. TYPICAL AMERICAN WIREBAR SIZES

Weight, Lb.	Length, In.	Depth, In.	Top Width, In.	Bottom Width, In.
135	35¼	3⅞	3¾	3 5/16
175	47½	3⅝	3 11/16	3¼
200	49½	3⅞	4	3⅝
225	50	4 1/16	4	3⅝
250	56	3⅞	4⅛	3 5/16
275	55⅜	4 7/16	4½	4⅛
300	55½	4⅝	4½	4⅛

Cakes are the most troublesome class of castings to make. They have a large set surface and this is rolled out to a mirror-like finish where every flaw is readily seen. Often they are cast on "mixed" rings, so that wirebars are interspersed on the mold ring and, as perfect pitch for a wirebar is not necessarily perfect for a cake, a slight disadvantage results. It is quite impossible to cast a small ingot and a heavy cake from the same ladle without adjustment in pitch, as the shrinkage and gas release conditions are so different in the two cases.

Occasionally copper is shipped as cathodes in place of ingots. This is a perfectly logical procedure, as the furnace operation is not a true refining and it has been abundantly shown that a cathode really freed from electrolyte can be melted to high-grade copper without any furnace refining whatever. On the other hand, the cathodes must be sheared to a suitable size, they are often brittle and there is always more or less metal loss in transit. Aside from nodules being dropped by the wayside, pieces are easily broken off by thieves. Also cathodes are quite variable in individual quality, while in the refining furnace thousands are averaged together. The result is that ingots still hold their own in the brass trade, although a fair proportion of cathodes are sold on an allowance below the price of wirebar copper.

New York City.

Legal Notes

By Wellington Gustin

What May Be Done Under Contract to Purchase Requirements

The Supreme Court of Pennsylvania has handed down a decision in the case of the Diamond Alkali Co. against the Aetna Explosives Co. The alkali company had filed a bill in equity against the Aetna company for an accounting of profits realized on the resale of soda ash delivered to it by the complainant under a certain contract which constituted the basis of the action. (107 Atlantic, 711.)

The material part of the contract between the parties, and involved in the controversy, after stating mutual promises to sell and buy, was: "Quantity: Buyer's entire requirements during 1916; minimum quantity 180 tons per month and maximum 250 tons monthly."

The kind was to be 58 per cent light soda ash, shipped in carload lots, price $1 per 100 lb. Buyer was to give seller at least thirty days notice of his requirements for each ensuing month. The agreement closed with these words: "There are no understandings or agreements relative to this contract or its subject matter that are not fully expressed herein."

The case was disposed of in the court below on bill and answer. A decree was rendered ordering the accounting as desired, and the defendant appealed to the Supreme Court.

Findings of the Lower Court

In the lower court the Chancellor found six facts, but only the third and fifth ones were material in the case on appeal. These findings are:

"Third. The shipments of soda ash, pursuant to orders from defendant, were less than the minimum specified in the agreement."

"Fifth. Defendant purchased and plaintiff delivered soda ash, which defendant did not use in its business as a manufacturer of explosives, and the excess quantity so obtained was sold by the defendant at a profit."

Now, the decree in the lower court was based on this last, the Chancellor construing the contract to be such that defendant could order only such quantities of soda ash between the minimum and maximum limits as were required in the manufacture of explosives.

Finding of the Supreme Court

The Supreme Court said that although the concluding clause of the contract states there are no other agreements or understandings, the lower court read into this contract: "Buyer's entire requirements in its business as a manufacturer in 1916." By referring back to the statement as to the contract it will be seen the words used are: "Buyer's entire requirements during 1916." The court said the requirements of its business as a manufacturer during 1916 may not have been 180 tons of soda ash a month, but whether so or not, it was bound by the terms of its contract to take that quantity from the plaintiff. The minimum and maximum quantities fixed in the contract were not merely probable estimates of the quantities which the Aetna company was to take, but were the definite fixed quantities which it could demand and which the alkali company was bound to deliver. The latter was bound to hold itself in readiness to make shipments ordered under the con-

tract, and the former, in turn, was bound to receive the minimum contracted for. (256 Pa., 295.)

Under the lower court's construction of the contract the defendant Aetna company could not resell any portion of the minimum quantity which it was required to take, if it found that the entire quantity was not actually required in its business. The lower court was of the opinion that "if 250 tons monthly was the quantity required to meet defendant's needs, it could have called for delivery of that quantity, but if fifty tons were sufficient, it could not demand more."

The question of the bad faith of defendant was not involved in the controversy. The complainant had simply averred that defendant had ordered soda ash in excess of its requirements in its business of manufacturing explosives and had resold the same; that by so reselling the defendant had perverted the contract. But the Supreme Court said the mutual rights and obligations under the contract were alone involved, and these were that for one year the plaintiff must be prepared to deliver, and the defendant to take, not less than 180 tons of soda ash per month, with the right to demand seventy more each month. In fact, plaintiff furnished less than 180 tons each month, on defendant's orders.

Now, to find the defendant guilty of "perversion" of the contract, the Supreme Court said, words must be written into it in the face of the clearly expressed intention to the contrary of both parties as stated in the concluding clause.

Case of Highlands Chemical Co. vs. Matthews Cited

The court said the reading of words into a contract was attempted in Highlands Chemical Co. vs. Matthews, 76 N. Y., 145, where the contract provided that the plaintiff should supply defendant with oil of vitriol for one year, "total amount to be called for during that time to be not more than 10,000 or less than 7,000 carboys." The defendant called for the maximum quantity, which the plaintiff failed to deliver. In a suit to recover for what had been delivered, the defendant claimed as a set-off the difference between the market price and the contract price of what had not been delivered to him. Thereupon the plaintiff attempted to import into the contract words in effect that the acid was to be used in defendant's business, and that therefore he had no right to demand more than was required for that purpose. The Court of Appeals held this could not be done, saying: "The defendant was required to take the minimum amount, whether he needed or desired it for the purposes of his business or not; and the correlative obligation rested upon the plaintiff to deliver any amount within the maximum fixed by the contract, if called for by the defendant. The contract of the plaintiff is not to supply an amount within the limits named, if needed by the defendant in his business. To introduce this qualification would be adding a new term to the contract."

Decision of the Supreme Court

Relying on this, the Supreme Court said it was no concern of the plaintiff what defendant may have done with what it was obliged to receive. If the price of the product had fallen it would have been compelled to bear the loss, and the court held that plaintiff had no right to an accounting for profits or for what it did with any of the product delivered to it under the contract. Hence the decree was reversed and dismissed at cost of the plaintiff.

Damages Awarded Infant Employee

In a personal injury case the defendant company had employed the plaintiff to work upon a laundering machine in one of its plants in New Jersey. His specific work was to keep the edge of the goods which were run through the machine from curling or getting folded, as it passed over the rollers. His hand apparently became entangled in the machinery, was drawn in between two of the rollers and was crushed. The workman was under sixteen years of age at the time of the accident, which fact was not known to the company, as the plaintiff had himself represented to the company's superintendent that he was then over sixteen years old.

The plaintiff brought suit upon the common law liability of an employer to compensate an employee for injuries received in his employment by reason of the negligence of the master. Upon trial a verdict was returned for the plaintiff, and the company appealed. (Lesko vs. Liondale Bleach, Dye & Print Works, 107 Atlantic, 275.)

Employee's Misrepresentation as to Age Is No Defense

On its appeal to the New Jersey Supreme Court the company urged that the workmen's compensation act provided the only means by which an injured employee can recover compensation for injuries received in the course of and arising out of, his employment, and that it abrogates the common law liability of the master for such injuries. But the court said this provision of the statute limiting recovery to compensation applies only where the contract of hiring is a valid one, and not where the contract is prohibited by the statute law of the state, as in this case. But the company argued further that where the false representation as to age had been the inducing cause of the employment, the infant employee is estopped from taking advantage of the statute; or, stated in another way, will not be permitted to deny the truthfulness of his statement made as to his age whereby he secured employment.

However, the court held that the doctrine of estoppel had no application where the employment of the infant is in violation of the provisions of the factory act, although the master employing the infant believes the representation to be true.

Law's Aim Is to Protect Children

Another contention for a reversal of the judgment was that the employee assumed the ordinary risk in the normal operation of the machine which resulted in the injury. Now, the court pointed out, the primary purpose of the factory act is to protect all children who are too young to appreciate the dangers arising out of work, and said that when the legislature had distinctly established an age limit under which children shall not be employed, it, in effect, had declared that a child under that age limit does not have the mature judgment, experience and discretion necessary to engage safely in work prohibited by the statute; and, consequently, a boy employed in violation of the legislative mandate is not chargeable with contributory negligence, or with having assumed the risks arising out of that employment.

Lastly, it was urged the verdict was excessive, but the court held the evidence did not justify a reduction. The verdict of the lower court was sustained.

Theoretical Study of Nitrogen Fixation by the Electric Arc—IV

Kinetic Aspects of the Nitrogen-Oxygen Reactions—Effect of the Arc in Dissociating N_2, O_2 and NO—Influence of Molecular Vibration Speeds—Probability Law—Concentrations of NO—Principles of the Electric Arc*

By CHARLES P. STEINMETZ

WHILE it is frequently assumed that the production of NO by the arc is merely a thermal effect, due to the high temperature of the arc, already Haber, Koenig and others have expressed the opinion that the nitrifying action of the arc discharge is at least partly a direct electrical effect, and have brought forward experimental evidence showing that under certain conditions arcs may give NO concentration far above those which could be expected by the thermal action. Further evidence for a direct chemical effect in the arc is given by Hayden in the A. I. E. E. *Transactions*, and a report of Dr. Noyes refers to the same possibility of a direct electronic action in nitrification.

My experience with electrical arcs has led me to the opinion that the nitrifying effect of the arc discharge is primarily a direct electrical effect, a dissociation of the gases in the arc stream into free atoms and a recombination of the free atoms into all possible combinations by the probability law, and that the thermal effect is a secondary one, in limiting the amount of NO which can be recovered from the arc.

The electric arc discharge probably is the most powerful dissociating agent, as seen by most chemical compounds in the arc giving the elementary spectra.

The phenomenon of nitrification by the arc then would be as follows:

In the arc stream, that is, the gas column which carries the electric current, the molecules of N_2 and O_2 are dissociated into their free atoms N and O. When leaving the arc stream, or when the arc stream stops by interruption of the current and the electrification action thus is withdrawn, these free atoms recombine, N with N, O with O and N with O, thus giving a mixture of N_2, O_2 and NO in the proportions determined by the probability law of the atoms meeting each other. If the temperature of the arc stream is so low that the dissociation velocity of NO is negligible, as might probably be the case with the mercury arc or with cadmium and zinc arc, this gas mixture survives; if the temperature of the gases coming from the arc stream is so high that the dissociation velocity is considerable, dissociation of NO occurs, the more the slower the temperature drops.

However, the formation of NO by the probability law from the dissociated gases in the arc stream and the dissociation by the temperature law during the cooling of the gases coming from the hot arc would merely be a theoretical segregation of the two phases of the phenomenon. In reality, when the electrical action of the arc is withdrawn from the mass of hot dissociated gases, N atoms meeting with N atoms will usually combine to N_2 molecules, unless their velocity, that is, temperature, is above the dissociation temperature of N_2. So O atoms meeting with other O atoms will usually combine to O_2 molecules; but N atoms meeting with O atoms will usually not combine, unless their velocity happens to be low, that is, materially below the average corresponding to the temperature, until the average velocity, that is, the temperature, has fallen sufficiently, for instance by giving off velocity to slow moving molecules, that is, by mixture with cold gases. If then the average velocity, that is, the temperature, falls slowly, before it has fallen sufficiently to permit the formation of many NO molecules, most of the free atoms of N and O will have vanished by combining to N_2 and O_2 molecules. The quicker thus the cooling of the hot mixture of dissociated gases the more N and O atoms would survive to the temperature where NO can form to any great extent.

The phenomenon thus would be that of the approach to equilibrium conditions of a mixture of N, O, N_2, O_2 and NO, from a mixture of N and O produced by the arc. If the arc temperature is very high, and the reaction velocity thus extremely high, it can easily be seen that the condition of thermal equilibrium, by Nernst's equation, preponderates, unless extremely rapid cooling is possible. Only with arcs of relatively low temperature, or extremely rapid cooling (such as is possible with very thin, that is, low current, arcs, which are rapidly and frequently interrupted, as for instance by the Bradley-Lovejoy method of arc nitrification), a material difference in the result may be expected, if the phenomenon is not thermal but electrical. It is under these conditions that abnormally high concentrations, etc., have been observed by Koenig and others.

However, since the Bradley-Lovejoy process was a commercial failure, and the Birkland-Eyde process in Norway a success, at least under the conditions prevailing there, most of the attention of the investigators has since been concentrated on the latter process. In this, however, due to the large high-current high-temperature arc, the thermal phenomenon probably predominates.

Nevertheless, in my opinion, the evidence is strongly in favor of the assumption that the effect in the arc is primarily an electrical one, a dissociation of the molecules into free atoms, and then recombination of these by the probability law, limited by the temperature stability of the resulting products.

Assuming then that a gas mixture like air, consisting of:

n_0 g. mol. N_2

o_0 g. mol. O_2

b g. mol. neutral gases, as A, etc.,

*For Parts I, II and III see CHEM. & MET. ENG., vol. 22, Nos. 7, 8 and 9, Feb. 18 and 25 and March 3, 1920, pp. 299, 353 and 411.

where:

$$n_o + o_o + b = 1$$

is dissociated by the arc, and the free atoms, recombining by the probability law, then from the gas mixture of:

n g. mol. N_2
o g. mol. O_2
a g. mol. NO
b g. mol. neutral gases.

where:

$$n + o + a + b = 1$$

The probability, in the dissociated state, of an N atom meeting another N atom, that is, of two N atoms meeting each other, bears to the probability of an N atom meeting an O atom, the ratio:

$$n : a = \frac{n_o}{2} : o_o \qquad (101)$$

The probability of an O atom meeting another O atom bears to that of an O atom meeting an N atom the ratio:

$$o : a = \frac{o_o}{2} : n_o \qquad (102)$$

(101) and (102) give:

$$n : a : o = n_o^2 : 2n_o o_o : o_o^2 \qquad (103)$$

and since

$$n + a + o = n_o + o_o = 1 - b \qquad (104)$$

It is:

$$a = \frac{2n_o o_o}{1-b}$$

$$n = \frac{n_o^2}{1-b}$$

$$o = \frac{o_o^2}{1-b} \qquad (105)$$

which gives:

	Air		1 : 1 Mixture of N_2 and O_2	
	Before Passing the Arc	After Passing the Arc	Before Passing the Arc	After Passing the Arc
N_2 concentration.....	$n_o = 0.777$	$n = 0.6116$	$n_o = 0.50$	$n = 0.25$
O_2 concentration.....	$o_o = 0.210$	$o = 0.0447$	$o_o = 0.50$	$o = 0.25$
NO concentration.....	.....	$a = 0.3307$	.....	$a = 0.50$
Neutrals, concentration b	$= 0.013$	$b = 0.013$	.....	.....

According hereto, the air coming from the arc stream would have an equilibrium concentration of NO of about 33 per cent, if the thermal equilibrium concentrations are left entirely out of consideration, as could be done only if the arc temperature is very low. Otherwise the NO concentration will be reduced by dissociation due to the approach to the thermal equilibrium at a rate depending on the initial temperature and the rapidity of the cooling. It probably makes no material, if any, difference if we assume the electrical equilibrium established instantly and the concentration resulting therefrom then reduced by the condition of thermal equilibrium, or if we assume both effects occurring simultaneously, as probably the case, and thus these high concentrations never reached. We may thus use the first assumption, that is, segregating the thermal and the electrical effect, as it allows us to calculate from the initial concentration of the chemical equilibrium, by the laws of thermal equilibrium, the residual NO concentration from the rate of cooling.

Dissociation Acceleration Constant

The velocity of thermal dissociation is, by (12):

$$v = -\frac{da}{dt} = c_2 a^2 - c_1 \left(n - \frac{a}{2}\right)\left(o - \frac{a}{2}\right) \qquad (106)$$

At concentration a, much above the thermal equilibrium concentration, as would be the case here, the second term of equation (106) is negligible, as seen from the table of reaction velocities III. Thus it is:

$$v = \frac{da}{dt} = c_2 a^2 \qquad (107)$$

It is then:

$$\frac{dv}{dT} = a^2 \frac{dc_2}{dT} + 2ac_2 \frac{da}{dT}$$

As a is independent of the temperature T, that is, a change of T does not change a except through c_2, it is:

$$\frac{da}{dT} = 0$$

Thus:

$$\frac{dv}{dT} = a^2 \frac{dc_2}{dT} \qquad (108)$$

It is, however, by (23)

$$\log_{10} c = -10.887 + 5.731T \times 10^{-3} \qquad (109)$$

or:

$$\log_e c_2 = -25.07 + 13.20T \times 10^{-3} \qquad (110)$$

Herefrom follows:

$$\frac{dc_2}{dT} = 13.20 \times 10^{-3} c_2 \qquad (111)$$

Substituting (111) into (108) gives:

$$\frac{dv}{dT} = 13.20 \times 10^{-3} a^2 c_2 \qquad (112)$$

Substituting (107) into (112) gives:

$$\frac{dv}{dT} = 13.20 \times 10^{-3} v \qquad (113)$$

Thus, integrated:

$$\log_e \frac{v}{v_o} = 13.20 \times 10^{-3} (T - T_o) \qquad (114)$$

where

v_o and T_o are two corresponding values, or, in common logarithms:

$$\log_{10} \frac{v}{v_o} = 5.731 \times 10^{-3} (T - T_o) \qquad (115)$$

That is, for constant temperature intervals $(T - T_o)$, the dissociation-velocity increases by a constant factor.

For $(T - T_o) = 100$, or 100 deg. rise of temperature, $\frac{v}{v_o} = 3.74$ fold, or the action velocity increases 3.74 times; for 200 deg. temperature rise, 14.0 fold.

From (114) follows

$$v = v_o e^{s(T - T_o)} \qquad (116)$$

where:

$$s = 13.2 \times 10^{-3} = .0132 \qquad (117)$$

Thus:

$$\frac{da}{dt} = -v_o e^{s(T - T_o)} \qquad (118)$$

If now the cooling of the gas mixture is carried out by the cooling function:

$$\frac{dT}{dt} = -f(T, t) = -bT^n \qquad (119)$$

That is, the gases are cooled proportional to some power of the temperature ($n = 4$: radiation; $n = 1$: conduction, approximately; $n = 0$: constant rate of cooling) it is:

$$\frac{da}{dT} = \frac{da}{dt} : \frac{dT}{dt} = \frac{v_o e^{s(T - T_o)}}{f(T, t)} = \frac{v_o e^{s(T - T_o)}}{bT^n} \qquad (120)$$

Thus, integrated:

$$a_1 - a = \frac{v_o}{b} e^{-sT_o} \int_T^{T_1} T^n e^{sT} dT \qquad (121)$$

for $n = 0$, or constant rate of cooling, this gives:

$$a_1 - a = \frac{v_o e^{-sT_o}}{sb}\left[e^{sT_1} - e^{sT}\right] \qquad (122)$$

If T_1 is the high initial gas temperature, T the much lower final temperature, the second term is negligible compared with the first term, and equation (122) simplifies to:

$$a_1 - a = \frac{V_o}{sb} e^{s(T_1 - T_o)} \qquad (123)$$

where a_1 and T_1 are the initial concentration and initial temperature, v_o the dissociation velocity at temperature T_o.

Substituting (107)

$$a_1 - a = \frac{c_2 {a_o}^2}{s\,b} e^{s(T_1 - T_o)} \qquad (124)$$

or, making $T_o = T_1$, thus $a_o = a_1$:

$$\frac{a_1 - a}{{a_1}^2} = \frac{c_2}{sb} \qquad (125)$$

and by (110):

$$c_2 = e^{-25.07 + sT_1} \qquad (126)$$

Thus:

$$a_1 - a = \frac{{a_1}^2}{sb} e^{sT_1 - 25.07} \qquad (127)$$

$$\log_{10}(a_1 - a) = 2\log_{10} a_1 - \log_{10} s \log_{10} b + .4343\, sT_1 - 10.887$$
$$= 5.731 \times 10^{-3} T_1 - 10.887 + 2\log_{10} a_1 - b - 8.121$$
$$= 5.731 \times 10^{-3} T_1 - \log_{10} b + 2\log_{10} a_1 - 9.008 \qquad (128)$$

If:

$a_1 = .33$

It is:

$\log_{10}(a_1 - a) + 5.731 \times 10^{-3} T_1 - \log_{10} b - 9.971$

or, if a and a_1 are given in per cent:

$\log_{10}(33 - a) = 5.731 \times 10^{-3} T_1 - \log_{10} b - 7.971$ (129)

or, approximately:

$\log_{10}(33 - a) = 5.731 \times 10^{-3} T_1 - \log_{10} b - 8$ (130)

That is, with an arc temperature or initial temperature T_1 and cooling constant b, starting with the initial concentration of electrical equilibrium of 33 per cent NO, the final concentration a, after cooling at constant rate, to temperatures where the dissociation velocity has become negligible, is given by equation (130).

However, this equation involves the assumption that a is high compared with the equilibrium concentration, and ceases to apply if a approaches the thermal equilibrium concentration. It may be used, however, to determine the range of T and b, within which an appreciable part of the initial concentration $a_1 = 33$ per cent can be saved; outside of this range, the thermal equilibrium conditions prevail.

From (129) follows:

$$T_1 = \frac{\log_{10}(33 - a) + \log_{10} b + 7.971}{5.731} \times 10^3 \qquad (131)$$

Residual Concentrations

In Table XIII (see p. 416) are given, for a cooling rate of $b = 10^5$ per sec., the arc temperature T_1, which gives various residual NO concentrations a, from 0, that is, temperature equilibrium, up to 32.9 per cent. These values are plotted in dotted lines, with the temperature as abscissæ, in Fig. 11.

Table XIV gives the arc temperatures required at various cooling rates b, from 1 to 10^8 deg. per sec., to give various residual concentrations, from $a = 32$ per cent, that is, practically chemical equilibrium, and the thermal effect does not yet come into consideration, up to $a = 0$, that is, the residual concentration is entirely determined by the temperature equilibrium.

These values are plotted in Fig. 13, with the cooling rate b as abscissæ and the temperature as ordinates. As seen, at each cooling rate, there is (theoretically) a relatively narrow temperature range of less than 300 deg., in which the effect changes from electrical to thermal. With arc temperatures above this critical range, the effect is entirely thermal; with arc temperatures below this range, it is entirely electrical, while with arcs of a temperature within this range, it is partly thermal, partly electrical. Thus at a cooling rate of $b = 10^5$, at arc temperatures above 2530 deg. abs. the NO concentration entirely depends on the thermal equilibrium; but at an arc temperature of 2460 deg. abs., or only 70 deg. lower, already a concentration of 20 per cent NO, if produced electrically, could survive, while at arc temperatures below 2260 deg. abs., practically the entire electrical equilibrium concentration of NO would survive.

Table XV then gives for an average cooling rate $b = 10^5$, that is, a rate varying for the different parts of the air between 10^3 and 10^7, the concentration which would result at various arc temperatures, when cooling the gases to 1400 deg. abs., by mixing air at 400 deg. abs., with the arc stream, A, with an electrical equilibrium of 33 per cent NO in the arc stream, B, with the action being entirely thermal.

In Figs. 11 and 12 are plotted the values of the residual concentration of the arc gases, and the concentration of the gas mixture resulting from the arc and the cool air, with the arc temperature as abscissæ. Fig. 12 gives the values in a larger scale, for electrical and thermal equilibrium, while Fig. 11 shows only the electrical equilibrium conditions, but shows the critical temperature range, where the action changes

TABLE XV. EQUILIBRIUM

Average cooling rate: $b = 10^5$ deg. per sec. distributed as follows:

$b =$	10^3	$10^{3.5}$	10^4	$10^{4.5}$	10^5	$10^{5.5}$	10^6	$10^{6.5}$	10^7
Per cent:	2	7	13	18	20	18	13	7	2	100

Cooled by air of 400 deg. abs. to temperature of 1400 deg. abs.

$\log_{10}(33 - a) = 5.731\, T_1 10^{-3} - \log_{10} b - 7.971$

	A Electro-Thermal		B Thermal	
	NO Concentration			
Arc Temp. Abs.	In Arc	Per Cent in Gas Mixture	In Arc	Per Cent in Gas Mixture
Below 1400	33.0	33.0	...	...
1400	33.0	33.0	0.06	0.06
1600	33.0	27.5	0.16	0.133
1800	33.0	23.6	0.33	0.236
2000	32.8	20.5	0.61	0.381
2200	30.6	17.0	0.98	0.544
2300	26.7	14.1	...	...
2400	20.9	10.45	1.47	0.735
2500	14.3	6.81	1.74	0.829
2600	8.23	3.74	2.01	0.914
2700	4.26	1.85	2.27	0.987
2800	2.81	1.17	2.42	1.008
2900	...	...	2.51	1.004
3000	2.54	0.98	2.548	0.977
3100	...	...	2.553	0.948
3200	2.55	0.91	2.554	0.912
3400	2.55	0.85	2.554	0.851
3600	2.55	0.80	2.554	0.798
3800	2.55	0.75	2.554	0.751
4000	2.55	0.71	2.554	0.710
4200	2.55	0.67	2.554	0.672
4400	2.55	0.64	2.554	0.638

TABLE XIV. ELECTRO-THERMAL EQUILIBRIUM

Cooling rate, deg. per sec.:	$b =$	1	10	10^2	10^3	10^4	10^5	10^6	10^7	10^8
Residual Concentration of NO: a = 32 per cent	$T_1 =$	1390	1565	1740	1915	2080	2255	2430	2605	2780
20 per cent		1595	1770	1945	2120	2285	2460	2635	2810	2985
10 per cent.:		1640	1815	1990	2165	2330	2505	2680	2855	3030
Thermal equilibrium:		1665	1840	2015	2190	2355	2530	2705	2880	3055

from thermal at higher, to electrical at lower temperatures.

It must be realized, however, that this matter of very high concentration in the arc stream, resulting from the probability law, is entirely speculative, and while there is good evidence for the assumption that the nitrifying action of the arc stream is not a mere thermal effect, but that a direct electrical effect comes in, it is not probable that the action is as simple as assumed in the preceding, nor that such high concentrations are reached, and more experimental evidence is necessary before fully understanding the nitrifying action of the electric arc. It is more probable that the concentrations

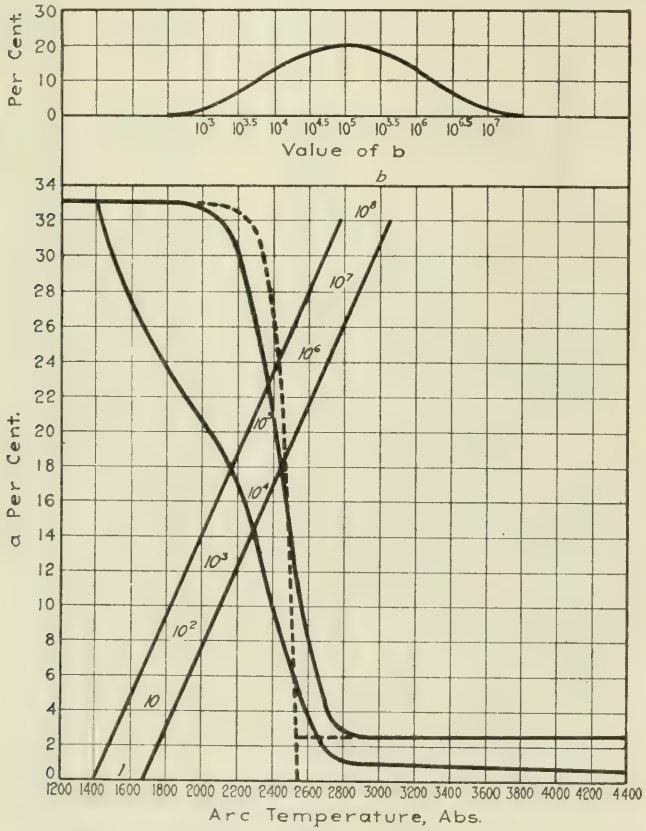


FIG. 11. ELECTRO-THERMAL EQUILIBRIUM *NO* CONCENTRATION

brought about by direct electrical action are much higher than those of thermal equilibrium, especially at lower arc temperatures, but are still far below the values given by the probability law, as assumed above.

Appendix: The Arc

As seen, the problem of economical, that is, efficient, nitrogen fixation by the electric arc is essentially dependent on the physical and electrochemical characteristics of the electric arc, in the solution of designing the operating conditions such as to produce the maximum amount of electrochemical action with the minimum expenditure of energy in the arc. Unfortunately, our knowledge of the physical and electrochemical characteristics of the various forms and types of electric arcs is still so limited that an intelligent and systematic design of arc nitrification processes for maximum efficiency will not be possible unless very much more is known on the nature of stationary and transient arcs, and before much further advance can be made a systematic research into the electric arc and its properties thus appears essential.

In the following shall therefore be given a short outline of our knowledge of the physical and other characteristics of electric arcs, as far as known, to serve as a starting point for further research on arcs.

The Normal Arc

In the following we shall limit ourselves to the presentation and discussion of the physical characteristics of the arc, without considering their theoretical explanations by the ionic theory or otherwise.

The typical or normal arc is best illustrated by the passage of a unidirectional continuous current between two terminals, of metal or similar conductors, such as carbon, magnetite, titanium carbide, etc., in an atmosphere of constant pressure, while not disturbed by air currents, external magnetic or electrostatic fields, etc.

The melting point of carbon is above its boiling point at atmospheric pressure. Therefore, when using carbon as arc terminals, no fused spot or pool can form on the terminal, as with other materials in which the

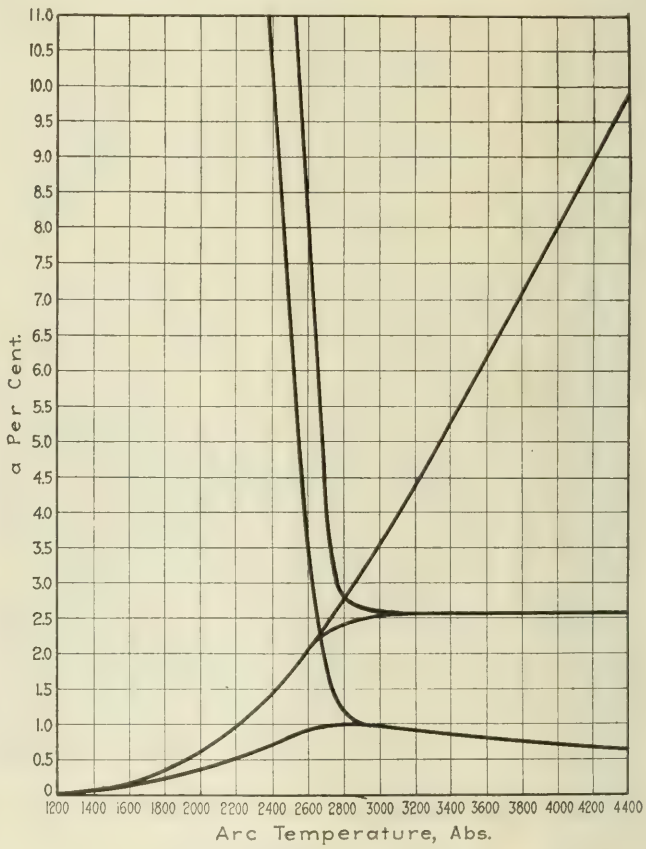


FIG. 12. ELECTRO-THERMAL AND THERMAL EQUILIBRIUM *NO* CONCENTRATION

melting point is below the boiling point. Also, at the temperature of the boiling point of carbon, the dielectric strength of gases and vapors has decreased so much that they are practically conductors. Therefore, the unidirectional character of arc condition is little pronounced in the carbon arc, and with alternating current supply the momentary interruption of the current at its reversal does not interfere with the arc. In these two characteristics, and the features depending upon them, the carbon arc differs from other typical arcs, so that the carbon arc is not well suited for the study of the characteristics of the typical arc. Well suited for this purpose are the mercury arc and the iron or magnetic arc, as the spectra of these two metals are very

sensitive to the temperature, the relative intensity of their lines greatly changing with the temperature and thereby affording a means of judging of the temperature.

Arc Spectrum

The light of the normal arc always shows the spectrum of the cathode material throughout the entire arc length, even if the cathode is strongly cooled. It seems herefrom that the presence of cathode material in the arc stream is necessary for the arc conduction.[1]

The spectrum of the anode material generally does not appear in the arc stream. Only if the anode contains material which is much more volatile than the cathode material, and the anode is allowed to become hot, the spectrum of such material appears in the arc stream. But even then it often appears only in that part of the arc stream next to the anode, and does not extend to the cathode, or at least occasionally fades out from the part of the arc stream near the cathode, sometimes with a sharp boundary line where the anode spectrum ends.

The intensity of the spectrum of the anode material in the arc stream is reduced by cooling the anode, or making it so large as not to get very hot, and the anodic spectrum may entirely disappear by cooling, at least from the part of the arc stream nearer the cathode.

It seems herefrom that the presence of anode material in the arc stream is not essential for the arc conduction, but that such material enters the arc stream rather by heat evaporation.

The cathode is gradually consumed by feeding material into the arc stream, and though this consumption of cathode material can be greatly reduced by cooling the cathode (relatively), it can apparently never entirely be eliminated. The consumption of the anode, however, greatly varies with its temperature, and by keeping the anode cool, as by making it larger, the consumption of the anode can not only be entirely suppressed, but the anode made to increase in weight, by the deposition of cathode material on it.

Continuity of Arc

The arc conduction is continuous, that is, the current must flow continuously, and when once interrupted for even a very short time, the arc ceases and does not start again when the voltage is reapplied, but to restart it by reapplying voltage such voltage must be so high as to jump a static spark across the arc terminals through the gas or vapor existing between them. Thus in general, alternating current arcs cannot be operated at the voltage sufficient to maintain a direct current arc between the same terminals, but go out at the end of the half wave of current. Only when the temperature of the arc stream is so high—as in the carbon arc—that the voltage required to jump the spark across the residual vapor between the electrodes is of the same low magnitude as the voltage required to maintain the arc, alternating arcs can be operated without materially higher voltage than direct current arcs.

The arc can be shifted from one anode to another one, not in contact with the former, by bringing the second anode into the arc stream. If then the second anode is nearer to the cathode than the former, or is given a higher potential difference against the cathode, the arc leaves the former anode and goes to the latter, either gradually or suddenly, or it may even be made to divide between the two anodes. The arc, therefore, does not need to be continuous at the anode.

A rod of insulating material or even a rod of metal may be passed through the arc stream without disturbing it. Thus the arc does not need to be continuous in the stream.

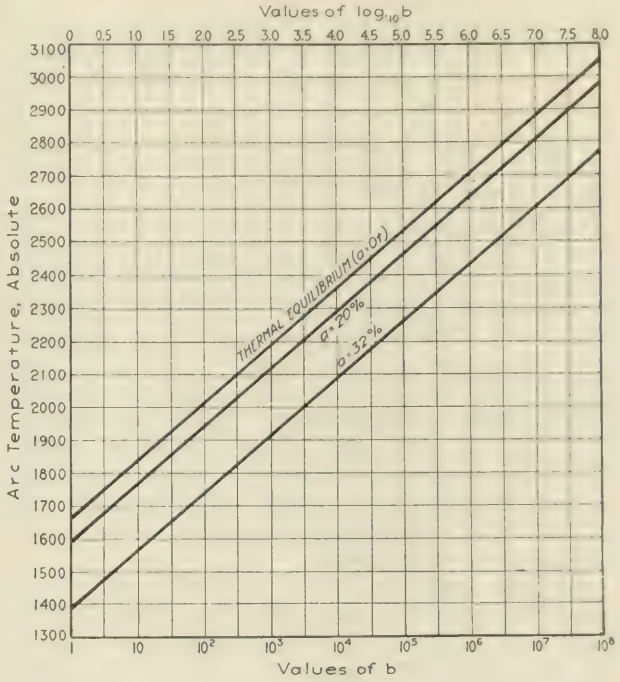


FIG. 13. ELECTRO-THERMAL EQUILIBRIUM

The arc cannot be shifted from one cathode to another one not in contact with the former, by immersing the latter into the arc stream, even if the second cathode is materially nearer to the anode, or of materially higher negative potential difference against the anode, unless the voltage between the second cathode and the anode is so high as to jump a spark and thereby start a new arc; as the spark voltage greatly decreases with the temperature, by immersing a second small cathode into the arc stream, after some time, the arc may jump to it, when the jump spark voltage has decreased by the second cathode becoming sufficiently hot. The arc can shift from one cathode to another one only when the second cathode is in direct contact with the first, and the negative terminal of the arc stream, or the "negative spot," moves continuously from one to the other cathode.

Cathode Stream

All these phenomena combined afford a strong evidence that the vapor of the negative terminal is an essential factor in the conduction of the current by the arc between the terminals, or, as it may be expressed, that the "cathode vapor stream," or "negative vapor stream," is the arc conductor which carries the current across the gap between the terminals. This statement, however, involves no assumption on the way the current is conducted, or on the nature of the conduction. The conduction might, for instance, be explained as ionic conduction in which the cathode vapor stream

[1] An apparent exception herefrom may occur when the cathode consists of a very refractory material, such as carbon, and the surrounding atmosphere consists of a gas or vapor which is a good arc conductor. Thus a typical mercury arc may be operated between two carbon electrodes in an evacuated space filled with mercury vapor. But even then the cathode disintegrates, and it is rather probable that the arc starts as carbon arcs, but transfers to the mercury vapor. The cathode in this case has the characteristics of the cathode of a carbon arc, and not that of a mercury arc.

plays a similar part as the metal conductor in the passage of the current through a copper wire, except that in the arc conductor, the cathode vapor stream is produced by the current, varies with it, and depends on it, and thus ceases with an interruption of the current.

Arc Temperature

Usually in the normal arc, by cooling the arc stream near the cathode, the major part of the cathode vapor can be condensed, or by cooling the cathode, the amount of cathode vapor which is produced can be greatly reduced, without appreciably affecting the electrical characteristics of the arc and the nature of its spectrum. Herefrom seems to follow that the amount of vapor produced at the cathode and existing in the arc stream is in the normal arc usually very much greater than the amount required to carry the current.

At constant pressure of the atmosphere surrounding the arc, the spectrum of the cathode vapor stream does not change with the change of current or voltage of the arc, but is the same with long arcs or short arcs, with arcs of small current or large current, though the amount of cathode vapor in the latter is much larger. The spectrum does not change either, if much of the cathode vapor is condensed out of the arc stream by cooling it near the cathode, or cooling the cathode. This is the case even with such arc conductors as mercury or iron vapor, in which the spectrum greatly changes with the temperature; and the spectrum is the low temperature spectrum.

Herefrom seems to follow that the temperature of the arc stream in the normal arc is constant and that at constant pressure of the surrounding atmosphere it depends only on the material of the cathode, and that it is the temperature of the boiling point of the cathode material. With an increase of the gas pressure of the surrounding atmosphere, the spectrum of the cathode stream of the normal arc changes in such manner as it would be changed by an increase of temperature. Thus with the mercury arc, the red lines, which are extremely faint in the mercury arc spectrum at high vacuum, become more prominent.

Mercury and Iron Arc

The mercury arc offers the most convenient way of studying these relations, as its temperature is relatively low, and in its commercial forms it is operated over a wide range of pressure, from high vacuum to more than atmospheric pressure. In the vacuum mercury arc in a glass tube, with sufficiently large condensing chamber beyond the anode, the current can be varied over a considerable range, and the outside temperature may vary between high summer and low winter temperature, but the spectrum remains the same, showing the red lines very faintly, while a carbon filament, inserted longitudinally into the arc stream, remains entirely dark (when seen through a red glass to cut off the mercury light), though entirely immersed into the arc stream, thus showing that the temperature of the arc stream is below incandescence. If, however, the condensing chamber is covered by a heat insulator, obstructing the escape of heat, and thus the condensation, the vapor pressure rises, and the red lines of the mercury spectrum become noticeable and even quite prominent, while a carbon filament immersed in the arc stream becomes incandescent,[2] both showing an increase of temperature of the arc stream. At the same time, the voltage consumed by the arc stream increases. With a mercury arc in a quartz tube, at atmospheric pressure, the red lines of the spectrum are still more prominent, showing still higher temperature, and the voltage per unit length of the arc stream is higher.

If in a vacuum mercury arc in a glass tube the condensing chamber is placed beyond the anode, so that all the mercury vapor must pass through the arc stream, exposure to low winter temperature does not affect the spectrum, though much of the vapor is condensed out of the stream, showing that a small part of the vapor is sufficient for conduction. So, also, an air blast, unless very powerful, has no effect. If, however, the condensing chamber is located near the cathode, so that the surplus mercury vapor produced at the cathode does not pass through the arc stream, but is condensed before reaching the stream, then exposure to winter temperature, or even a moderate cooling blast against the arc tube, changes the spectrum. The red spectrum lines become more prominent, and the exploring carbon filament in the center of the arc stream becomes incandescent, thus showing an increase of temperature of the arc stream, though the vapor pressure has decreased. In this case, it seems, the condensation has gone so far that not sufficient mercury vapor is left in the arc stream to carry the current, and the mercury vapor apparently becomes superheated. This would then not be a normal arc any more, but an arc in superheated vapor, or a "gas arc."

By passing a high-frequency condenser discharge through a mercury vapor tube, we get an arc in which the red mercury lines are much more prominent than the green lines, and the color of the light is pinkish red. In this case, the currents are very high, but of so short duration that they cannot produce much mercury vapor, and the residual mercury vapor in the tube, in carrying the large momentary currents, is very highly superheated.

The iron arc also can be used to study these relations, though not so conveniently, due to its higher temperature. In the iron spectrum, the change with the temperature is the reverse from that of the mercury spectrum. In the iron spectrum, the intensity maximum shifts toward shorter wave lengths, with increasing temperature. Thus, while the radiation of the direct current iron arc at atmospheric pressure, with a temperature probably the boiling point of iron, gives essentially white light, a condenser discharge between cold iron terminals gives very little visible light, but a large amount of ultra-violet radiation, and is indeed the most convenient source of ultra-violet light.

Transient or Gas Arc

Herefrom the conclusion seems to be justified that the temperature of the arc stream in the normal arc is the temperature of the boiling point of the material in the arc stream, that is, is the boiling point of the cathode material and therefore constant for all normal arcs of the same cathode material, at constant pressure of the surrounding atmosphere, but increases with increasing, and decreases with decreasing pressure of the atmosphere surrounding the arc. A rise of temperature of the arc stream above the boiling point of the cathode material would occur only by the sudden application of large current of such short duration that there is no time to form a sufficiently large saturated

[2]This does not mean that the arc stream is above incandescence, as the filament, longitudinal to the arc, shunts some current from the arc in this case, and thereby becomes heated.

vapor stream, or by such intense cooling of the arc stream that by condensation the amount of material in the cathode stream is reduced below the amount of saturated vapor required to carry the current.

In very long (relatively) arcs of short duration the former may be the case, especially if the arc terminals are cooled and thereby the amount of vapor reduced, and if the arcs are rapidly moved by air currents, magnetic fields, etc. In such arcs the voltage is increased beyond that required to carry the current across the gap between the electrodes in a normal arc through a bridge of saturated cathode vapor. Such arcs may in the middle of the arc stream show hardly a trace of the spectrum of the cathode material, but give essentially the spectrum of the surrounding atmosphere.

Such arcs may be called "gas arcs," as the conduction is by the gas existing in the space surrounding the arc, or "air arcs." They are not normal arcs, cannot persist for any length of time in stationary condition, but then would change to normal arcs by a cathode vapor bridge forming. Thus they must either be continuously moved through the air, by air currents, magnetic or electrostatic fields, mechanical motion of their terminals, etc., or must be of short duration, started and again interrupted.

Such gas arcs give the spectrum of the surrounding atmosphere, but show little, if any, of the spectrum of the electrode material, and that only near the electrodes. Their temperature probably depends very little on the electrode material, but very largely on the gas pressure of the surrounding atmosphere, and probably also on the nature of this atmosphere. It is doubtful whether a well defined arc stream ever forms, due to the transient nature of such arcs.

Very little is known of the electrical and other characteristics of such arcs, and experimental investigation is greatly needed, as it is these gas arcs or "transient arcs" which are the means of nitrogen fixation in the arc process.

Equations of the Arc

No entirely satisfactory equation has yet been derived expressing the relations between the constants of the arc, such as voltage, current, arc length, gas pressure in space surrounding the arc, etc. For the normal or stationary arc at constant gas pressure, several more or less approximate forms of equation have been proposed, but for the transient or gas arcs, which are the ones of importance in nitrification, practically no data are available, as far as I know.

The voltage consumed by a stationary or normal arc consists of two parts: a voltage consumed at the arc terminal, the terminal drop, and a voltage consumed along the arc stream, the stream voltage.

The terminal drop is independent of the current in the arc, and apparently also of the gas pressure in the space surrounding the arc, but is a function of the material of the arc terminal, and in general the lower the more volatile the material of the arc terminal. It varies from 13 volts with mercury to about 16 volts with cadmium and zinc, to 30 volts with iron and its conducting compounds, to about 36 volts with carbon. Apparently, at least with some materials such as carbon, not all the terminal drop is at the terminal surface itself, but a part of it in the vapor space immediately surrounding the terminal.

The stream voltage is approximately proportional to the arc length, it depends on the material of the arc stream, and is in general the lower the more volatile the material of the terminal and thus of the arc stream. It increases with increasing, and decreases with decreasing gas pressure in the space surrounding the arc. It increases with decrease of current, and decreases with increase of current and as first approximation frequently has been assumed as inversely proportional to the current, and the stream voltage e_1 expressed by the equation:

$$e_1 = \frac{cl}{i} \qquad (1)$$

where l is the arc length, and c a constant.

The total arc voltage then would be:

$$e = e_0 + \frac{cl}{i} \qquad (2)$$

where e_0 is the terminal drop.

This equation (2) is not infrequently found in theoretical discussions of arcs. It is, however, not even approximately correct, and while the stream voltage varies with the current, and in opposite direction to it, its variation is much less than inverse proportional to the current.

From a large amount of experimental data with arcs of various lengths and currents, with various different electrode materials, I once derived the empirical equation giving the arc stream voltage as inverse proportional to the square root of the current, that is,[3]

$$e_1 = \frac{cl}{\sqrt{i}} \qquad (3)$$

and:

$$e = e_0 + \frac{cl}{\sqrt{i}} \qquad (4)$$

or rather:

$$e = e_0 + \frac{c(l + \delta)}{\sqrt{i}} \qquad (5)$$

where δ is a small correction term in the arc length l, which apparently corrects for the heat and other energy losses from the end of the arc toward the electrode.

Still more extended investigations on arcs, recently undertaken, and covering a much wider range of arc length, current, etc., seem to show that equation (5) is not rigidly correct. It is, however, a far closer approximation than any other proposed arc equation in my knowledge, so that, pending further investigation, equation (5) may be considered as representative of the normal or stationary arc.

This equation (5) has the further advantage that it is not merely empirical—though derived empirically—but appears rational.

Assuming the amount of electrode vapor carried into and through the arc stream as proportional to the current, which appears reasonable, at constant gas pressure in the space surrounding the arc, the arc section then is proportional to the current. This seems to agree with experimental evidence. Consider now that the electric power consumed in the arc stream, $e_1\ i$, must be dissipated from its surface, by conduction, convection and radiation. If then, as seems probable from the previous consideration, the arc temperature —with given electrode material and constant gas pressure in the surrounding space—is constant, then the energy dissipation per unit surface of arc stream is constant, that is, $e_1\ i$ is proportional to the arc length l and proportional to its circumference, that is, the

[3] *American Institute of Electrical Engineers, Transactions*, 1906, p. 789; "Transformation of Electric Power Into Light."

square root of its section and thus of the current, that is:

$$e_1 \, i = c \, l \, \sqrt{i}$$

and herefrom immediately follows equation (3):

$$e_1 = \frac{cl}{\sqrt{i}}$$

Also, if the mass of arc vapor is proportional to the current, at constant temperature, the power required to produce the arc stream vapor is proportional to the current, $= c' \, i$.

Considering, as reasonable, the terminal drop e_o of the arc as the electrical equivalent of the power required to produce the arc vapor, it is:

$$e_o i = c' \, i$$

This gives:

$e_o =$ const., that is, the terminal drop is constant, independent of current and arc length, but dependent upon the arc temperature and thus the electrode material.

The following are approximate values, for a few materials, of the constants e_o, c, δ in the arc equation (5) for a normal arc at atmospheric pressure with the arc length l given in cm.:

	e_o Volts	c	δ cm.
Mercury	13	..	....
Zinc and cadmium	16	..	....
Iron and magnetite	30	50	0.12
Titanium and its carbide	31	..	....
Carbon	36	52	0.8

Determining the Active Strength of Sulphate Cooking Liquor

Recent experiments have determined that the action of NaOH is substantially twice as drastic as that of Na_2S between the ratios of one part NaOH to one part of Na_2S and four parts NaOH to one part Na_2S when applied to sulphate cooking liquor.

The active strength of the cooking solution in terms of NaOH is expressed by the equation $S = M + (N \div 2)$, where S is the active strength of the solution, M the concentration of NaOH, and N the concentration of Na_2S.

A rapid method of determining the strength of a cooking solution is as follows: Add 10 c.c. of cooking liquor to about 50 c.c. of water in a porcelain dish. Add 10 c.c. of a saturated solution of $BaCl_2$. Stir vigorously, and titrate with normal hydrochloric acid to phenolphthalein end point. The number of c.c. required is directly proportional to the strength. This method is the most convenient for use in the digester house, because of its simplicity and the fact that it does not involve a consideration of the ratio of NaOH to Na_2S.—*Abstract from Forest Products Laboratory "Technical Notes."*

British Research Associations

Under the provisions laid down by the British Government for the organization of research associations in different industries and trades, thirteen associations have been formed, four are in an advanced state of development, three are under consideration and three more are proposed. Among the industries which have taken advantage of the government's co-operation in scientific and industrial research are sugar, iron, photography, portland cement, scientific instruments, rubber, glass, refractory materials, non-ferrous metals and shale oil.

Investigation of Fatigue of Metals

An investigation of fatigue phenomena in metals under repeated stress has just been started under the joint auspices of the National Research Council, Engineering Foundation, and the Engineering Experiment Station of the University of Illinois. The Engineering Foundation is providing $15,000 a year for two years for this investigation and the Engineering Division of the National Research Council is acting in an advisory capacity, largely through its Committee on Fatigue Phenomena in Metals. The experimental work is being done in the laboratories of the Engineering Experiment Station of the University of Illinois, under the immediate direction of Prof. H. F. Moore, research professor of engineering materials and chairman of the committee above mentioned.

Plans are laid for a two years' program of tests, and apparatus and material are already arriving for the tests. It is hoped to secure a considerable amount of data on tests of various metals, including a number of tests of each metal to 100,000,000 reversals of stress. It is hoped to study the various short-time physical tests which are used for metals—such as the impact test, magnetic analysis, and short-time bending tests—to see whether any of these tests give reliable indices of the ability of the metal to resist fatigue under millions of repetitions of low stress. It is hoped that some reliable commercial test for this important property may be developed by this investigation.

A test party of four or five persons is being organized and the University of Illinois is fitting up a special laboratory with about 2500 sq.ft. of floor space for the use of this investigation.

Borax in Fertilizers

Two pounds per acre of anhydrous borax marks the limit of safety with which it may be used in fertilizer when the fertilizer is put in the row so that seeds or plants are brought into virtual contact with it. This is the opinion of the specialists of the Department of Agriculture who have been studying the matter of borax in fertilizer. As a result the Department has advised all fertilizer manufacturers and dealers in fertilizer that more than 2 lb. of borax per ton of mixed fertilizers will not be allowed unless the presence of an excess of that amount is indicated plainly on the container.

When fertilizer is broadcasted and thoroughly mixed with the soil, the Department's specialists agree, 10 lb. of borax may be contained in the fertilizer used on an acre of ground without danger to the crops. The Department describes the experience of farmers in some sections of the country as disastrous as a result of using fertilizers containing borax. It is to guard against a similar experience that the Department on Dec. 9 put into effect its drastic regulations regarding the borax content of fertilizer.

Borax is described as being "highly toxic to crop plants," and was contained in the potash derived from at least one of the new sources which were resorted to after the war had cut off foreign supplies of potash. The Department also has ascertained that nitrate of soda as imported also contained some borax. The Department is also authority for the statement that borax was "not known to have been present in appreciable quantities in the materials commercially available for fertilizer uses prior to the war."

The Technology Plan

By William H. Walker
Director of the Division of Industrial Co-operation and Research, Mass. Inst. of Technology

THE Technology Plan is an organized attempt to effect a closer co-operation between scientific and industrial effort; between the technical school and the individual industry throughout the country. Although a working relationship between educational institutions and industrial organizations has been discussed at great length, and on many occasions, little real practical progress has as yet been made.

The Technology Plan recognizes that for the present, at least, there must exist somewhere in this scheme of co-operation an element of individual and mutual responsibility on the part of those engaged in it. It recognizes that a purely philanthropic enterprise does not engender in the managers of industry that confidence which is an essential element in its success. Such men are not yet deeply interested in a strictly *pro bono publico* method of co-operative work. Hence the Technology Plan is neither eleemosynary in organization nor philanthropic in its aims and methods.

Essential Feature of the Plan

The essential feature of the plan is an agreement, expressed as a contract, between individual industrial organizations and the Massachusetts Institute of Technology, under which the industry pays an annual retaining fee to the Institute, in return for which the Institute assumes certain definite obligations of such a character as it is in position to meet. These obligations are in very general terms as follows:

The great demand of the industries today is for men trained to solve the many problems with which these industries are confronted. This requires, first, a knowledge of the principles of science, and second, a training in the application of this knowledge to the solution of the ever-recurring difficulties. While the first requirement is reasonably well met by the undergraduate courses of instruction at the Institute, only to a limited extent can the second be obtained in the four years allotted to undergraduate work. The student must be encouraged to spend an additional year or more in a research laboratory or advanced study.

Students Taught to Solve Industrial Problems

Since the best way to learn an art is to practice it, the student is best taught to solve industrial problems by having him attempt the solution of such problems under able and experienced guidance. These problems, however, have their origin in, and owe their existence to, the industries themselves. The first point of co-operative contact, therefore, in this arrangement between industry and the Institute of Technology is that the Institute agrees to use, so far as it can, such problems as the industry will submit to it as basic material for its research work for those graduate students interested in industrial development; to give men already well grounded in science the benefit of the opportunity of working under experienced instructors upon the type of work for which they are urgently required.

Steady Stream of Trained Men for Industry

It is true also that much investigation in "pure science" can be conducted as profitably in fields of research which are closely akin to industry as in those realms of science far remote from general interest. This does not mean that the search for knowledge for its own sake will not continue to subtend a large arc of the activities of the Institute of Technology; but rather that such search will be activated and inspired by the realization that the hard work involved and the results obtained are recognized as an essential part of a comprehensive whole. Hence the Institute agrees in its contract to maintain a steady stream of trained men constantly flowing into industry with the best preparation for scientific work which it is possible for it to give. Also, the results of research work thus obtained will swell the store of knowledge on which the scientific progress of the community as a whole depends.

To Seek Appropriate Positions for the Graduates

But a corollary of this duty of preparing educated men is the duty to see that, as far as possible, these men take positions for which their natural ability and aptitude most nearly fit them. Further, it is desirable that, as these men develop into specialists in any particular field, their sphere of usefulness be made as wide as is practicable. Hence the Institute undertakes to maintain a record of the qualifications, experience and special knowledge of its alumni; to advise the contractor where such knowledge and experience as it seeks is available; to assist the contractor to obtain the technical help he requires, whether from its own alumni or from available engineers elsewhere. While this service has been rendered to some degree in the past, it has been a minor part of, and incidental to, other activities. It will now become a contractual obligation.

Executives Also to Be Educated

Coincident with the education of scientific men, there exists the necessity of educating the executives of the industries in the great economic value of science when applied to the business of their organizations. The sporadic "Yankee genius" of the past, productive though it was, must be replaced by the method of scientific research. Genius must be provided with that most efficient tool yet produced—scientific method. While it is true that the world will ever need more knowledge, the pressing duty of industry for the present is to apply the knowledge now available. To meet this situation, the Institute provides for conferences with members of its staff, not only in its own building but also at the factories of the contractor. It is hoped that the contractor will be so imbued with the possible benefits to be derived by the application of science that he will avail himself of one of the sources of technical aid readily accessible, not only at the Institute, but among consulting engineers and industrial scientists throughout the country.

Close Co-operation Sought

A realization of that close co-operation between the industrial interests and the educational institutions of the country which in Germany was made so effective by the domination of both by the state can, in America, be brought about only by a voluntary personal relationship between the executives of the companies and the instructing staffs of the institutions. The Technology Plan aims to make this relationship more easily possible; to provide a point of contact between the two interests; to open a channel of communication through which the manufacturer and the technical consultant can more easily meet. The contractor can obtain the value of his retainer only by utilizing the facilities thus made

available. There will therefore be present in the Technology Plan this incentive, at least to try.

The instructing staff of an educational institution is made up, at least theoretically, of men peculiarly adapted to render great public service by conducting research of a fundamental character, i.e., they are seekers after new knowledge, and yet, at the same time, are teachers and trainers of young men. It is important that these men be not withdrawn into purely industrial work by reason of the greater financial return offered by great corporations, or the acute pleasure which many red-blooded men feel in being professionally connected with great technical developments. Hence the Technology Plan provides a method by which the staff is enabled to profit by contact with men of affairs and receive the inspiration which comes from the capitalization of effort, and, at the same time, fertilize and catalyze the instructional work of the teaching staff.

Hope Is to Interest Consulting Engineers Throughout the Country

The Institute, therefore, agrees that if the contractor has special technical problems requiring extended consultations, investigations, tests or research work it will advise the contractor where and by whom such service can best be rendered. When one considers the splendid laboratories with which the Institute of Technology is equipped, covering as they do almost every department of applied science, and its staff, trained in the use of such laboratories, it is obvious that much of the work will be done within its own organization. But it is neither the desire nor the intention of the Technology Plan to limit the contractor to the facilities of the Institute. It is the hope of the Division of Industrial Co-operation and Research, the organization set up to handle the 190 contracts already made, that it can enlist the interest of the great body of able consulting engineers throughout the country. When, therefore, consultation, test, investigations or research work are of such nature as can be best furnished by established commercial organizations, the Institute will advise the contractor where, in its judgment, the work can best be cared for.

The Technology Plan is, therefore, a more effective means of introducing technical research to the manufacturer; of making the application of science to industrial problems popular; of creating an appreciation on the part of the leaders of industry of the value of science and the necessity of providing, not alone for its application, but for its continued growth and development.

Copy of the Contract

Following is a copy of the contract between companies and Massachusetts Institute of Technology:

Agreement made this (blank) day of (blank) 19.... between (blank), hereinafter referred to as the Company, and the Massachusetts Institute of Technology.

The Company agrees to pay to the Massachusetts Institute of Technology a retainer of (blank) dollars, in five annual installments of (blank), payable on the second day of January of each year from 1920 to 1924 inclusive.

The Massachusetts Institute of Technology agrees to make available to the Company, during the five years 1920 to 1924 inclusive, its library and files, and to arrange for conferences with its technical staff on problems pertaining to the business of the Company.

The Massachusetts Institute of Technology further agrees to maintain a record of the qualifications, experience and special knowledge of its alumni that shall be as complete as practicable, and upon request to advise and assist the Company to obtain:

Information as to where such knowledge and experience are available.

Information regarding men for special problems.

Information regarding men for permanent employment.

The Massachusetts Institute of Technology further agrees to maintain a list of undergraduates who may wish positions upon graduation: to advise the Company upon request as to the records and qualifications of these men, and to arrange for interviews with them.

The Massachusetts Institute of Technology further agrees that in case the Company at any time during the period covered by this contract should have special technical problems requiring extended consultations, investigations, tests, or research work, it will advise the Company where this service can be best obtained. If, in the judgment of the Massachusetts Institute of Technology, this service can best be rendered by its staff or in its laboratories, a member of its staff shall undertake such service for a fee to be mutually agreed upon by the parties hereto.

It is earnestly hoped that the plan here outlined will be adopted with improvements by other educational institutions for the benefit of both education and industry.

Cambridge, Mass.

Chemical Industry in Sweden

The Roberts Co. is making essences in Oerebro. A match factory has two plants for the production of phosphorus by the electric smelting method, which will satisfy the Swedish match industry, according to the *Zeitschrift für Angewandte Chemie.* Potassium nitrate is made by the double decomposition method. A government commission is looking into the manufacture of common salt from sea water. A soda works, making sodium carbonate by the Leblanc method, was undertaken during the war, and it was still uncertain in September last whether it would continue or not. There are a number of works established for the production of chromium salts, but only one of them remains and its future is dependent upon protection, according to the report published in the *Journal* of the Society of Chemical Industry. An aluminum works is under construction to reduce the metal from refractory loam by an unpublished process. Calcium carbide and calcium cyanamide are produced on a large scale, and ammonium sulphate has been made from the cyanamide in limited quantities. The country expects to be independent in future in regard to caustic soda, caustic potash and bleaching powder. Making sodium hypochlorite has been discontinued. The Birkeland-Eyde establishment at Ljunga has a small ammonia oxidation plant, and it is only here that atmospheric nitrates are made and sold. In the chlorate establishment at Trollhättan some other material than platinum is used for electrodes.

The Bohemian Glass Industry

The well-known glass-manufacturing district of Jablonec (Gablonz), in the Republic of Czechoslovakia, alone exported from Feb. 1 to Oct. 31, 1919, products valued at 17,000,000 Czechoslovak crowns, mostly to the United States, France and Italy. Previous to the war, of the 202 glass furnaces in the Austro-Hungarian empire, 162 were in the Czechoslovak domain. Of the total production for 1913, valued at 117,400,000 crowns (the normal value of the Austro-Hungarian crown was 20c. United States currency), 105,500,000 crowns represented the Czech and Slovak products.

SOUTHERN COTTON OIL CO.'S SAVANNAH WORKS

Pictorial Description of the Cotton Oil Industry

Comparative Statistics of Food Values and Efficiency of Refining Practice of Cottonseed Oil — Photographs in Sequence Illustrating the Industry From the Boll on Through the Gin, Oil Press, Refinery, Packaging and Shipping Departments

By DAVID WESSON

As a summary to the presidential address[1] before the American Institute of Chemical Engineers, the accompanying collection of photographs, charts and tables were projected on the screen, with the intention of giving the audience a better mental picture of the cotton oil industry than could be conveyed by means of words alone.

The relative value of different foods is indicated in Fig. 1. In the first column, the percentage of fat in different food materials is shown and in the last column, the number of calories per lb. It will be noticed that the vegetable oils show 4,080 calories and are the most concentrated foods on the list.

The relative digestibility of different fats is charted in Fig. 2. This has been worked up from data furnished by the Bureau of Home Economics, based on the careful experimental work of Dr. Holmes. The upper part of the list shows the principal animal fats, the lower part gives the various vegetable fats and oils. The coefficient of digestibility is shown in figures in the first column and graphically in the second. It will be noticed that, with one exception, all the fats shown have coefficients above 90, while the vegetable oils all run between 95 and 100. It is quite evident from this table that the claim frequently made that olive oil is more digestible than cottonseed oil is not substantiated. We must bear in mind, in looking at the next three figures, that we are dealing with statistics. You must remember that Mark Twain used to say, "There are three kinds of lies, namely, lies, damned lies, and statistics"; we can say, however, on governmental authority—and we all believe what our Government tells us—that the statistics I am showing herewith are at least 90 per cent correct.

Fig. 3 shows the relative production of vegetable oils in the United States as compared with the production of animal fats. Leading the list of the vegetable oils is cottonseed oil, while at the bottom of the list is olive oil, which is hardly visible in the chart. The dotted lines after linseed, cocoanut, peanut and soya bean oils indicate the additional amount of these oils which was imported into the country in 1918. Please pay particular attention to the difference in the production of lard compounds, or *vegetable shortenings*, as they should be called, and lard. It will be noticed that they amount to more than the hog product. Please notice also the great difference between the production of butter fat and oleomargarine. With the present high cost of living, there is no question that the latter should be produced in much greater quantities.

The growth of the cotton oil industry is shown in Fig. 4. It will be noted that in 1870 only about 4 per cent of the crop was crushed, while in 1917-18 about 90 per cent of the crop was crushed. The other curves show the millions of tons of seed and the millions of barrels of oil.

Table I shows the statistics for the cotton oil industry for the year ended July 31, 1919.

TABLE I. SEED AND PRODUCTS YEAR ENDED JULY 31, 1919

Seed crushed, 4,450,189 tons at $70.00	$311,513,230
Oil made, 1,319,926,000 lb. at $0.17½	230,900,000
Cake and meal, 2,158,787 tons at $50.00	107,939,350
Hulls, 1,124,118 tons at $15.00	16,861,770
Lint, 929,199 bales (500 lb.) at $0.04½	21,696,797
Total value mill products	$377,397,917

Plate 1 gives a good view of a cotton field during the picking season. This view was taken some years ago when labor was far more plentiful than at present.

Fig. 5 shows the relation between the market prices of seed and summer yellow oil during the war period.

Plate 2 is an enlarged illustration of a single cotton boll.

When the cotton is picked, it is hauled to the gin. Plate 3 gives a good idea of a gin during the picking season. Loads of seed cotton are lined up awaiting their turn. It looks like a rather uneconomical system to have a whole lot of teams and men standing idle losing a number of hours' good time waiting for the cotton to go through the gin. This picture, however, was

[1] History and Development of the Cottonseed Oil Industry. CHEM. & MET. ENG., vol. 21, No. 13, pp. 661-662.

taken some years ago, when labor was not so scarce as it is now.

A good idea of the interior of a gin house is given in Plate 4, showing the gins to the right and the baling press to the left. Ventilating pipes carry off the dust and dirt from the cotton as it is being ginned. The gins consist of a lot of rapidly revolving saws which tear off the fiber from the seed. The fiber and seed are delivered separately, the fiber going into the baling press, and the seed being delivered to the mills. Plate 5 shows how seed looks in a small pile. It represents about a handful of seed.

Fig. 6 shows two sections of the cottonseed. The little black dots seen throughout the seed contain a resinous coloring matter called "gossypol," which is responsible for the dark color in the crude oil. The seeds are really small nuts about $\frac{3}{8}$ in. long and about $\frac{3}{16}$ in. in diameter. They are surrounded by a leathery shell or hull, from which grow the cotton fibers. The gin

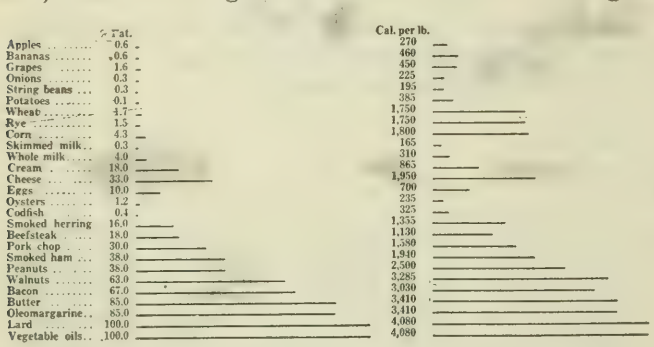


FIG. 1. RELATIVE VALUE OF DIFFERENT FOODS

always leaves a certain amount of fiber adhering to the hull. Fig. 7 shows an enlarged section of the cottonseed, portraying particularly the structure of the hull, as well as the kernel.

Table II shows analyses of cottonseed from Georgia and Texas. Please notice the big variation in the percentage of oil in the meats, that in Georgia being very much higher than that in the Texas seed, while the ammonia and protein are much higher in the Texas than in the Georgia seed.

When the seed reach the mill, they are first unloaded from the cars or wagons and delivered to the seed house. This seed house, Plate 6, is for a small mill. Ordinarily,

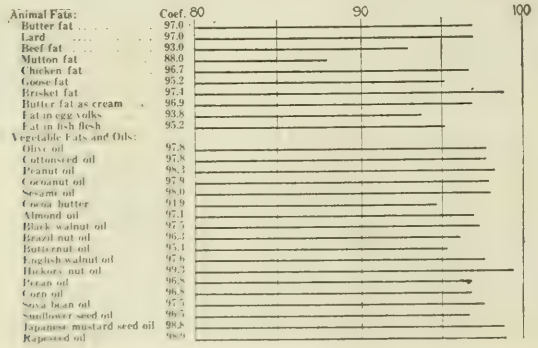


FIG. 2. RELATIVE DIGESTIBILITY OF FATS

at the bottom of the tunnel is a conveyor, into which the seed is shovelled. In a small mill, however, a conveyor is not necessary, as the seed can be put into carts and carried from the tunnel when the house is full. It is then emptied into the elevator boot at the end of the building, as shown in Plate 7.

A shaking screen which separates the seed from the bolls, stones, sticks, etc., is shown in Plate 8. The trash is collected in a bag at one end of the screen, while the clean seed is fed to a conveyor, which carries the seed to the linters, shown in the background of Plate 9. These linters are really gins which remove the lint re-

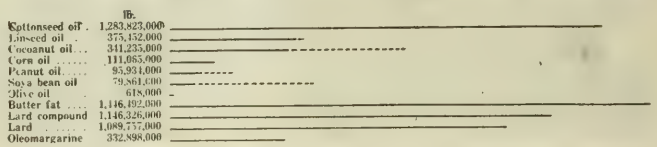


FIG. 3. PRODUCTION IN U. S. OF VEGETABLE OILS COMPARED WITH ANIMAL FATS

maining on the seed. The quality of the lint depends on the amount removed per ton of seed. During the war, the Government demanded the largest possible output, and it was the practice to remove 150 lb. of lint per ton of seed. This lint contained considerable cut hull and trash. Good practice at the present time removes 80 to 100 lb., while, if a superior quality is desired, two cuts are made: the first cut taking off 25 to 40 lb., while the second cut yields the inferior lint, as much being removed as may be desired. The linted seed next passes through the hullers, which chop the seed up fine. The mixture of hulls and meats is then passed through a series of screens and reels, which separate the hulls from the meats. Plate 10 gives a good idea of the appearance of the separating machinery in a modern mill.

Plate 11 shows a picture of a model press room, which looks as though it had been cleaned up for shutting down the mill for an indefinite period. It is altogether too clean for a mill in actual operation!

Plate 12 was taken while the mill was working. In the center is shown a French heater, where the meats are cooked, while, to the left of it, is shown the cake

TABLE II. COTTONSEED ANALYSES

	Georgia, Per Cent	Texas, Per Cent
Hulls	45.00	47.00
Meats	55.00	53.00
Oil in meats	37.00	31.20
NH_3 in meats	6.60	8.40
Protein in meats	36.99	43.50
Mill yields per ton of seed:	Pound	Pound
Cake	1,010.00*	1,056.00*
Oil	337.50	256.00
Linters	155.00	145.00
Hulls	375.00	515.00
Loss	123.00	100.00
* NH_3 in cake, per cent	7.16	8.00

former, where the cooked meats are formed up into cakes before going to the presses. The broom in the foreground is a guarantee that this picture was not fixed up for the photographer.

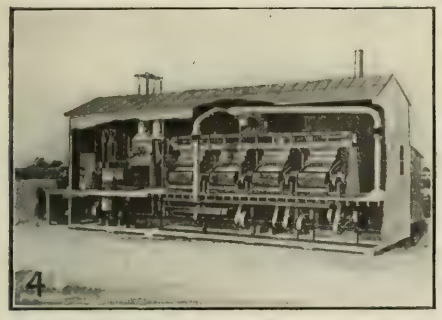
Another view in the same press room is given in Plate 13, showing the working of the presses. These presses make two or three turns an hour. In figuring the capacity of the mill, it is common practice to figure one ton of seed for each press plate for 24 hr.

Plate 14 shows the meal shed, where the cake, after being taken from the presses and ground, is piled up in bags ready for shipment. Plate 15 is a typical illustration of an old-time oil mill. At one end is the mill proper with the boiler and engine room, next to which is the press room, and, beyond the linters, a separating machine, while at the further end is shown the seed house, on one side, and the hull and meal houses on the other. Plate 16 is a modern mill. The large building to the right is the seed house, and the low building to

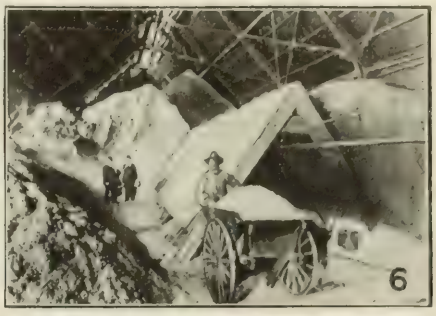
1

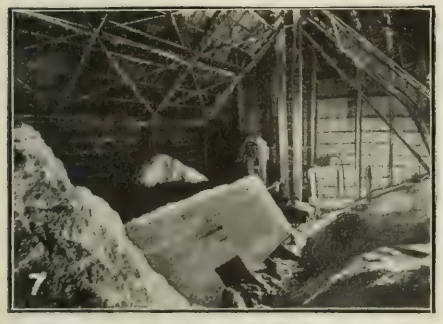
2

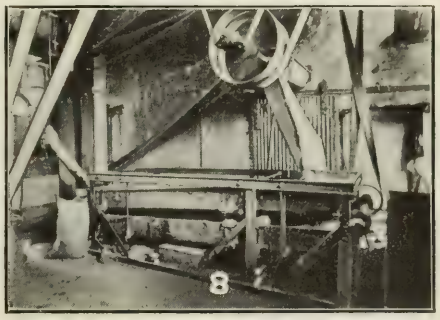
3


4

5

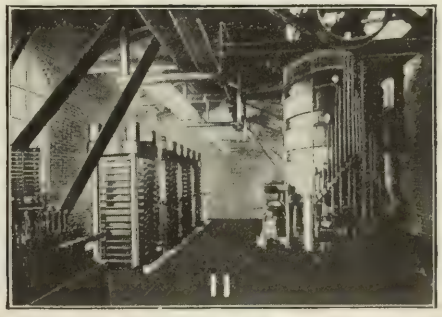

6


7

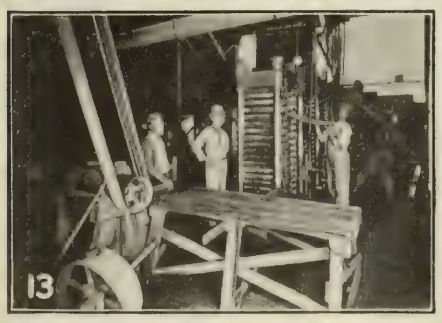

8

9

10


11

12

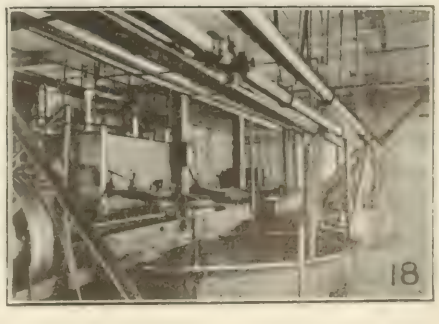

13

14

15

16

17


18

the left is the mill proper. This mill is operated mostly by electricity.

The latest thing in oil mill construction is illustrated in Plate 17. It is the New South Oil Mill at Helena, Ark. The concrete cylindrical tanks are used for storing the seed, and, according to reports, there has been no trouble so far this season from the seed heating or otherwise deteriorating.

With the reservations made regarding statistics, Fig. 8, compiled partly from the results given by D. A. Tompkins in his work on "Cotton and Cottonseed Oil," published about 1901, shows the improvement made in cottonseed milling from 1875 to 1920. In the early days of the industry, the seed was considered to be half hulls and half meats. Not much attention was paid to waste, and, besides, the gins left a great deal more fiber on the hulls than they do at present. In 1875, it will be noticed, the yield from a ton of seed was 225 lb. of oil and 675 lb. of meal. At that time, the hulls were

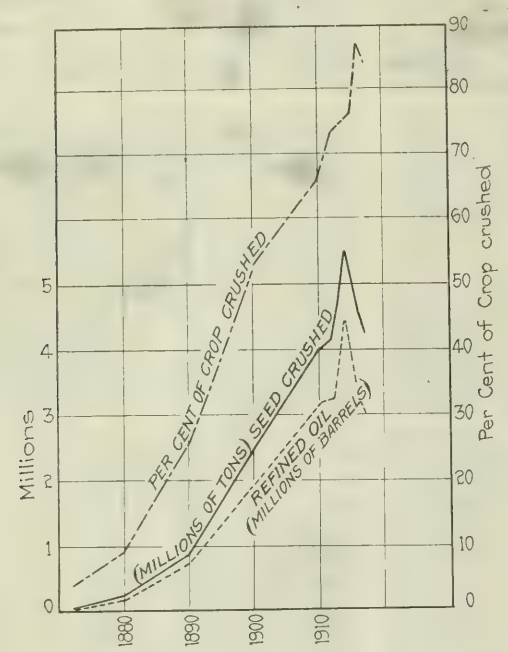


FIG. 4. GROWTH OF THE COTTON OIL INDUSTRY

burned under the boilers and not much attention paid to them. The large proportion of oil left in the meal will be noticed. In 1900 a much larger output of oil is shown, while account is made of the lint and loss, amount of hulls being the same. In 1920 we would have a quite different yield, only 60 lb. of oil being left behind in the meal, which, it will be noticed, amounts to 980 lb. altogether. It will also be noticed there is a large yield of lint, while the hulls are shrunk to 490 lb. The rest of them are something like the salesman's overcoat and the expense account; in this case, the missing hulls have disappeared in the meal.

Fig. 9 shows the results of milling a ton of seed for the year ended July 31, 1919. The crude oil, as it comes from the mill, is very dark in color, averaging about that of claret, but with a somewhat brownish cast. When it reaches the refinery, it is pumped into refining tanks shown in Plate 18, holding from 60,000 to 120,000 lb. These are provided with agitating machinery, and also large steam coils for heating the oil rapidly. Above the tanks are smaller ones for weighing or measuring in the caustic soda required for the refining. The proper amount of caustic is run into the oil, while it is being agitated, and, after the agitation has continued for some little time, small flakes begin to form. The machinery is then slowed down and heat applied. The flakes grow larger and larger, and owing to the decreased density of the oil, on account of the heating, the flakes soon begin to flow, and when in the right condition for settling rapidly, the steam and agitation are shut off, and the tanks are allowed to settle, preferably for 24 hr. Plate 19 represents the bottom of the refining kettle, provided with a cone and heating

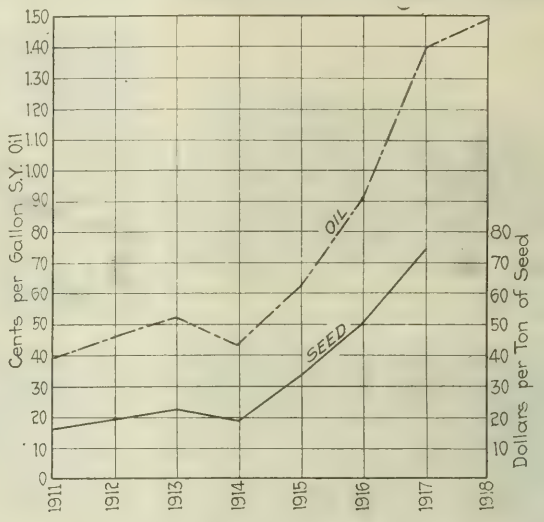


FIG. 5. MARKET VALUES OF SEED AND OIL DURING THE WAR PERIOD

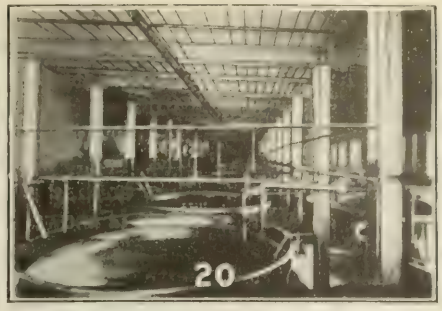
jacket for melting out the soap stock after the oil has been pumped off. The light yellow oil is pumped off into large tanks, such as are shown in Plate 20, where it is allowed to settle and drop out the fine soap, which is still suspended therein.

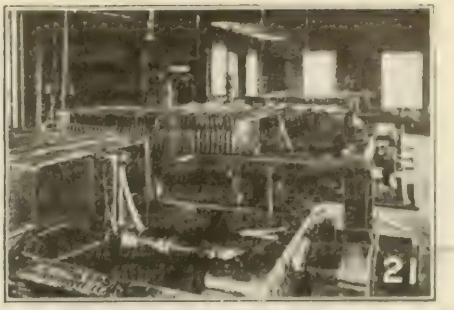
Fig. 10 shows the relation between free fatty acids in the crude oil and refining losses. These curves were plotted from refinings made all through the season and can be considered as typical. The settled oil is transferred to kettles with heating coils and agitating machinery where a small percentage of fullers earth

FIG. 6. TWO SECTIONS OF THE COTTONSEED

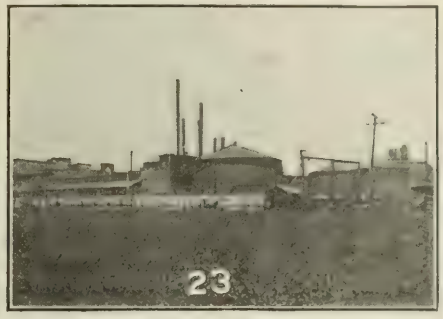
is added and well mixed with the hot oil, which is next pumped through filter presses, as shown in Plate 21. This removes the fullers earth and delivers the clear white oil, which next goes to the deodorizing kettles, after which it comes out almost water white.

19


20

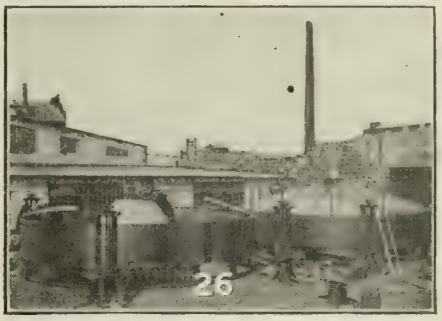

21

22


23

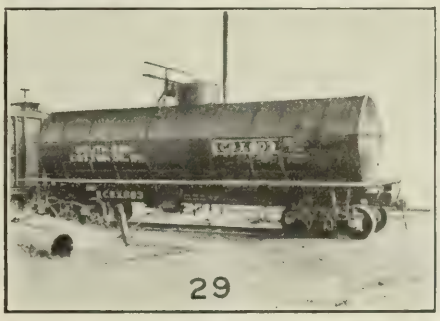
24

25


26

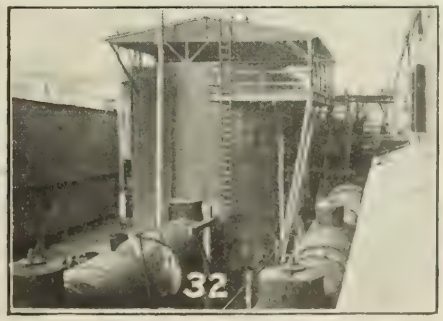
27

28

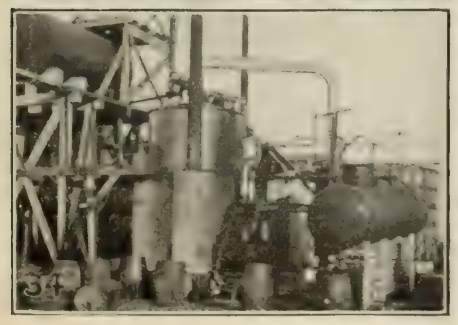

29

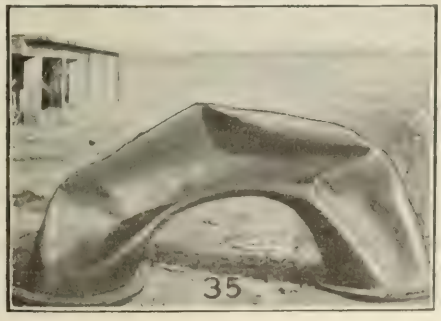
30

31


32

33


34


35

36

The first refineries constructed in this country were mostly frame buildings, which were sufficient to protect the tanks and machinery from the weather. Plate 22 shows one of the oldest plants of the Southern Cotton Oil Co., located at Gretna, La.

Plate 23 shows the refinery of the Southern Cotton Oil Co. at Savannah, taken about 12 yr. ago. The plant has greatly expanded since that time, as shown in the large picture at the head of this article.

Another old plant, built about 1887 by the Olivers at Charlotte, is shown in Plate 24.

With such a demand for the fine quality of oil produced in America, it was necessary to put up plants in Europe. A plant which was in successful operation up to 1916 in Germany is shown on Plate 25. This plant

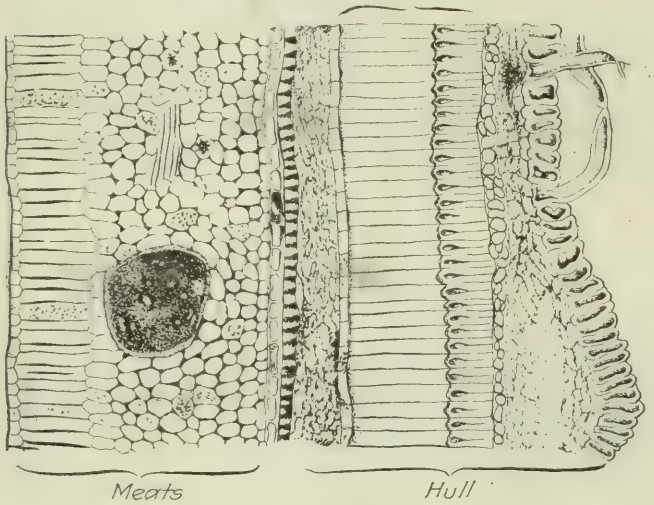


FIG. 7. ENLARGED SECTION OF THE COTTONSEED

rejoices in the euphonious name of the Wesson Gesellschaft für Deutschland mit Beschrenkene Helftung. At the present time, it has somewhat beschrenked. It is of interest in this connection to show how storage tanks are constructed in Germany. The practice prior to the war was to first lay down the bottom of the tank, then set up the top ring on jacks and build the roof, as shown in Plate 26. The tank was gradually raised and new rings put on from the bottom until the bottom ring was finally put on and closed up, as shown in Plate 27. This saved the expense of scaffolding, and, at the same time, kept the men on the ground.

Transportation is an important feature in all industries. It is quite common around oil mills, even today, to see ox teams, as shown in Plate 28. On the face of it, these teams appear rather slow and possibly expensive transportation, but when it is considered that old scrawny steers can be bought very cheap and fattened on meal and hulls at the same time they are making themselves useful as beasts of burden, it is not such a bad proposition as appears on its face. In the early days of the industry, the crude oil was shipped from the mills to refineries in the North in all kinds of cooperage. The speaker has frequently seen lighter loads playing around New York harbor which looked like a package of firecrackers. The barrels, on examination, are found to have been used for kerosene, naphtha, lubricating oils, varnish, whiskey, and what not. In this connection, I remember at the old plant of the N. K. Fairbank Co., 14th St., New York, the night man emptied a lot of oil barrels into a tank to be refined the next morning. The oil in the tank had a flavor never before noticed in crude cottonseed oil. It was found that by mistake a barrel of whiskey had been emptied along with the oil, and there was great lamentation on the part of the steamship company, as well as the men who committed this gross carelessness. Nowadays, crude oil is almost entirely handled in large tank cars, holding as much as 250 bbl. of 400 lb. each. Such a car is shown in Plate 29.

Plate 30 shows the tracks at a modern refinery filled with tank cars ready for unloading. For European shipment, the oil has to be shipped in carefully prepared barrels. Plate 31 shows a steamer being loaded for Europe at our New Orleans refinery.

In a talk on the cotton oil industry, sight must not be lost of the soap stock. The early refineries used to boil this material up with caustic soda and convert it into a soft, yellow soap, which was used more or less by woolen mills. This soap was also boiled down on strong brine until it carried about 30 per cent of water, which made it suitable for export to England, where large quantities were used. About 1886, it was found that by mixing the soap with soda ash, it could be made into very useful washing powder, which has since been advertised extensively by means of the Gold Dust Twins. In the plant of the Southern Cotton Oil Co. at Savannah, the speaker once needed some large soap kettles in a hurry, so he removed the covers from some storage tanks, lagged outside with wood, built a roof over the tops of the tanks, and these were used for some years quite successfully. As these tanks are somewhat of a novelty in the way of soap kettles a picture is shown in Plate 32.

Plates 33 and 34 show the first plant put up in Savannah for the distillation of the black grease made by decomposing the cottonseed soap stock with sulphuric acid. It was more or less of a temporary affair, which met with a sad accident and burned down a couple of years after it was put up.

On account of more or less destructive distillation

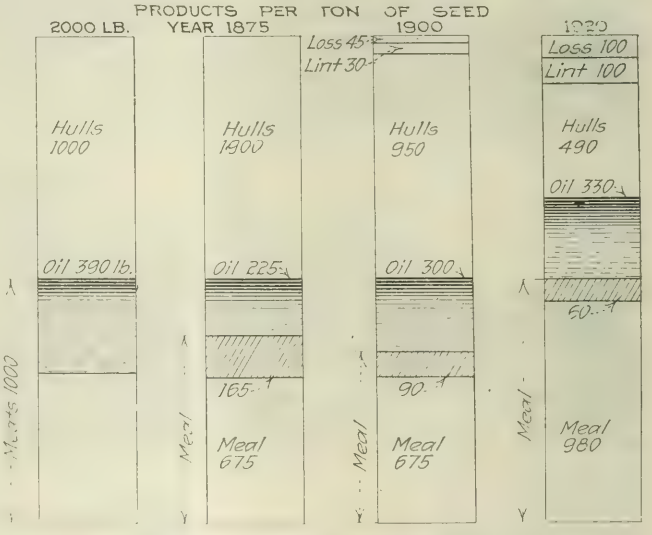
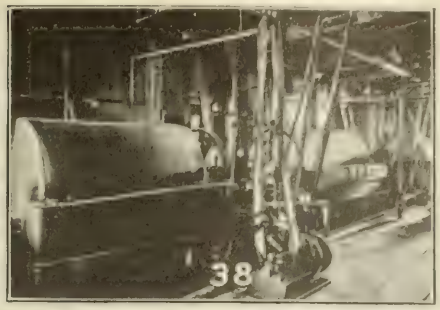


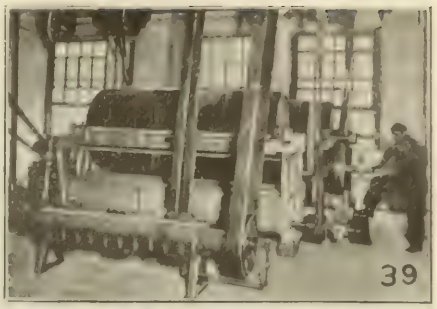
FIG. 8. IMPROVEMENT IN COTTONSEED MILLING, 1875-1920

taking place, owing to the impurities of the black grease, the vapors in the stills were very destructive to copper. Plate 35 shows a copper connection between two of the condensers after it collapsed one day and scared the operators nearly to death.

The modern way of handling soap stock is by means of the Sharples super-centrifuges, which are shown in

37


38


39

40

41

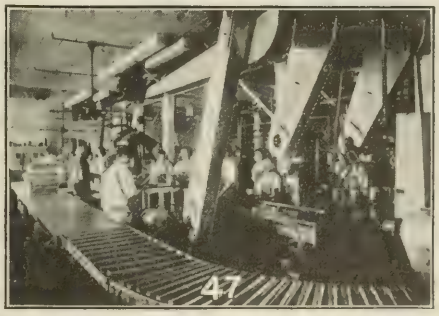
42

43

44

45

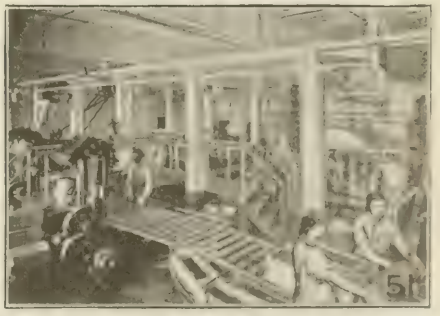
46


47

48

49

50


51

52

53

battery in Plate 36. These recover between 60 and 70 per cent of the entrained oil from the soap stock and reduce the refining loss about 1 per cent. Plate 37 shows one of our latest vegetable shortening plants, located in Chicago. In the manufacturing of vegetable shortening, the oil and hard fat, which, in these days, is almost exclusively hydrogenized cottonseed oil, are mixed in large tanks and then passed over revolving cylinders through which brine from an ice machine is circulated. Plates 38 and 39 show these cylinders in operation. The lard is fed into a trough in which the cylinders set and is chilled on the surface of the cylinder as it revolves. Knives scrape the chilled lard from the surface of the cylinder, in such a way that it continually drops through into a trough in which there is a rapidly revolving shaft covered with blades which break up all the lumps and beat a certain amount of air into the lard. Pumps take the shortening, which is of a creamy consistency, from this trough and pump it directly into the packages.

Plate 40 shows the filling room in the Savannah plant, taken about 15 yr. ago, and Plate 41 shows another view in the packing room. Please notice the large amount of labor present, and also notice that it consists almost entirely of men. Another view of the same work at that time is given in Plate 42, and Plate 43 shows the filling of tubs and large packages. Plate 44 shows the way the product was loaded into cars about 12 or 15 yr. ago.

During the last few years, automatic machinery has been installed and in the words of the song, we "let the women do the work." In Plate 45 girls are shown

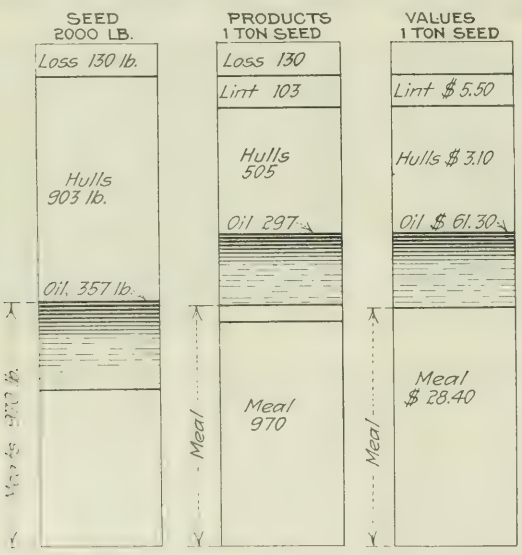


FIG. 9. RESULTS OF MILLING A TON OF SEED

filling large size cans. These are handled altogether by automatic machinery, as is shown in Plate 46, which is a picture of the same filling room shown on a preceding plate. Notice the few hands present and the neat orderly character of the work.

Other views of the same room are given in Plates 47 and 51 and show one of the automatic carriers for handling filled tins. Plate 48 shows the arrangement for filling and automatically soldering oil in cans.

An automatic carrier for loading tubs into cars is shown in Plate 49. This is on the shipping platform and will serve cars along a platform 200 or 300 ft. in length, the only labor needed being to put the tubs on to the carrier and properly pile them in the cars where they are delivered.

In the old days, help around the refineries consisted largely of negroes. Plate 53 shows the gang that used to work in the Memphis refinery of our company.

Plate 52 shows one of the early chemists already

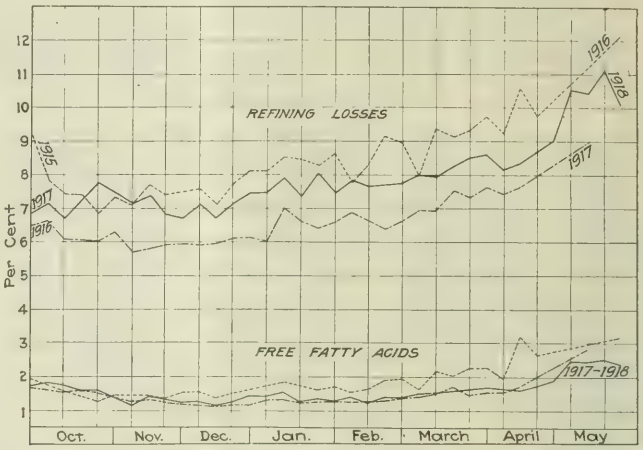


FIG. 10. RELATION BETWEEN FREE FATTY ACIDS IN CRUDE OIL AND REFINING LOSSES

mentioned, and the kind of an outfit used by him for testing his crude oil to see if it was refined properly. This gentleman now occupies an exalted position with one of the large companies.

Plate 50 is another laboratory view, and shows a young chemist grading oil samples for color. In the early days of a certain refinery I know of there was a colored assistant for nearly every white man in the refinery.

A great deal has been said of the wonderful virtues of highly refined cottonseed oil. Eighteen years ago I made some experiments with a certain well-known brand of oil, which has been extensively advertised, believing that the butter fat of cream could be replaced by the oil and successfully worked into ice cream. An experiment tried in my laboratory seemed to prove the theory to be correct, as is shown in Plate 54.

Government Picric Acid Plant for Sale

The ordnance branch of the War Department is offering for sale the buildings, land and equipment comprising the picric acid plant near Little Rock, Ark., which was constructed for war purposes. The buildings which are being offered for purchase include a sulphuric acid plant, a sulphuric concentrator plant, a nitric acid plant, a phenol storage building and a nitrate building, in addition to more than 65 shops, dwellings and small structures.

Not included in the proposed sale, however, are the water supply and gas systems and a power house, which were recently sold to the Arkansas Light & Power Co., providing that company would furnish future purchasers of the remaining buildings and plants with power, gas and water accommodations at prevailing rates.

The plant is readily convertible, officials of the War Department point out, into an oil refinery or fertilizer manufacturing establishment. With the increasing realization on the part of Arkansas and Louisiana cotton and rice growers of the necessity of fertilizer, attention has been called to the particularly favorable location of the plant for the manufacture and distribution of fertilizer.

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

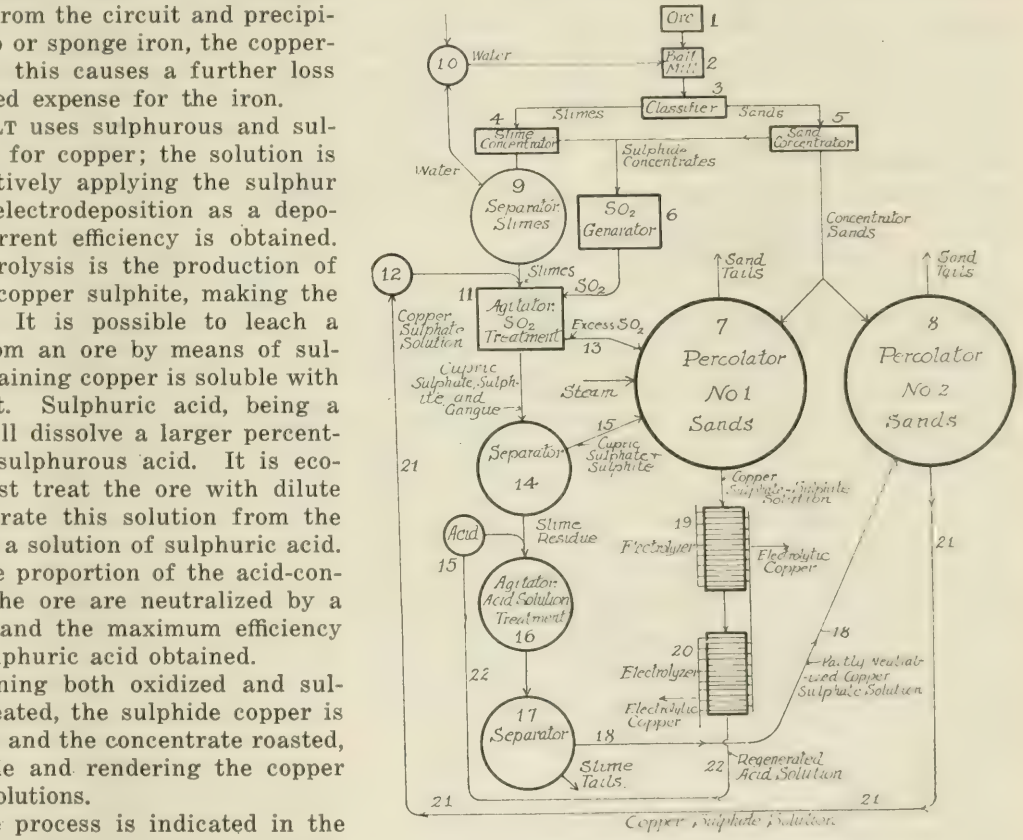
Hydrometallurgical Process for Copper Ores.—In the extraction of copper from its ores by leaching with dilute sulphuric acid the cost of the acid is a major item of expense and, where the ores contain excessive amounts of lime or other acid-consuming constituents, is often prohibitive. The solution of copper is also accompanied by a solution of iron, which is usually associated with oxidized copper ores, and if the copper is to be recovered from the solution by electrolysis, the pressure of excessive amounts of iron results in low current efficiency necessitating the removal of the iron from solution. The usual method is to withdraw a portion of the solution from the circuit and precipitate the copper upon scrap or sponge iron, the copper-free liquor being wasted; this causes a further loss of sulphuric acid and added expense for the iron.

WILLIAM E. GREENAWALT uses sulphurous and sulphuric acids as a solvent for copper; the solution is electrolyzed and by effectively applying the sulphur dioxide liberated in the electrodeposition as a depolarizer an economical current efficiency is obtained. A further result of electrolysis is the production of sulphuric acid from the copper sulphite, making the process self-sustaining. It is possible to leach a portion of the copper from an ore by means of sulphurous acid, but the remaining copper is soluble with difficulty by this reagent. Sulphuric acid, being a more effective solvent, will dissolve a larger percentage of the copper than sulphurous acid. It is economical, therefore, to first treat the ore with dilute sulphurous acid, to separate this solution from the ore and then retreat with a solution of sulphuric acid. By this procedure a large proportion of the acid-consuming constituents of the ore are neutralized by a relatively cheap solvent and the maximum efficiency of the more expensive sulphuric acid obtained.

In case an ore containing both oxidized and sulphide copper is to be treated, the sulphide copper is removed by concentration and the concentrate roasted, supplying sulphur dioxide and rendering the copper soluble in the leaching solutions.

The application of the process is indicated in the accompanying flow sheet. The ore from bin 1 is mixed with water and ground to from 8 to 20 mesh in the ball mill 2, the pulp flows to a classifier 3 and is separated into sand and slime. The sulphide copper is separated from the slimes in the concentrator 4, and from the sand in the concentrator 5, the concentrates being delivered to a roaster 6, designated in the sketch as "SO_2 generator." The concentrator sands are delivered to the percolators 7 and 8. In the flow sheet No. 1 percolator contains fresh sands and No. 2 a charge treated with sulphurous acid or sulphur dioxide only. The slime tailings from concentrator 4 flow to the separator 9 and are dewatered, the water returning to tank 10 and then being fed to the ball mill as desired. The dewatered slimes pass to the agitator 11 for treatment with the SO_2 gases from the roaster 6, together with neutral copper sulphate solution from the treatment of a previous charge in percolator No. 2. A fairly strong gas is preferred for this operation and the excess of sulphur dioxide is introduced into the bottom of percolator No. 1 and is consumed in acting upon the copper and other constituents of the sands that are affected by the gas or its solution in water. The mixture of gangue, cupric sulphate and sulphite, ferrous sulphate and sulphurous acid is separated from the residue in a Dorr thickener 14 and the solution fed to percolator No. 1. The slime residue, now containing the more difficult extractable copper, passes to the acid Dorr agitator 16.

The copper solution from the separator 14 in passing through the sands in the percolator No. 1 issues thoroughly clarified and practically neutral and contains the copper as sulphate and sulphite, ferrous iron and some sulphurous acid. The solution flows to the electrolytic cells, copper being deposited on the cathodes and an equivalent amount of sulphuric acid being liberated at the anodes. This liberated acid reacts with copper sulphite, forming copper sulphate



FLOW SHEET OF PROCESS

and liberating sulphur dioxide, which acts as a depolarizer and also reduces any ferric salts; these in turn act as a depolarizer. The deleterious effect of ferric salts is thus obviated to a large extent.

The solution from the electrolytic cells 19 and 20, which is impoverished in copper and enriched in acid, flows into the acid solution reservoir 15 and thence into the acid agitator 16 and there extracts the copper remaining in the slimes. The pulp flows to a Dorr thickener 17, the slime tails go to waste and the solution to No. 2 percolator, where the remaining acid is consumed in acting on the copper in the sands. The solution from the percolator is now nearly neutral and is delivered to the storage tank 12 and used in treating a fresh batch of slimes in agitator 11 as desired. (1,328,666; Jan. 20, 1920.)

Sodium Fluoride.—To a suspension of sodium fluosilicate in water, a solution of soda ash is added at such a rate that the solution reacts continuously either acid or neutral. The mixture is kept at a temperature of about 205 deg. F. and is agitated constantly until all of the soda ash solution has been added. When the agitation is stopped, the sodium fluoride crystals, being heavier than the silica particles, settle first and may be separated by repeated fractional settling. The crystals contain 98.26 per cent sodium fluoride. (1,324,030; FREDERIC C. BOWMAN, of New York, assignor to General Chemical Co.; Dec. 9, 1919.)

Alkali-Metal Cyanides From Calcium Carbide.—When calcium carbide is heated with sodium (or potassium) chloride or carbonate until the latter fuses and a stream of nitrogen is forced through the mass, alkali-metal cyanide is formed, presumably according to the reactions:

$$2NaCl + CaC_2 + N_2 + C = 2NaCN + CaCl_2 + C$$
$$2Na_2CO_3 + CaC_2 + N_2 + C = 2NaCN + CaCO_3 + C$$

The presence of free carbon in the mass is beneficial if not essential to the formation of the cyanide on a commercial scale. (1,324,119; CHARLES B. JACOBS, of Bloomfield, N. J., assignor by mesne assignments to Air Reduction Co.; Dec. 9, 1919.)

Book Reviews

HENDRICKS' COMMERCIAL REGISTER OF THE UNITED STATES FOR BUYERS AND SELLERS, twenty-eighth annual edition, 1919-1920. 2703 pp. Price, $12.50. New York: S. E. Hendricks Co., Inc.

The constant expansion of the chemical industry is bringing it into closer contact with other manufacturing industries and, as a result, the chemist is looking outside of his own field for new raw materials and new markets. To him, the usefulness of a trade directory such as Hendricks', which covers the entire manufacturing field from raw material to finished product, is self-evident. In spite of the wide range of materials considered, the treatment of each industry is very thorough and the chemist will find that the products of and equipment for the chemical and allied industries have received careful attention. The directory is of particular interest to the sales and purchasing departments. For the former it contains complete lists of all prospective customers and for the latter it shows at a glance the producers of any material required.

An improvement in the new edition is the method of exterior indexing by coloring the front edge red, white and blue to indicate the different main sections of the book. The first section (blue) of 162 pages is the "Index to Trades," in which every product listed in the book is indexed and cross indexed for ready reference. The following section (red) is the main classified trades list and contains 1,813 pages covering over 18,000 different products. In the third section (white), 216 pages are devoted to trade names, arranged alphabetically and followed by the name and address of the manufacturer. An alphabetical list of all the companies referred to in the book, together with their addresses and main lines of business, completes the volume. ALAN G. WICKOFF.

* * *

"THE JOURNAL OF THE INSTITUTE OF METALS." Vol. XXII. 428 pp. and 31 plates. Edited by *G. Shaw Scott, M. Sc.* (1919: The Institute of Metals, 36 Victoria St., London, S. W., 1, England. Price 31/6 net.)

This volume contains the technical papers presented before the fall meeting held in Sheffield in September, 1919; the 1919 May Lecture held in London—"Radio-Activity," by Prof. Frederick Soddy; and abstracts of metallurgical literature. This section containing abstracts is by no means the least valuable feature in the eyes of anyone interested in non-ferrous metals; an idea of their excellence may be had if the names of the men who prepared them are listed: The editor, and Messrs. Archbutt, Desch, Hanson, Johnson, Mazzucchelli.

Various contributions of more than usual interest should be cited. Dr. Desch's "Second Report to the Beilby Prize Committee of the Institute of Metals on the Solidification of Metals From the Liquid State" has been reprinted almost entirely in CHEMICAL & METALLURGICAL ENGINEERING, vol. 21, p. 773 (Dec. 24, 1919) under the caption "Effect of Surface Tension on Crystalline Form." Dr. Jeffries' "Note on the Micro-Mechanism of the Aging of Duralumin" is also given in the same volume, p. 553. Messrs. Stead and Spencer's beautiful micrographs of curved crystalline plates contained in their paper "The Ternary Alloys of Tin-Antimony-Arsenic" were utilized in Mr. Seyt's interesting letter on "Contributions by Metallography to L'Art Nouveau" (CHEMICAL & METALLURGICAL ENGINEERING, vol. 21, p. 656).

Other papers are worthy of careful attention by men in special branches of metalworking. Such are "Season Cracking," by W. H. Hatfield and G. L. Thirkell; "Properties and Manufacture of Sterling Silver," by E. A. Smith and Harold Turner; "Britannia-Metal," by F. C. Thompson and F. Orme; "A Typical Bearing Metal," by Miss H. E. Fry and W. Rosenhain; "Molding Sands," by P. G. H. Boswell, and "The Early History of Electro-Silver Plating," by R. E. Leader. All of these papers excited lively discussions in which additional interesting sidelights were disclosed, while two of them are appended by exhaustive bibliographies of the available literature. E. E. THUM.

* * *

SEWAGE DISPOSAL. By *Leonard Kinnicutt, C. E. A. Winslow* and *R. Winthrop Pratt.* 548 pages, illustrated. New York, 1919. John Wiley and Sons, Inc.

The new second edition of this book will be of considerable interest to the large number of engineers familiar with the first edition, and of great value to everyone interested in the general problem of sewage treatment. As a very readable history of the art of treating the collected wastes of civilization brought up to date by the addition of several chapters and supplementary paragraphs, it is a concise, clear presentation of the general problems involved and the various methods of attacking them, with descriptions and tabulations of the results obtained. It should be classed as an intermediate book, as it assumes an elementary knowledge of chemistry and bacteriology, but describes the various processes and accepted theories in a manner that will be clearly understood by the average reader. The details of design are passed over in a general manner to make way for the full discussion of the broader problems of sewage purification within the scope of one volume.

The chapters on Screening, on Sludge Disposal and on Chemical Precipitation have been reconstructed and enlarged. A discussion of the Boston and New Haven studies of the Miles Acid Process has been inserted. The newer processes of two-story tank operation and activated sludge treatment setting forth experience obtained at Cleveland, Chicago and Milwaukee have been discussed in new chapters; and two chapters have been added, one dealing with excretal disposal in the absence of sewerage, and the other dealing with general principles controlling the selection of type and required refinement of operation of sewage treatment plants. It is to be regretted that the valuable tables giving results of operation copied from the first edition were not brought up to date to indicate the effect of time and experience upon the efficiencies of some of the older plants.

The general air of the volume is optimistic concerning the ultimate solution of the sewage problem, and it is pointed out that whereas each newly-discovered process of treatment has been hailed as the end of the search and then has failed to live up to expectations, the knowledge of the subject is constantly increasing, so that the best method of treatment for a given condition may now be selected from a greatly augmented number of processes and special designs. MALCOLM PIRNIE.

Personal

WALTER M. BERRY has been appointed gas engineer for the Bureau of Standards, Washington, D. C., succeeding R. S. McBRIDE, who is now in the Washington, D. C., office of the McGraw-Hill Co.

AUGUSTINE DAVIS has resigned as president of the Davis-Bournonville Co. No successor to the presidency has been elected, and there has been no change in other officers of the company.

BARON G. DE GEER, superintendent of the open-hearth and electric-steel furnaces at Domnarfvet, Sweden, is visiting the steel plants in the United States.

A. H. FAY, mining engineer in charge of accident and certain other statistics for the U. S. Bureau of Mines since the foundation of the Bureau, has resigned to enter private employment.

FREDERIC J. LE MAISTRE has severed his connection with E. I. du Pont de Nemours & Co., and has formed a partnership with Wallace P. Cohoe, of 111 Broadway, New York, under the firm name of Wallace P. Cohoe & Frederic J. Le Maistre, associated consulting chemists and engineers, New York and Philadelphia. The Philadelphia office will be at 810 Bellevue Court Building.

BARON J. MANNERHEIM of Sweden is in the United States as a special representative of the Swedish Pulp Association. He is the guest of Dr. James E. Campbell, president of the Dexter Sulphite Pulp & Paper Co., who is conducting him through the local paper and pulp mills.

R. H. MINTON, recently elected president of the American Ceramic Society, will leave for Europe this month for an extended investigation of conditions in ceramics abroad.

FOREST RUTHERFORD, consulting metallurgist, 120 Broadway, New York City, has returned to New York after making an extended trip through the Southwest.

CASPER SMITH, president of the Smith Chemical & Color Co., New York, has recently returned from a two months' business trip through the United States, extending from coast to coast.

H. L. SULMAN has been awarded the gold medal of the Institution of Mining and Metallurgy, London.

WILLIAM A. WALDIE, for the past few years chief chemist at the Cleveland plant of the Glidden Co., has resigned to associate himself with the Ohio Varnish Co. in the capacity of director of research.

Obituary

JOSEPH M. FLANNERY, president of the Standard Chemical Co., Pittsburgh, Pa., died at his home, Feb. 18. To Mr. Flannery is due the introduction of vanadium in the steel industry, marking an epoch in the advance of steel making.

J. K. PROCTOR, founder and for many years president of the Philadelphia Textile Machinery Co., Philadelphia, Pa., and originator and inventor of the "Proctor" driers, died Feb. 11, of pneumonia.

CHARLES A. WEEKS, the inventor of the Weeks rotating furnace for non-ferrous metals, died on Saturday, Feb. 21. His death was a surprise and shock to friends and associates alike. Previous to the invention of the electric rotating furnace, Mr. Weeks built a number of rotating gas and oil furnaces from which he obtained his original basic ideas covering the subject. He invested his own capital for the manufacture of a furnace of approximately two tons capacity which was installed and operated at the General Electric Co., Schenectady, nearly eight years ago. The reason that the furnace was not immediately placed on the market was because the non-ferrous field had developed only to a small extent—crucibles were cheap and a systematic investigation of losses in melting had not shown up the tremendous losses through volatilization.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 8.—There has been little change since last week's report.

	Cents per Lb.
Copper, electrolytic	19 00
Aluminum, 98 to 99 per cent	33 00
Antimony, wholesale lots	12 00
Nickel, ordinary	43 00
Nickel, electrolytic	45 00
Tin, Straits, spot	64 50
Lead, New York, spot	9 00
Lead, E. St. Louis, spot	8 37½
Zinc, spot, New York	9 30
Zinc, spot, E. St. Louis	9 00

OTHER METALS

Silver	oz.	$1.29½
Cadmium	lb.	1 50
Cobalt	lb.	1.50
Platinum	oz.	150 00
Iridium	oz.	250 00
Palladium	oz.	150 00
Mercury	75 lb.	90@92

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	26.50
High brass rods	23.75
Low brass wire and sheets	28.50
Los brass rods	29.50
Brazed brass tubing	38.25
Brazed bronze tubing	43.00
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	32.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap	23½@24½
Aluminum, sheet scrap	22½@23½
Aluminum clippings	25½@27
Copper, heavy machinery comp	14½@14¾
Copper, heavy and wire	13½@14
Copper, light and bottoms	12½@12¾
Copper, heavy cut and crucible	16½@17
Brass, heavy	11½@12
Brass, casting	10½@10¾
Brass, light	9@9¼
No. 1 clean brass turnings	9½@10
No. 1 comp. turnings	12 @12½
Lead, tea	5½@5¾
Lead, heavy	6 @6¼
Zinc, scrap	6 @6½

The Iron and Steel Market

Pittsburgh, Pa., March 5, 1920.

Despite the many claims of production of pig iron and steel and the finishing of steel being greatly hampered by transportation conditions, operations continue to grow, although with occasional backsets. The attitude of the iron and steel industry in this matter is in somewhat striking contrast to the sanguine temperament it usually exhibited before the war. Pig-iron production is now at about 90 per cent of capacity, figured against the conservative estimate of 43,000,000 gross tons per annum, or 86 per cent, figured against the more liberal and probably more accurate estimate of 45,000,000 tons capacity.

In some quarters it is being asserted that steel production is not in keeping with pig-iron production, although the ingot report for January showed an 83 per cent production and that pig iron is accumulating at steel works. This, if true, would be extremely awkward for the pig-iron market, which has had the spectacular advance to above $40, and not simply for prompt delivery, but for deliveries extending over the second half of the year. It is decidedly doubtful whether steel products could be sold at this time for delivery throughout the second half of the year at prices that would justify the payment of $40 for the pig iron from which to make the steel.

Inasmuch as iron and steel markets have for years been made partly by psychological influences and not wholly by the actual physical conditions as to supplies and requirements, it is of value to consider the producing trade's mental attitude at this time, as suggested by the above illustrations. In last week's report one aspect of buyers' psychology was referred to—the growing revolt against price dictation by the automobile industry, which does not consume any such percentages of the steel output as to justify

its having much voice in setting prices for the whole market. In the past week the automobile trade has given further exhibitions of its disregard for the cost of materials and its anxiety to secure heavier deliveries. It has paid 12@14c. a lb. for automobile body sheets, leading some sheet mills to buy limited tonnages of sheet bars at $90. A week ago the high point was $80, and the purchases at fancy prices had been made chiefly by middle interests or consumers, for the purpose of making conversion contracts. There are still fairly large deliveries of sheet bars at the March 21 price of $42. The 10-yr. pre-war average was between $25 and $26.

Several large producers have been covering their regular customers for second quarter deliveries at 2.90@3c. for bars, 3@3.10c. for shapes and 3.25@3.50c. for plates, but they are quite indisposed to advertise the fact, some because they have no room for new customers and some, perhaps, because they wish to charge higher prices to buyers not their regular customers.

Market Lacks Real Test

When steel is so scarce and the market exhibits such signs, superficially at least, of there being such buying power, it is altogether without precedent that at the beginning of March producers should be selling only to second quarter. The market lacks the real test, of whether buyers would take hold for third quarter or second half. The Steel Corporation, of course, is sold much farther ahead, but its prices are altogether different.

Export bookings are now very light, the exchange situation and perhaps some other factors preventing there being as large demand in that quarter as formerly. For small lots for prompt shipment, however, export houses are seeking largely in vain.

Conservative estimates are that in the present freight-carrying movement the railroads will take, with a few orders already placed, a total of 40,000 cars. More sanguine estimates place the total at 100,000 cars, but even the larger figure would be less than one-half the number bought in some previous years. Not much more rail buying is expected for this year. As to general construction work, the railroads seem to have little planned. Altogether, the volume of steel likely to be taken by railroads during the remainder of this year is very much smaller than the estimates apparently made by other steel buyers who have been fearful that they would not be able to secure the steel they needed.

In view of the large and increasing production, the growing conservatism of buyers, the smaller export prospects, the quantity of railroad steel to be taken and the disinclination of many investors to engage in construction projects at this time, it seems quite possible that the steel market will assume a new alignment within a few months. There is little if any reason to doubt that there will be a full demand for steel at moderate prices, but some of the prices now going are distinctly immoderate.

Pig Iron

The market is extremely quiet. Bessemer and foundry remain at $42, valley, and there is no particular reason to expect a recession in the near future, but basic, after declining from $43 to $41.50, as recounted a week ago, is by no means strong at the lower figure.

Steel

As noted above, sheet bars have sold at $10 higher, $90, this being in small lots. Producers having regular sheet mill customers have entirely abandoned the idea of covering their customers at $60, but might possibly do $75. Billets are in light demand and still lighter supply, with prices not determined, possibly $55 to $65.

Ferro-Alloys

Small prompt lots of ferromanganuese have been going at $175@$200 and even higher. For second half the regular price is $160, delivered. Spiegeleisen is $57@$60, furnace. Electrolytic ferrosilicon is quoted at $140, delivered, for 75 per cent. Bessemer ferrosilicon is $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, March 5, 1920.

Buyers are experiencing difficulty in locating supplies in most branches of the chemical market. This condition has been brought about by the heavy exporting of the past few weeks and by certain other details beyond the control of the producers. Many manufacturers are unable to consider any more contracts at present, as their entire production is sold months ahead.

The market continues active in inquiry, with most prices quoted being nominal, as spot material in practically every line is very scarce. *Barium* products have been especially active, and prices have kept pace; producers are sold up and there is very little on the spot market. Quotations ranging from $140@$175 per ton have been received on *barium chloride*. *Soda ash* remains scarce. There were some small spot supplies reported sold at $3 for the light and $3.10 per cwt. on the dense. *Sodium bisulphate*, powdered, has been active during the past week, with quotations of $7@$7.50 per ton for carlots and $8@$10 for less than carlots. Supplies on *caustic potash* at present are short, but the price of 25@32c. per lb. holds firm. *Sodium cyanide*, under the influence of weak demand, dropped to 24@25c. for carlots and 26@27c. per lb. for less than carlots, against 30@32c. and 31@34c. of the previous week. *Caustic soda* still remains under pressure of considerable demand with very little improvement in supplies. Present quotations range from $4.35@$4.60 per cwt. All *ammonium* products, under the influence of the recent coal shortage, remain firm in price. It is reported that the decreasing supply of English *salammoniac* is now exhausted, and a steady increase in this item is predicted by some. *Ammonium chloride*, granular, white, is being listed at 15@16c. for carlots and 17c. per lb. for less than carlots, while *gray* is slightly lower at 13@13½c. per lb. It is impossible to obtain an exact price on *sodium bichromate*, as prices demanded are based entirely on the quantity asked for. Prices as high as 45c. per lb. have been reported.

Coal-Tar Products

There is considerable criticsm among the members of this industry concerning the failure of the proposed bill before the Senate to be passed by that body. General opinion seems to have favored the bill if only for the reason of having some protective measures to check the growth of the German dye industry in the United States and at the same time encourage our domestic producers to meet the demands of this country. Under the influence of this unsettled condition the market has remained quiet, with action in price being displayed by only a few of the items which are feeling an acute shortage. *Dimethylaniline* is off the spot market and producers are contracted for several months ahead. A nominal quotation of 95c.@$1.20 per lb. has been received. The scant supply of the past few weeks on *H acid* has not improved to any extent and the quotation of $1.60@$1.75 per lb. still holds firm. *Salicylic acid*, tech., holds firm under the present demand at 43@45c. per lb., while U. S. P., with a slightly heavier demand, is listed at 55c.@60c. per lb.

Waxes

There has been a slight increase over the usual amount of business in the *wax* market during the past week. Supplies on all grades of *carnauba* are cramped. Nominal quotations have been received, on No. 1, 80@88c. per lb., No. 2 regular, 65@78c., and No. 3, North Country, 46@48c. *Paraffines* remain firm throughout, with a continued heavy foreign demand especially from the Far East.

Naval Stores

Turpentine is again on the upward trend due to shortage of supplies in New York, and present market is about $1.99 per gal. *Rosins* have come up slightly under the pressure of the heavy buying that was felt while prices were down. K-N grades are listed at $18.50@$21.50 and B-D at $17@$18.50. Foreign inquiry in this market has been at a standstill during the past few weeks and those engaged in this trade are anxiously awaiting a more favorable exchange.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.60 – $0.65
Acetone	lb.	$0.16 – $0.20	.21 –
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	—	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09½
Oxalic, crystals	lb.	.35 – .40	.43 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	—
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	—
Sulphuric, 66 deg., drums	ton	—	—
Sulphuric, 66 deg., carboys	ton	—	—
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P	lb.	—	1.35 – 1.45
Tannic (tech.)	lb.	—	.42 – .55
Tartaric, crystals	lb.	—	.69 – .74
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	1.50 –	1.52 – 1.57
*Alcohol, denatured, 188 proof	gal.	—	.65 – .78
*Alcohol, denatured, 190 proof	gal.	—	.67 – .74
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.13 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.15 – .16	.17 – .19
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14¾
Ammonium nitrate	lb.	.10 – .12	—
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	—	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	—	.10¾ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride	ton	140.00 – 150.00	160.00 – 170.00
Barium dioxide (peroxide)	lb.	.26 – .27	.28 – .30
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		—	—
Blue vitriol (see copper sulphate)		—	—
Borax (see sodium borate)		—	—
Brimstone (see sulphur, roll)		—	—
Bromine	lb.	.90 – .95	—
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	—	.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	— 3.50	4.00 – 4.50
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10¾ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)		—	—
Caustic soda (see sodium hydroxide)		—	—
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 – .05½	.08 –
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)		—	—
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		—	—
Epsom salt (see magnesium sulphate)		—	—
Formaldehyde, 40 per cent	lb.	—	.45 – .65
Glauber's salt (see sodium sulphate)		—	—
Glycerine	lb.	—	.24½ – .26
Iodine, resublimed	lb.	—	4.10 – 4.30
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	—	.13 – .17
Lead nitrate, crystals	lb.	—	.70 – .80
Litharge	lb.	.11½ – .12¼	.12½ – .13
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	—	.13 – .14½
Magnesium sulphate, U. S. P	100 lb.	3.75 – 3.45	3.50 – 3.75
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.20
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.12½ – .13	.17 –
Phosgene (see carbonyl chloride)		—	—
Phosphorus, red	lb.	—	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .37
Potassium bitartrate (cream of Tartar)	lb.	—	.56 – .60
Potassium bromide, granular	lb.	—	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 –
Potassium hydroxide (caustic potash)	lb.	.25 – .32	.35 – .42
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	—	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	—	.40 – .70
Potassium sulphate	ton	$225.00 –	—
Rochelle salts (see sodium potas. tartrate)		—	—
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake (sodium sulphate)	ton	18.00 – 21.00	—
Silver cyanide	oz.	—	1.25 –
Silver nitrate	oz.	—	81 – 82¼
Soda ash, light	100 lb.	2.50 – 2.60	— 3.00
Soda ash, dense	100 lb.	2.70 – 2.75	— 3.10
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb	.05½ – .06½	.07 – .07½
Sodium borate (borax)	lb.	.08½ – .08¾	— .09
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.40	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	—	4.85 – 5.25
Sodium hyposulphite	lb.	—	.03¾ .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.15 – .17	— .18
Sodium peroxide, powdered	lb.	—	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02¼
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	—	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05¾ –	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 –
Zinc carbonate, precipitate	lb.	—	.20 –
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.11¾ – .12½	.13 – .15
Zinc oxide, dry American	lb.	—	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.42 — .50
Anthracine, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.25 — 1.35
Benzidine, sulphate	lb.	1.00 — 1.15
Benzoic acid, U.S.P.	lb.	.90 — 1.10
Benzoate of soda, U.S.P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .29
Benzyl chloride, 95-97%, refined	lb	.35 — .40
Benzyl chloride, tech	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .55
Beta naphthol, sublimed	lb.	.65 — .80
Beta naphthol, tech	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal	.85 — 1.00
Cresylic acid, 50%, first quality, drums	gal	.60 — .70
Dichlorbenzol	lb.	.07 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline	lb.	.95 — 1.20
Dinitrobenzol	lb.	.26 — .37
Dinitroclorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb	.45 — .55
Dinitrophenol	lb	.32 — .36
Dinitrotoluol	lb	.38 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal	.38 — .40
Diphenylamine	lb.	.55 — .65
H-acid	lb.	1.60 — 1.75
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.12 — .15
Monoethylaniline	lb.	1.50 — 1.75
Naphthaline crushed, in bbls. (250 lb.)	lb	.06 — .08
Naphthaline, flake	lb.	.07 — .08
Naphthaline, balls	lb.	.08½ — .10
Naphthionic acid, crude	lb.	.75 — 1.25
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.30 — .35
Nitro-toluol	lb	3.75 — 4.25
Ortho-amidophenol	lb.	.15 — .20
Ortho-dichlor-benzol	lb.	.80 — 1.25
Ortho-nitro-phenol	lb.	.25 — .40
Ortho-nitro-toluol	lb.	.25 — .45
Ortho-toluidine	lb	2.50 — 3.50
Para-amidophenol, base	lb	2.50 — 3.25
Para-amidophenol, HCl	lb	.12 — .18
Para-dichlor-benzol	lb	1.00 — 1.35
Paranitraniline	lb.	1.35 — 1.50
Para-nitro-toluol	lb	2.15 — 3.00
Paraphenylenediamine	lb	1.75 — 2.50
Paratoluidine	lb	.60 — .70
Phthalic anhydride	lb	.12 — .25
Phenol, U. S. P., drums (dest.), (240 lb.)	gal	2.00 — 2.50
Pyridin	lb	3.75 — 4.50
Resorcin, technical	lb	6.50 — 6.75
Resorcin, pure	lb.	.43 — .45
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.55 — .60
Salicylic acid, U. S. P.	lb.	.90 — .95
Salol		

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.22 —	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42 —	$0.45
Beeswax, refined, yellow	lb.	.47 —	.48
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.65 —	.78
Carnauba, No. 3, North Country (nominal)	lb.	.46 —	.48
Japan	lb.	.17 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.07½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11¼
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal	.48
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.00	—$18.50
Rosin E-I	280 lb.	18.05	— 18.75
Rosin K-N	280 lb.	18.50	— 21.50
Rosin W. G.-W. W.	280 lb.	21.50	— 24.25
Wood rosin, bbl.	280 lb.	15.50	— 17.50
Spirits of turpentine	gal.	.....	— 1.99
Wood turpentine, steam dist.	gal.	.....	— 1.93
Wood turpentine, dest. dist.	gal.	.....	— 1.85
Pine tar pitch, bbl.	200 lb.	8.50	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 14.75
Retort tar, bbl.	500 lb.	15.00	— 15.25
Rosin oil, first run	gal.	.93	— .95
Rosin oil, second run	gal.	.96	— .97
Rosin oil, third run	gal.	1.10	— 1.15
Rosin oil, fourth run	gal.	.....	— 1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.42½ —	$0.44
Upriver coarse	lb.	.31½ —	.35
Upriver caucho ball	lb.	.31½ —	.34½
Plantation—First latex crepe	lb.	.40½ —	.49
Ribbed smoked sheets	lb.	.46 —	.48
Brown crepe, thin, clean	lb.	.41 —	.43
Amber crepe No. 1	lb.	.45 —	....

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.23½ —	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½ —	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½ —	.23
Corn oil, crude, in bbls.	lb.	.19 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	17.50 —	18.00
Cottonseed oil, summer yellow	lb.	19.00 —	20.00
Cottonseed oil, winter yellow	lb.	.24½ —	.25½
Linseed oil, raw, car lots	gal.	1.77 —	
Linseed oil, raw, tank cars	gal.	1.72 —	
Linseed oil, boiled, car lots	gal.	1.80 —	
Olive oil, commercial	gal.	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15½ —	.17½
Palm, Niger	lb.	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22¾ —	.24
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined in bbls.	gal	1.70 —	
Rapeseed oil, blown, in bbls.	gal	1.60 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½ —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16¾ —	.20

FISH

Winter pressed Menhaden	gal.	$1.15 —	...
Yellow bleached Menhaden	gal.	1.20 —	...
White bleached Menhaden	gal.	1.22 —	....
Blown Menhaden	gal	1.28 —	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	13.50 —	18.00
Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
Fluor spar, acid grade, ground, f.o.b. mines	net ton	50.00 —	52.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.07
Graphite, crucible, 88% carbon content	lb.	..... —	.08½
Graphite, crucible, 89% carbon content	lb.	..... —	.08¼
Graphite, crucible, 90% carbon content	lb.	..... —	.09
Graphite, crucible, 91% carbon content	lb.	..... —	.08½
Graphite, crucible, 92% carbon content	lb.	..... —	.09½
Graphite, crucible, plus 92%	lb.	..... —	.12
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine, nominal	lb.	1 55 —	1.60
Shellac, orange, superfine	lb.	1.65 —	1.70
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn	gross ton	160.00 —	170.00
Spiegeleisen, 16-20% Mn	gross ton	50.00 —	60.00
Ferro-molybdenum, per lb. of Mo	lb.	2.50 —	2.75
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.50

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	9.00 —	15.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.50 —	10.00
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

MIDDLETOWN — Wesleyan University, 374 High St., is having plans prepared for the construction of a 2-story chemical laboratory. Estimated cost, $500,000. Henry Bacon, 101 Park Ave., New York City, archt. and engr.

Idaho

OROFINO—The Crustaline Lime Co. is in the market for a 125-ton daily capacity rotary kiln, etc. Total estimated cost, $100,000.

Illinois

CHICAGO—The Steel Sales Corp., 129 South Jefferson St., has purchased a site at Crawford Ave. and 35th St. and plans to build a 1-story, 400 x 600-ft. steel fabrication plant on same. Estimated cost, $250,000.

HIGHLAND PARK—The city is having plans prepared and estimates submitted for the construction of a filtration plant, extensions to distribution system and installation of a 5,000,000-gal. additional pumping equipment. Alvord Burdick, 8 South Dearborn St., Chicago, engr.

KEWANEE—The city is having a study made of its problem of sewage disposal. Alvord & Burdick, 8 South Dearborn St., Chicago, engrs.

ROCKFORD—The city is having plans prepared for the construction of an intercepting sewer and a disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engrs.

Indiana

BLOOMINGTON—The city is having plans prepared for the enlargement of present sewage disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engrs.

KOKOMO—The Pittsburgh Plate Glass Co., Vaile Ave., has awarded the contract for the construction of new buildings and extensions to its plant, here, to Stone & Webster, 120 B'way, New York City. Estimated cost, $2,000,000. J. W. Buzzell, contract mgr.

SEYMOUR—The Water Co. plans to improve power station. Improvements consist of a new sedimentation basin of 2,000,000-gal. capacity and rebuilding of the steam plant.

Iowa

AMES—The city had plans prepared for the construction of a sewage disposal plant, consisting of pumping plant, Imhof tank, sludge bed and trickling filters, etc. Estimated cost, $100,000. P. E. Hopkins, mgr. dept. of engr.

OAKDALE—The Bd. of Control, State House, Des Moines, will soon award the contract for the construction of a 2-story laboratory in connection with the State Sanatorium, here. H. F. Liebbe, State House, Des Moines, archt.

Kansas

COFFEYVILLE—The Kansas Oil Refining Co. plans to build additions to its oil refinery, 2 mi. from here. Estimated cost, $500,000. H. R. Heal, genl. mgr.

Louisiana

NEW ORLEANS—The New Orleans Gas Light Co., Bayonne and Common Sts., has awarded the contract for the installation of a new purification system in its proposed plant, to the Western Gas Constr. Co., Fort Wayne, Ind. Estimated cost, $312,000.

NEW ORLEANS—The Surgical Supply Co., 1425-1427 Canal St., is in the market for buffing machines, nickel plating equipment, etc. John A. Moran, secy. and treas.

Maryland

CANTON (Baltimore P. O.)—The Baltimore Copper Smelting & Rolling Co., 4th Ave. and 5th St., had plans prepared for the construction of a 1-story, 204.3 x 329.8-ft. copper rolling mill at 1st and 2nd Sts. and 3rd Ave. Estimated cost, $130,000.

Massachusetts

CAMBRIDGE—Lever Bros. Co., Portland St., is having plans prepared for the construction of a 6-story mfg. plant addition. C. Timain, 201 Devonshire St., Boston, archt. and engr.

CHESTNUT HILL (Boston P. O.) — Boston College, University Heights, is having plans prepared for the construction of a 5-story chemical and physical laboratory on the campus, here. Maginnis & Walsh, 100 Boylston St., Boston, archts. and engrs.

LEE—The Smith Paper Co. has awarded the contract for the construction of a 2-story, 50 x 140-ft. paper mill, here, to the Lynch Bros. Brick Co., Holyoke. Estimated cost, $60,000.

WEST SPRINGFIELD (Springfield P. O.) —The Gilbert & Barker Mfg. Co., Cold Springs Ave., will soon award the contract for the construction of 5 factory buildings, including a 1-story, 80 x 400-ft. brass foundry, 1-story, 40 x 80-ft. zinc building, a 1-story, 160 x 230-ft. sheet metal building, etc. Estimated cost, $750,000. McClintock & Craig, 33 Lyman St., Springfield, archts. and engrs.

Michigan

DETROIT—The General Testing Laboratories, analytical and research chemists, 97 Woodward Ave., plan to enlarge their plant and are in the market for equipment for general physicians' analytical work and bacteriology. J. A. Wolf, genl. mgr.

MARYSVILLE — Smith, Hinchman & Grylls, archts. and engrs., 710 Washington Arcade, Detroit, will soon award the contract for the construction of a 1- and 2-story, 380 x 420-ft. foundry at Michigan Ave. and Cuttle Rd., for the General Aluminum & Brass Co., Boulevard and St. Aubin Sts., Detroit. Estimated cost, $500,000.

MILFORD—The village is making surveys and plans and submitting estimates for the construction of a complete sewer system, including vitrified sewers and disposal works. Estimated cost, $100,000. C. W. Hubbell, 2348 Penobscot Bldg., Detroit, engr.

PLEASANT RIDGE (Detroit P. O.)— The village plans to construct complete storm water and sanitary sewer systems with sewage disposal works in the streets in the vicinity of Woodward Ave. C. W. Hubbell, 3248 Penobscot Bldg., engr.

Minnesota

DULUTH—The Northwest Products Co., c/o Marshall Wells Co., Lake Ave., has awarded the contract for the construction of a 1-story, 44 x 60-ft. paint mfg. plant, to Jacobson Bros., 410 Columbia Bldg. Estimated cost, $15,000.

Nebraska

LINCOLN—The city, together with four suburbs, is having a report prepared for the construction of additional intercepting sewers and sewage disposal plant. Alvord & Burdick, 8 South Dearborn St., Chicago, engrs.

New Jersey

BAYONNE—The Nitrate Agencies Co. will build a factory on West 1st St. Estimated cost, $50,000.

New York

BUFFALO—The General Drop Forge Co., 1738 Elmwood Ave., is having plans prepared for the construction of a 1-story, 100 x 100-ft. heat-treating plant. Estimated cost, $75,000. Ernest McGeorge, 1900 Euclid Ave., Cleveland, O., archt. and engr.

NEW YORK—The Bd. of Purchase, Municipal Bldg., will receive bids until March 12 for furnishing and delivering copper sulphate to the dept. of Water Supply, Gas and Electricity. Grover A. Whalen, chairman.

NEW YORK—The Natl. Gum & Mica Co., 12 West End Ave., will build a 25 x 100-ft. factory on West End Ave. Work will be done by day labor. Noted Feb. 4.

SALAMANCA—The Kendall Refining Co., Kendall Ave., Bradford, Pa., plans to construct a 2-story, 30 x 40-ft. office and storage building and three steel, 12,000-gal. tanks, on Broad St. Estimated cost, $50,000-$60,000.

Ohio

ASHLAND — R. A. Davis, Mayor and Pub. Serv. Dir., City Hall, will receive bids until March 16 for the construction of a filter building and installation of equipment in same. Noted Feb. 18.

CLEVELAND—The Aetna Rubber Co., 815 East 79th St., plans to construct a 1- and 2-story, 100 x 130-ft. factory. Estimated cost, $100,000. H. Kappler, mgr.

Pennsylvania

HOLMSBURG JUNCTION (Philadelphia P. O.)—The Precision Grinding Wheel Co., manufacturer of grinding wheels, 1215 Filbert St., Philadelphia, is building the first unit of a modern plant on the New York Division of the Pennsylvania R.R. Complete equipment will be installed in same. Grinding wheels made of synthetic corundum or crystallized aluminum oxide, also silicon carbide, will be manufactured by the vitrified, shellac, silicate and rubber processes. H. A. Plusch, mgr.

SPRINGDALE—The West Pennsylvania Power Co. is receiving bids for furnishing filter equipment for the proposed 1,000,000-gal. filtration plant. Chester & Fleming, Union Bk. Bldg., Pittsburgh, engrs.

STEELTON—C. P. Turner, engr., Bethlehem Steel Co., is building a 2-story, 50 x 100-ft. laboratory, for the Bethlehem Steel Co. Estimated cost, $50,000. Bissel & Sinkler, Otis Bldg., Philadelphia, archts.

Texas

ORANGE—The Mogul Oil Refining Co. plans to build a 10,000-bbl. refinery. Estimated cost, $1,000,000.

Wisconsin

CARROLLVILLE—H. J. Esser, archt., Camp Bldg., Milwaukee, will soon award the contract for the construction of a 3-story, 375 x 500-ft. food factory, here, for the United States Glue Co. Estimated cost, $500,000.

MILWAUKEE—The Sewage Comn. will receive bids until April 8 for furnishing and installing a fine screen plant for the sewage disposal plant. T. Chalkley Hatton, chief engr.

RACINE—The Racine Mfg. Co., 6th and Mead Sts., is receiving bids for the construction of a 1-story, 100 x 150-ft. dry kiln on Mead St.

Quebec

MONTREAL—The Dominion Glass Co., Wellington St., is in the market for a platinum evaporating dish of a 125 c.c. capacity to be used for laboratory work. C. K. McLeod, chemist.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 P.M., Dr. R. B. Moore, chief

chemist, U. S. Bureau of Mines (*Lantern*); "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 P.M., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Fire-foam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Fire-foam Co. (*Experimental, cinema and lantern*).

THE FARADAY SOCIETY (London) will hold a meeting on March 23, at which there will be a general discussion on "Basic Slag From the Metallurgical and Agricultural Standpoints."

THE INSTITUTE OF METALS will hold its annual general meeting March 11 and 12 at the Institute of Mechanical Engineers, Storey's Gate, Westminster, S. W. 1, London, England.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE GLIDDEN CO. of Cleveland has taken over the Yarnan Rosin & Turpentine Co. of Brunswick, Ga., and Gulfport, La.

THE AMERICAN METALLURGICAL CORP., Franklin Trust Bldg., Philadelphia, Pa., announces the opening of an office at Credland Chambers, 111 Queen St., Sheffield, England, the title of the headquarters there to be the Midland Metallurgical Ltd. The foreign headquarters will be under the direction of Beecroft & Partners, an old and well known engineering organization of Staffordshire, England, G. C. Castle to be directly in charge. The foreign headquarters will carry on the same type of work as carried on by the American Metallurgical Corp., namely, covering the entire field of electrometallurgy and chemical developments.

R. C. GOSROW, metallurgical engineer and electrometallurgist, announces the establishment of his office at 701 Claus Spreckels Bldg., San Francisco, Cal., to engage in consulting work on the metallurgy of iron, steel, ferro-alloys and ore-reduction processes, the heat treatment of steel and steel improvement, the design, construction and operation of electric furnaces, electric furnace processes. He will also be Western representative for the Pittsburgh Furnace Co. of Milwaukee, Wis.

C. R. HAYWARD, assistant professor of metallurgy at the Massachusetts Institute of Technology, and H. M. Schleicher, formerly director of the Central Research Laboratory of the U. S. Smelting, Refining & Mining Co., have opened an office under the name of Hayward & Schleicher at 69 Massachusetts Ave., Cambridge, Mass., as research metallurgists.

THE WILKENS-ANDERSON CO., Chicago, Ill., announces that W. G. Calkins of Detroit, Mich., has developed a new combustion boat for the determination of carbon in steel, known as the NoNoX combustion boat, which is a practically non-oxidizing metallic boat, combining the refractory qualities of non-metallic boats such as porcelain, silica, etc., with the strength and shock resisting properties of a metal. This company also announces that Herbert S. Wilson, chief chemist of the Collons Safety Razor Co., has devised the Wilson carbon determination apparatus, which is a new departure.

THE MONO CORP. OF AMERICA, 48 Coal & Iron Exch., Buffalo, N. Y., announces that it has purchased the entire stock of Mono apparatus and accessories from the F. D. Harger Co., Buffalo, N. Y. This includes all rights for the manufacture and sale of its various types of Mono apparatus for the automatic analysis of CO_2, CO, O, H, SO_2, N, Cl, etc. F. D. Harger has not severed his connection, but will serve as general manager of the new corporation. A service and inspection department, connected with the laboratory, is now in operation and a competent chemical engineer in charge. Capable erectors will be placed at the disposal of customers in connection with the erection of new work and regular inspection trips will be arranged to visit existing installations with a view to bringing about closer co-operation between the customer and the corporation.

GEORGE B. CAREY AND ASSOCIATES of Lexington, Ky., have purchased the Chinn Mineral Co.'s calcite and baryta fields at Muncy's Landing, near Harrodsburg, Ky., and plan to start working them at once.

THE SHERWIN-WILLIAMS CO. has recently purchased the Acme White Lead & Color Works of Detroit and Frank Hemingway & Co., manufacturers of chemicals, dyes and insecticides, with plants at New York and Bound Brook, N. J. This old established Cleveland concern owns lead and zinc mines, operates its own smelter, lead corroding plants, lithopone plant, linseed oil mill, dye and color plants and can factory. It owns the Sherwin-Williams Co. of Canada, Louis Berger & Sons, Ltd., of London and Louis Berger & Son and the Sherwin-Williams Co. of Australia.

THE ESSEX ANILINE WORKS, INC., will remove its present main offices at 39 Oliver St. to 88 Broad St., Boston, Mass. The laboratory will remove to the works at South Middleton, Mass., and shipments of dyestuffs will be made from that point.

THE MICHIGAN SMELTING & REFINING Co., Detroit, Mich., announces that at the annual meeting, held in the administration offices, John R. Searles was elected president and general manager to succeed the late Joseph Sillman, founder of the business. Other officers and directors were elected as follows: Norman Sillman, vice-president; Henry Levitt, secretary and treasurer; directors: John R. Searles, Emory W. Clark, Walter P. Crysler, Leo M. Butzel, Henry Levitt, Norman Sillman and Chas. O. Patch.

THE PRECISION GRINDING WHEEL CO., Philadelphia, Pa., has recently secured the services of H. A. Plusch as secretary and factory manager, and A. S. Vane has been made president and manager.

THE MATHIESON ALKALI WORKS, INC., has established its headquarters in New York City, and hereafter it will sell all of its products direct, instead of, as heretofore, disposing of the greater part through Arnold Hoffman Co., Inc., of Providence, R. I. The company expects to occupy its permanent executive and general offices at 25 West 43rd St., New York, on and after March 5. Accordingly on and after that date, all communications should be sent to that address.

J. C. HENRIQUES and M. A. STONE, JR., have organized a staff of consulting engineer, and formed the Engineering & Appraisal Co., Inc., with offices at 103 Park Ave., New York, opposite Grand Central Station. Their field of work will cover the design and construction of mills, factories, power plants and chemical works; the design and development of special machinery and the formulation of commercial propositions on which the formation of new manufacturing corporations may be based. The company is prepared to design and construct industrial plants for every purpose. Members of the staff are specialists in the utilization of waste steam and the application of steam to chemical and other processes; the derivation of oxygen, nitrogen and other gases; the application of refrigeration and cold storage; the evaporation and concentration of solutions and liquids, and the design and development of special machinery.

THE ADVERTISING ENGINEERS, INC., 50 Union Sq., New York City, has opened an office for the purpose of carrying on the business of counselors and complete service for advertisers of engineering and technical products. Curtis F. Columbia will act as Eastern manager. He was formerly publicity engineer for the New Jersey Zinc Co. and the United States Gypsum Co. and has for a great number of years been closely connected with the metallic industries. Associated with Mr. Columbia are Virgil G. Marani, former Building Commissioner of Cleveland; Victor Hugo Halperin, formerly advertising manager of the General Fireproofing Co.; F. W. Leggett, director of publicity of the Bell Telephone Co.

Manufacturers' Catalogs

THE AMERICAN STAVE & COOPERAGE CO., Chelsea, Mass., is distributing a booklet on its tanks, profusely illustrated.

THE METALLURGICAL RESEARCH ENGINEERING CO., Chicago, Ill., is issuing a series of useful charts giving in tabular form results of a number of physical tests on the steels of various analyses and heat treatments.

THE LINK-BELT CO., Chicago, Ill., has just issued two new catalogs. Book No. 375, entitled "Link-Belt Labor-Saving Elevators and Conveyors," illustrates and describes in 108 pages the many different types and the purposes to which they can be used. Book No. 380 is on electric hoists and overhead cranes, which covers in 100 pages electric hoists, monorail trackwork for electric hoists, electric telphers, overhead traveling cranes and revolving locomotive cranes, which are illustrated and described.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., is issuing a new small folder describing C-H Electric Space Heaters known as Pub. 494. One of the illustrations shows the space heater with a 2-ft. rule held alongside to illustrate further the fact that this heater is 2 ft. long. It is referred to in the folder as "Two Feet of Electrical Heat." A large broadside has also been printed, reproducing many of the current advertisements on this space heater and including in it a list of publications in which the advertisements are appearing, together with the dates. This company has also issued two booklets: Booklet A, on "Motor-Operated Brakes for Alternating Current Service," and Booklet S, on "C-H Magnetic Separators."

THE WALTER A. ZELNICKER SUPPLY CO., St. Louis, Mo., is distributing a folder (No. 275) giving a list of the special offerings of rails, cars, locomotives, steam shovels, generator sets, air compressors, engines, boilers, hoisting engines, pipe, steel piling, tanks, etc.

THE NORTON CO., Worcester, Mass., has just issued nine booklets as follows: Health Bulletin; Storage, Handling and Supervision of Grinding Wheels; Safety as Applied to Grinding Wheels; Alundum Tile and Terrazzo Aggregates; Test of Alundum Tile at Columbia University; Safety Code for the Use, Care and Protection of Abrasive Wheels; Indiana Hill an Industrial Village, by Clifford S. Anderson; Principles of Cylindrical Grinding and Norton Service.

HOLZ & CO., INC., New York City, is distributing Bull. No. 22-23, on the Holz Universal Photo-Micrographic and Macrographic Metallographic Bench Model 1920, for magnifications from 1 to 3,500 diameters, with apparatus for "selective" vertical illumination and other important improvements.

W. S. ROCKWELL CO., New York, has issued Bull. 200, which illustrates and describes in detail a new and novel type of furnace—side-opening heat-treatment furnace. It was developed to heat treat material varying widely in shape and size. This furnace is 36 ft. wide. Stock approximately this length may be placed in the furnace for heat treatment, or the furnace may be partitioned off into individual chambers 5 ft. 9 in. wide or multiples thereof. Thus, while one chamber was heating stock say 5 ft. long, the other part of the furnace could be heating stock either much longer than 5 ft. or smaller. This furnace is now being widened to provide a working chamber 105 ft. wide in the clear, the length remaining the same. This increased width will provide facilities to anneal and heat treat the largest shafts and similar pieces handled in this forge shop. The doors of the furnace can be raised or lowered independently of one another. They are operated by compressed air and counterweights. They are dovetailed and form guides within themselves that prevent the escape of hot gases. The roof of the furnace is constructed of flat tiles, avoiding the thrust caused by the ordinary arch construction. The furnace is underfired, assuring a uniform heat treatment. It is provided with preheaters over the vents. The air in these preheaters thus returns through the burners the greater portion of the heat in the spent gases that would otherwise be lost. The fuel consumption in this furnace is extremely low, due to the efficient application of the heat and the utilization of the waste heat ordinarily lost. Oil or gas may be used as fuel. Expansion of the brickwork, or of the furnace as a whole, is taken up by the heavy springs at the side of the furnace.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, March 17, 1920 — *Number* 11

Mr. Lane Points the Way

IN HIS letter of resignation as Secretary of the Interior the Hon. FRANKLIN K. LANE wrote to the President as follows:

"In parting, let me say a general word as the fruit of my experience here. Washington is a combination of political caucus, drawing room and civil service bureaus. It contains statesmen who are politicians and politicians who are not statesmen. It is rich in brain and in character. It is honest beyond any commercial standard. . . . But it is poorly organized for the task that belongs to it. . . . Ability is not lacking, but it is pressed to the point of paralysis because of an infinitude of details and an unwillingness on the part of the great body of public servants to take responsibility. . . . We have so many checks and brakes upon our work that our progress does not keep pace with the nation's requirements. We could save money for the Government if we had more discretion as to how we should use that given us. . . . As matters are now devised there are too few in the Government whose business it is to plan. Every man is held to details, to the narrower view, which comes too often to be the department view or some sort of parochial view. We need for the day that is here and upon us . . . more opportunity for planning, engineering, statesmanship above, and more fixed authority and responsibility below."

These are words of wisdom. In somewhat the same line of thought the Hon. FRANK O. LOWDEN, Governor of Illinois, said at a meeting in Brooklyn the other day that while industry has advanced within the last century to meet new conditions, the art of government had stood still. In some respects it had gone backward. We have bureaus and commissions by the hundred, and these overlap in function, but lack correlation. We have no department of public health, and yet there are about forty-two bureaus in Washington that relate to it. On taking office in Illinois he found a great number of commissions, and commissions are usually given to discussion rather than to action. In co-operation with the Legislature they succeeded in superseding the commissions with nine departments of government—and no more—with one man at the head of each, and he is made responsible for its conduct. The head of the Department of Finance has no other obligation, but he can withhold disbursements even of money appropriated if he does not believe the expenditure is proper. The appeal over such a decision is to the Governor. In the United States Government all departments are spending departments. Even the Secretary of the Treasury is loaded with administrative details—such as the United States Coast Guard, Public Buildings, etc.—and appropriations for all departments may be spent in full without check. Unless our wasteful methods are reorganized, taxation will constantly grow, and with the present burden, if we run into bad times, it will take us a very long time to overcome them; because no one will venture expenditures for new enterprises with the increased hazard of loss and the certainty of taxation if profits ensue.

This sounds right to us also. The fact is for nearly 150 years we have been run by politics in affairs of government, and politics have failed. We are growing impatient under the inefficiency of political administration. We are sick and tired of politics, although we must have them, just as we must have boots and shoes. But just as we do not want to restrict our lives and thoughts to boots and shoes, so we do not want our government to consist of politics and nothing else. The inefficiency of both Republican and Democratic Congresses of the United States for many years past is a thing to be ashamed of. We have not the patience to listen to the men who "point with pride" to the achievements of any of them. We want to hear of opinions and plans without any fireworks. That letter of HERBERT C. HOOVER to his friends probably did not please the politicians. They were not used to it. They want points to yell over, and this was modest but earnest. To us it appealed as the very attitude of mind which we long for in our representatives in government.

Practicing Industrial Good-Fellowship

THERE is more merit than fault (until the habit becomes a nuisance) in the man who stands up for his home town and district. The trouble is that in our patriotic boasting we may confine ourselves to the talking points that we have learned, and mere recitations often lose weight and even interest in discussions among the thoughtful. Thus a vapid, fat, lazy, inert man of the East, who cannot see the difference between an inch and a centimeter, is likely to make the observation with half-closed eyes, between the puffs of his cigar, that a man from the West is unable to perceive the fine distinctions which are clear to his brother of the East. And a similarly undesirable person from the West sometimes offends with the assertion that because a man is from the East he must perforce lack vision and understanding. Such persons give us a pain in the mind.

On the other hand we may observe traditions and habits that have developed in various parts of the country which are, in a way, sectional and it is to a certain conflict of habit in industry between the East and the West that we now desire to call attention.

When the late Dr. JAMES DOUGLAS undertook to engage in smelting copper, he was modest enough to be-

lieve that he did not know everything there was to be known on the subject. He caught, let us say, the air of the great plains and the big hills, and he thought large. He felt that no matter what his part in it might be, the American copper industry was a thing in itself, and the more it prospered the better it would be for all concerned. He was scrupulous in the defense of the interests for which he was responsible, but as an artist in smelting copper he wanted to learn as much as he could, and he was enough of a psychologist to know that the way to learn is to tell. So he kept open house for metallurgical engineers and, since turn about is fair play, others made him welcome also.

The Western copper mining and smelting industry grew by leaps and bounds, and its traditions of hospitality remain to this day. Occasionally an engineer or metallurgist of one of the great establishments in Montana or Arizona goes on a vacation for a month or so, and instead of coming to New York to analyze Broadway it is probable that he will go where competitive operations are in progress and visit his brother engineer or metallurgist. Everything is open to him. He finds some new wrinkles that he resolves to adopt, and he tells his friend how he or his staff has conquered difficulties that still loom large in the eyes of his host. The patentable ideas in industrial improvement are far fewer than those that are not patentable, and as a result of this friendly visit the stockholders of both concerns may profit. There is no tragedy in the accretion of profits by competitors.

We have not reached the last word in metallurgy, by any means, but just because of this open-mindedness and give-and-take quality of Western engineers they have ventured to build much larger units and they have succeeded in producing metals with far greater economy than if everyone had worked in secret and been limited by his own imagination and technical experience. It is fair to say that industrial good-fellowship has contributed largely to the American copper industry.

This tradition is less developed in the East in chemical industry. We have in mind two engineers who came from the West and were engaged as respective managers of competitive works making a standard product. They had worked together in a friendly way in the West and were familiar with the tradition of industrial good-fellowship. One of them was even imbued with the belief that this tradition might find a welcome in the East. He had trouble with a certain step in a process and was about to post off to his friend to confer with him about this and other methods of procedure. He planned, as usual, to match his experience with that of his friend and to see how conditions and quality and yields might be improved. He had some ideas that he hoped to try out, but he wanted first to talk them over with someone competent by education and experience to advise with him. The directors got wind of his intention and they proceeded to throw fits. Their manager was about to confer with their greatest competitor and thought to give away all their secrets! (The competitive corporation in the meantime was doing very well, thank you, with *its* secrets.) Such a breach of sound business methods had never been heard of by the board, and the manager was informed, with such charity and patience as should be employed with innocent offenders, that he must not go. He had better not, they said in their abundant caution, even associate with his friend. If he could get the information desired without giving anything in return, that would be desirable, but he must bear in mind that the hazard of letting information as to their establishment slip out was to be avoided. On the other hand, if he could manage to lure away some employees that worked under his friend, this would find favor with them, and they were even prepared to make a special appropriation to accomplish it.

Here they struck a snag. The poor fellow suffered from inhibitions. He had grown up to believe that it was contrary to professional ethics to hire away employees from other works, and he would not even try to do so.

He is a chastened man, and the directors continue to direct—which is as it should be. Directors should direct or get out and give way to men who know enough to do so. But as we have intimated before, one of the greatest needs of chemical industry in America is resignations or obituary resolutions among the boards of directors of a considerable number of establishments.

Technicalities
Concerning Alcohol

ALCOHOL has long been distinguished by marked legislative attention, having been revenued and licensed for years and years and finally regulated to such a degree that only those proficient in law could make out exactly what rights still belonged to it. Even in regard to these, our most noted lawyers find scores of technicalities of a pro and con variety. As an illustration, take the brief of the law firm of ELIHU ROOT endeavoring to persuade the Supreme Court that the Eighteenth Amendment to the Constitution, which made national prohibition possible, was not legally adopted and is therefore invalid. Mr. ROOT contends that this method of legislation is novel, not supported by precedent and is distinctly opposed to proper procedure. Also the amendment "directly and substantially" tends toward the "destruction of the right of the several states to local self-government" and interferes with the taxing and police powers of the state.

It is a humorous incident that Congress in proposing the amendment left out the usual preamble advising the states that two-thirds of both houses of Congress deem the amendment necessary, which, by the way, ought to set an excellent example to those concerned with the enforcement of the law. Also the length of red tape to which users of industrial alcohol must submit ought to be beneficially influenced by this practical precedent in Congress. It is at least hoped that the preambles and other extravagant time-consuming non-essentials will not continue to play a predominant part in matters pertaining to industrial alcohol regulations.

New regulations for the alcohol industry have recently been enacted and a concise interpretation will be found on another page in this issue. A careful study is recommended to those who are in any way concerned with industrial alcohol, not only for their present guidance but to determine what changes can be made in future regulations to lighten the burden on the users of it in industry without impairing the effectiveness of the prohibition law. The Government is clearly on record as being desirous of promoting legitimate uses of alcohol. It remains for industry to co-operate with the Government in order to determine and put into effect regulations which will be satisfactory to all concerned.

Users should bear in mind that at present only four denatured alcohol mixtures are free from both governmental regulations and taxes and may be sold, distributed and used without any restrictions. The ten-part-wood-alcohol mixture has been withdrawn because of the great number of deaths caused by its use as a beverage. The courts have decided to hold for trial all parties found responsible in wood alcohol poisoning cases, and heavy sentences have been imposed on all those convicted. Nevertheless other denaturants, such as certain petroleum distillates, pyridine, nitrobenzol, sulphuric ether, etc., are more than filling the gap made by removing the ten-part-wood-alcohol product from the open market. It is hoped, however, that better formulas will be developed that will give the public a less obnoxious denatured alcohol, at once fool-proof and nonpotable.

While all authorized denatured alcohols are tax free, pure ethyl alcohol is allowed to go tax free only under bond and regulations, and only to those who make scientific application of it. Special care must be taken to prevent thefts and resultant misapplications, the occurrence of which results in the $4.18 tax being collected from the bond. There is no more ingenious burglar than the alcohol thief. He has been known to bore through the floor of a car or room right into steel drums, if necessary, to secure his prize. Desire is the mother of ingenuity.

The Steel Industry Can Function

FEARS entertained, or at least expressed, last December, that the iron and steel industry would not be able to function well this year, or at least during the early months, are now largely dispelled. The change in viewpoint is partly psychological, and therefore carries a favorable augury for other industrial activities of men. During the war the feeling was, "It can be done," but after the war there seemed to come a feeling, "It can't be done." There was always something claimed to be in the way. Since the steel industry was formerly noted for its sanguine temperament, its more courageous viewpoint at this time may be expected to be followed by a better feeling all around in industry.

The steel industry was afraid it would not have enough labor, or that if it had labor the men would not know how to work or would not be willing to work, and fears were also expressed that there would not be enough transportation, particularly for coal and coke. In January there was little complaint of labor shortage and not much of labor inefficiency, yet throughout the month there was much complaint of car shortages, affecting the movement of beehive coke, of coal for byproduct ovens and steel plants and of intermediate and finished products. Yet when records were compiled it was found that pig-iron production in January was 14 or 15 per cent greater than in December, and steel ingot production was 83 per cent of capacity, taking capacity at 49,000,000 tons a year. In December some mills had predicted that they would not be able to average more than about 75 per cent production during the first quarter of the new year, this being based on assumptions of a lower rate than that in January and of a higher rate in March.

The actual test of operation has furnished some other surprises, or divergences from prognostications. During the war there was heavy new construction of open-hearth steel furnaces, whereby a common estimate was that steel ingot capacity was increased by 40 per cent during the war, from about 35,000,000 tons a year at the beginning of 1915 to about 49,000,000 tons in 1919. Then it was asserted that steel-rolling capacity had not been increased correspondingly, hence at the close of the war, with the manufacture of shell steel, involving little rolling, discontinued, the steel industry would find itself capable of making more steel, in ingot form, than it could finish. Unfinished steel would therefore be found relatively plentiful and finished steel relatively scarce.

Nothing of the sort has developed. Ingots have not been offered in the market at all. Blooms and billets have been scarce and have brought very high prices relative to the average prices at which finished steel has been delivered. The circumstance is the more remarkable from the fact that the demand for finished steel as a whole has not followed the usual analysis or distribution among the various finished products. With such conditions, unfinished steel should be abnormally plentiful, through some finishing departments being unable to supply the demands upon them and other finishing departments having an especially light demand for their particular forms of product.

Another prediction made before the close of the war was that sheet rolling capacity would be found insufficient to the demand, because so few sheet mills had been built during the war. In the last analysis such a condition might be proved, theoretically, to exist at present, but the actual experience in the trade in the past few weeks has been of sheet consumers bidding up prices of sheet bars, purchasing any lots they could secure, and experiencing no difficulty in finding sheet mills with reserve capacity, ready and anxious to make conversion contracts to turn consumers' sheet bars into sheets for them. The fancy prices have been paid not for the conversion of the bars into sheets, but for the sheet bars themselves.

Again, there was argument as to the supply of basic pig iron. It was maintained in some quarters that there had been so much new construction of basic open-hearth furnaces that basic pig iron would be made extremely scarce, while one rejoinder was that the scarcity might not occur, because the steel mills would experience a greater scarcity of labor than the blast furnaces, whereby the steel mills would not be able to consume pig iron in proportion to their physical capacity. Pig iron did become scarce, it is true, and prices advanced rapidly, but the advance was led by foundry iron, not basic, the basic grade for a long time trailing far behind foundry iron in the matter of price.

These and other observations that could be made all make the same showing—that the steel industry really can function, and function well. It can operate in circumstances that were claimed would present insuperable obstacles. The industry should now take on fresh courage, forget theoretical obstacles, and bend all its energies toward building up markets, rendering service to consumers, producing its material at the lowest possible cost and encouraging consumption by selling its output at the lowest margin consistent with a fair return upon the capital and effort involved in production.

Readers' Views and Comments

Mr. Hoover and the Presidency

To the Editor of Chemical & Metallurgical Engineering

SIR:—In view of the notes you have published recently regarding Mr. Hoover and the Presidency you may be interested in giving your readers an opportunity to get a little deeper insight into the man and his history. The accompanying quotation is reported to be from a letter written by Mr. Hoover to Casper W. Hodgson, a Stanford classmate, and is taken from a recent issue of the New York *World*.

It discloses the saving grace of humor so essential to the peace of mind of those who become popular subjects of conversation.

> I have noted your feeling that I should answer some of the solemn discourses on my private life and crimes. I do seem to get into the way of politically minded folks even when trying to keep out of politics.
>
> Some things that have been said of me cause me a sense of financial oversight. For instance, I have made quite careful inquiries and I regret that so far I cannot find—
>
> (a) The $10,000,000 I am said to have made in my early youth, or even middle age, or altogether, or any respectable part of it.
>
> (b) The investments that I am supposed to have in Great Britain.
>
> Like the negro porter who was asked to change $10, I am grateful for the compliment. I am sorry that these sums do not exist, for they would be useful for Children's Relief.
>
> I have also given deep consideration to the other items mentioned:
>
> (a) Am I a British subject? Did I ever apply for such citizenship? No. Many generations of persecuted Quaker ancestors would rise in their graves at such a discovery. They should remain quiet, however, for no Californian could live three months in London climate and become a British citizen if he knew it. One thing that reassures me that this did not happen without my knowledge is that the British refused to allow me to come into their island during the war without an American passport. Also, I feel that my accent was disinfected of any English, French, Chinese, Russian or other taints by my presence in the United States a portion of every calendar year of my life except three—even including the five in which the United States has exercised its right to draft my services, a good portion abroad.
>
> (b) Did I ever rent a "residence" abroad? I plead guilty of this crime, but in mitigation I do appeal to the feelings of fathers who object to hotel life for babies and children.
>
> (c) What about the political lunch where I was supposed to have entered upon a dreadful conspiracy against the weal of the American people? My real distress in this matter is not to prove an alibi, or even to complain that my name was not even mentioned, as the guests assert, but it is that I was not even invited and therefore lost an excellent lunch.
>
> (d) I plead guilty to the criminal charge of pursuing my engineering profession in foreign parts again and again. I have a fervent hope, however, that this new doctrine of criminality will not deter our citizens from extending American professions and business anywhere in the world. They always bring something home and pay taxes on it.
>
> (e) I gather also that it is moral turpitude on my part to have managed large enterprises. The hope to rise from the ranks of labor to the ranks of management will, however, probably not be crushed from the hearts of the American boy even by this onslaught.

Whether Mr. Hoover is ever elected President or not, the politicians will at least have become acquainted with a man who is independent, incisive and direct.

ENGINEER.

Chemistry for Undertakers

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the December, 1919, number of the *American Funeral Director* there is a contribution by Prof. C. A. Moadinger on "Chemical Conditions of the Body and Fluids" which is so full of new ideas that I could not forbear to make a transcript of some of them for the benefit of my fellow-readers. In a boxed note on the text, it is stated that the professor comes from Brooklyn, which is confirmed by the telephone directory. From the same source it appears also that he is an undertaker. In regard to the chemistry of human bodies both in life and in death he states that only lately has he been able to resume his work, that in this he has addressed himself more particularly to elementary features, and that he has "gotten" it down to a state that he believes will be understood by his audience.

"The first chemical condition of the body" that he studied was the organic salts which go to make it up, and these organic salts, he tells us, are phosphates of lime and carbonate of lime. Next to water, phosphate of lime is said to be the principal ingredient of the body, while of the carbonate there is only one-seventh as much. If we have an excess of lime in the blood, there occurs a lime deposit on the inner and middle coats of the arteries; then we have arteriosclerosis.

If into a body which contains an excess of lime, embalming fluid is injected, why is it that the fluid does not seem to be assimilated, and why does the body remain soft? The professor puts the question and answers it, as follows: "You had an excess of lime in the blood. The excess of lime, by the action of the formaldehyde that you injected, caused the carbonate of lime, which is flakes. If you take a phosphate of lime solution, or lime-water, and put a little formaldehyde into it and hold it up, you will see it flaky all through. The carbon from the formaldehyde combining with the lime forms carbonate of lime, which is flakes, and these get into the little blood-vessels and capillaries and plug them so that no fluid is allowed to pass through. That is the condition you have with excessive lime in the blood." Evidently, flakes cause undertakers as much trouble as they do steel makers!

In cases of hardened arteries the professor notes that frequently the injections of embalming fluid seem ineffective; that the injection is "hard" and the bodies are not so rigid as they might be. "This," he says, "is due to the fact that your osmotic action was lost, the lime forming a coat on the inner walls and preventing the passage of the formaldehyde and other chemicals through the blood-vessels through the tissue. You know osmosis is the passage of one liquid through a membrane into another liquid."

Other difficulties in embalming he also attributes "to the action of the formaldehyde upon the lime, which forms a carbonate of lime."

"Another chemical in the body," he says, "is known as magnesium, and is found in the muscles and the brain, but more predominant in the muscles than in the brain—here we have again by the action of formaldehyde on this magnesium a carbonate of mag-

nesium formed, which is insoluble and forms flakes." Chloride of sodium he declares to be the most important chemical found in the body, and he says it is contained in all the parts; in blood, bones, brain, hair, and in every tissue of the body. He explains its ubiquity as follows:

> We must have salt, first as an alkaline in the blood to keep it in the alkaline condition; to keep it from coagulating so that it will give us a clear, perfect flow. Sometimes you crave something salty—which shows your system is in need of sodium chlorine to carry on the work of lubricating the blood—sodium chloride acted upon by formaldehyde produces no other chemical. But sodium chloride aids osmosis, and if it were used more in embalming fluids, you would get better osmosis. Common salt injected into the body aids in preventing the formation of carbonate of lime from phosphate of lime.
>
> We have a sodium potassium and potassium phosphate in the body, and these are found mostly in the kidneys—some are alkaline and some are acid. The action of formaldehyde on sodium phosphate and potassium phosphate has no bad effect outside the body.
>
> The sodium and potassium carbonates are entirely different because they contain a certain amount of carbon which is found in the body, and the action of formaldehyde on carbonates increases rather than destroys them, and we get a higher degree of carbonization so that we have a precipitate thrown down from the sodium and potassium carbonates.
>
> The sodium and potassium sulphates are in very small amounts in the body, and play but little part. If anything they aid considerably to cosmetic effects, and that is all.
>
> The formation of uric acid from eating fresh beef forms in the kidneys in the form of crystals which are insoluble. These crystals break down—decompose, as it were—to form carbonate of ammonia, which forms in the kidneys and gets in the urine. This penetrates the system and gives the peculiar odor to bodies dying from Bright's disease. In these cases the action of formaldehyde is entirely lost—it is changed into an entirely different composed part; the ammonia takes up more of the carbon from the formaldehyde, changes it back into an acid similar to formic acid, and the action is lost as far as disinfectant, astringent and preserving properties are concerned.

It is rare indeed that so many novel observations in chemistry are recorded in a single paper. Prof. Moadinger contributes two new organic salts in sodium phosphate and sodium carbonate. The reaction of formaldehyde in "forming" carbonates is worthy of note. A new definition of osmosis is contributed. We learn of the "predominance" of magnesium in human muscles, of the lubrication of blood by sodium chlorine, and of common salt as an "aid" to osmosis. The point as to the alternating acid and alkaline reactions of "sodium potassium and potassium phosphate" seems well taken, especially in regard to the kidneys, while an entirely unexpected function of formaldehyde in increasing "carbonization" is recommended to the attention of all persons engaged in work on synthetic resins. Entirely new is the action of sodium and potassium sulphates as aids to "cosmetic effects." It suggests additional research as to the cosmetic effect of lithium sulphate and opens up the entirely new field of *cosmesis*, whatever that may be. New to the writer also is the dissociation of uric acid to ammonium carbonate, and the third note on the behavior of formaldehyde, this time in the presence of ammonia.

Not infrequently, Mr. Editor, you have urged in your editorial columns the spread of chemical understanding among the people. I offer these selections from Prof. Moadinger's address before the Missouri Funeral Directors' Association as the very flower of popular chemistry.

MARTIN SEYT.

New York, N. Y.

American-Scandinavian Foundation Fellowships

THE traveling fellowships established by the American-Scandinavian Foundation of New York City promise to rival the Rhodes scholarship plan in interest aroused among American colleges. Twenty fellowships, each with a stipend of at least $1,000, and in some cases $1,200, will be awarded in May to American students, men and women, for technological research and humanistic study in the Universities of Sweden, Denmark and Norway. When it was announced a year ago that young American engineers and students of science would be given opportunity to study under such eminent scientists as Svante Arrhenius, founder of the theory of electrolytic dissociation, or Hjalmar Lundbohm, director of operations on the great iron mountains at Kiruna, officials of American technological institutions recommended for consideration the names of promising recent graduates. The men who were appointed, and who are now in Sweden, represent the best known scientific schools from Massachusetts to Wyoming. It is required that all candidates be of American birth, and all of these men had rendered scientific or military service in the army of the United States.

Scope of Fellowship Plan Extended

Since that time, the scope of the fellowship plan has been greatly extended. The number of fellowships has been doubled so that five students will be sent to Denmark and five to Norway in addition to the ten to be appointed for Sweden. Not only will fellows be appointed for the study of chemistry and physics, hydro-electrical engineering, metallurgy and forestry—in all of which subjects Scandinavian countries excel—but also for agricultural sciences and for language and literature. Denmark's agricultural system and her system of folk high schools have attracted to Denmark many an educational commission from foreign countries; and English literature has drawn freely from the North from the time of the sagas of Beowulf to that of the tales of Hans Andersen. Fellows will also be appointed to Norway for the study of oceanography, the new science of the sea fathered by Fridtjof Nansen and Helland-Hansen; and for the study of weather forecasting under Prof. Bjerknes of the Bergen Geo-Physical Institute.

These twenty fellowships for American students are one-half of a group of forty exchange fellowships between America and the Scandinavian countries financed on the one side by twenty American individuals and corporations, and on the other side by twenty Scandinavians. In other words, ten students will come here from Sweden, five from Norway and five from Denmark.

How to File Applications

Application papers with letters of recommendation must be filed at the office of the American-Scandinavian Foundation, 25 West 45th St., New York, before April 1. The selection of fellows will be made by a jury of university professors and technical experts appointed by the Foundation.

Successful candidates will be notified about May 1 and are expected to sail from New York in early summer, so that they may have several weeks before the opening of the universities, to travel about in the countries to which they are appointed, familiarizing themselves with the language and life of the people.

Award of the Nichols Medal to Dr. Langmuir

THE Nichols Medal of the American Chemical Society was awarded for the second time to Dr. Irving Langmuir of Schenectady on Friday evening, Feb. 5, at Rumford Hall of the Chemists' Club, New York. Despite snow, sleet, rain and wind, it was a capacity audience, and its enthusiasm was as great as though some new and gifted star had arisen in the opera firmament.

Prof. Ralph H. McKee of Columbia presided, and Dr. William H. Nichols, past president of the Society, made the presentation.

Dr. Nichols gave a brief sketch of Dr. Langmuir's life and work, and with no regret that he had given up teaching and devoted himself more abundantly to research with the splendid opportunities and facilities at hand in Schenectady, he could not resist the thought what an inspiration he would have been to the coming generation of chemists if he had continued to teach. Dr. Nichols intimated that plans were in the making to improve materially the situation of professors of chemistry at universities and technical schools. Details may not be divulged as yet, but he hoped they would be in initial operation within the coming year. In awarding the medal he expressed the general approval of the recipient's fellow chemists, not only of the originality and vast scope of his work, but also of his constant disposition to accord credit to all those whose contributions had illuminated him and who had aided him in his research.

DR. IRVING LANGMUIR

In accepting the medal Dr. Langmuir said that his curiosity in regard to the structure of atoms and molecules had begun when he was studying physical chemistry with Professor Nernst at Göttingen. Research in reaction velocities fixed in his mind the idea that there must be reasons for the phenomena exhibited, and that it was our business to find them out. Atoms and molecules had seemed real things to him rather than vague and shadowy concepts. His subsequent work confirmed this curiosity.

About a year ago he had been asked to deliver an address on adsorption at a colloquium of the staff of the research laboratory of the General Electric Co. at Schenectady. He felt that such a lecture would be but a review of the work already done and already available. On the other hand, in regard to the structure of atoms and molecules there was a field in which thought should be encouraged. The researches of physicists indicated atomic structures as built up of electrons revolving in circular or elliptical orbits around a nucleus. But if chemical reactions depend upon atoms and molecules, these must have some definite structure; they must have individuality; and there is not much individuality in concentric circular orbits all in one plane.

In a short section relating to the Cubical Atom in a paper on "The Atom and the Molecule" by Prof. G. N. Lewis of California, and published in the *Journal of the American Chemical Society* in 1916, he believed that enlightenment might be found. This, he said, had been his real starting point, and his work followed that of Prof. Lewis, who had, however, considered only the simpler elements. The speaker thought the theory might apply to all elements, and subsequent research has confirmed him in the belief. So leading, indeed, was this little four- or five-page note on the Cubical Atom in its suggestion that he ventured the opinion that Dr. Lewis was at least as fully entitled as himself to receive the medal. During the war, while engaged on submarine problems, he met many foreign men of science of the first rank and was surprised to observe that Lewis's contribution seemed to be wholly unknown to them.

We can, he said, count the atoms in a gram molecule more easily than we can take the census of a city. Atomic and sub-atomic magnitudes are as available to us as those of astronomy, but we are less accustomed to consider them. A few examples may help. Thus if a lump of matter the size of a baseball were magnified to that of the earth, the atoms would be the size of a baseball. If the molecules of a cubic inch of air were changed to grains of sand small enough to pass through a 100-mesh sieve, the sand would fill a trench 3 ft. deep and a mile wide from New York to San Francisco. Recent work has shown that atoms consist primarily of a nucleus. Here all the positive charges are concentrated. The number of positive charges in the nucleus of an atom is the same as the atomic number of its element in the periodic scale. Thus hydrogen is No. 1, helium No. 2, lithium No. 3, etc., right up to uranium which is No. 92, and the nuclei of the atoms of different elements differ from one another in the number of their positive charges in this respect. Arranged around each nucleus are electrons in the same number as its positive charges. All electrons are alike. The nucleus of an atom is very small and its diameter is not more than one hundred-thousandth of that of the atom itself. If we were to magnify an atom to the diameter of one mile, then the electrons would be about 5 ft., while the nucleus would be about the size of a walnut.

Bohr's theory of rotating electrons has found favor among physicists, but it does not satisfy the chemist. It does not explain the simplest facts. It does not explain, for instance, why lithium is not an inert gas. Lewis could not accept Bohr's theory, and he made electrons stationary, but this concept is not necessary. All that Dr. Langmuir claims is that whatever the rotation or movement of an electron in an atom may be, it is not in an orbit around the nucleus except perhaps in the cases of hydrogen and helium, but rather within a circumscribed space in relation to the nucleus. An electron in an atom has, to borrow a biological term, its restricted *habitat*, and within this habitat there is no objection to its rotation or movement. This provides three-dimensional space for the electron instead of holding it to rotate in a single plane of two dimensions. The key to the octet theory is the inert gases. These are stable, do not form molecules, and apparently have a

structure in which an approximate balance of forces obtains. Low boiling points indicate this, for the obvious reason that the field of force surrounding the atoms must be very slight. If we should consider consciousness as a function of inert things, it would appear that these erstwhile pariah elements represent an ideal of matter. All chemical energy, change and reaction would appear as due to an effort to achieve their constitution. They represent a form of arrangement toward which electrons of the outer shells of other atoms seem driven to compose themselves. Abundant reasons were given to explain why, as the associations of positive and negative charges of these inert elements grow in complexity with increasing atomic weights, the number of other elements which may conform to their structure also increases. We shall give but a slight outline of some of the features presented, and refer to Dr. Langmuir's several contributions to the *Journal of the American Chemical Society*, of which the first appeared in June, 1919, and to an article on the Langmuir Postulates by Ellwood Hendrick in our issue of July 15, 1919.

Outline of the Langmuir Postulates

The hydrogen atom has one positive charge at the nucleus and one electron. Helium has two positive charges and one electron in either hemisphere surrounding the nucleus. That of the atom of every other element has positive charges corresponding to the atomic number and, as in the helium atom, a pair of electrons, as with helium, surrounding it. Additional electrons to make up the number of the positive charges are arranged within concentric spheres outside this kernel (consisting of the nucleus and two electrons) so as to indicate a cube. In other words, if we were to divide two concentric spheres surrounding the kernel into eight parts we should find within the eight spaces between the spheres the "habitat" of each electron, and this is called its cell. It does not leave this cell unless its place is on the outside of an atom. The average position of electrons in each shell or pair of concentric spheres is at one of the eight corners of a cube. The chemical activity is chiefly on the outside of atoms, and among the inert gases all eight places in the outer shell are occupied by electrons, which explains the internal balance of forces and the chemical inertia of their atoms. No other element has this arrangement, and when the octet-forming drive of the seven outside electrons of an atom of fluorine, for instance, draws from an atom of sodium its single outside electron so that the arrangement of electrons of both is similar to that of a neon atom, then the fluorine atom becomes a fluorine ion, because it is negatively charged, while the sodium atom becomes a positively-charged sodium ion. (The atomic numbers are F, 9; Ne, 10; and Na, 11). Electrostatic force will hold the two ions together. Such combinations of ions do not form molecules, but join in a lattice, as described by Bragg. Molecules are formed as set forth in the papers referred to by the sharing between atoms of pairs of electrons in common.

The concept of the cubical atom is one of convenience rather than of precision, as is the benzene ring. Atoms of the inert gases are probably in fact approximately cubical in the arrangement of their electrons, but in a molecule consisting of atoms and ions having different concentration of charges at their nuclei, it stands to reason that the cubical forms are subject to considerable distortion.

A pleasing incident was a number of models of atoms and molecules prepared by Leffert Lefferts, which were displayed with gusto by Dr. Langmuir. That of acetic acid, which looked something like the framework of a toy airplane, was immediately recognized by the speaker for what it was designed to be, as indeed were all the other models as well.

Given adequate familiarity with the Langmuir Postulates along with the proper scholarship in science, a chemist should be able to visualize definitely the structure and form of atoms and molecules, and to consider the play of forces within and without them. He should even be able to predict within approximate limitations the physical qualities of a substance before it is synthesized. He should be able to foretell the gas, liquid or solid phase at ordinary temperatures, its electrical conductivity, crystal forms, color, etc.

When Dr. Langmuir presented his first paper on the subject at the Buffalo meeting of the American Chemical Society, Professor Washburn of Illinois offered the opinion that the occasion was momentous, and that we had listened to the greatest contribution to chemistry since John Dalton presented the atomic theory. We have not heard that he has changed his opinion.

British Production of Alcohol From Coal

The extraction of alcohol from coke-oven gas on a commercial scale was proved to be possible at a meeting of the Cleveland Institute of Engineers at Middlesbrough (England) by Ernest Bury, of Skinningrove Iron & Steel Works. Mr. Bury showed that he had succeeded in extracting ethyl alcohol and its derivatives. The practical working of Mr. Bury's process at the Skinningrove plant, where 5,800 tons of coal are carbonized per week, revealed an average yield of 1.6 gal. of alcohol per ton of coal carbonized. The ethylene in the gas is absorbed in sulphuric acid, forming ethyl sulphuric acid, which is hydrolyzed to ethyl alcohol.

The total weight of coal reduced to coke in the United Kingdom in 1918 having been 14,635,000 tons, the application of Mr. Bury's process to the entire amount of coal would yield 23,416,000 gal., the value of which would be £2,341,600 ($11,395,000). The recovery of alcohol at the gas works of the country would yield a further 27,000,000 gal., or alcohol and benzol, taken together, would amount to 114,000,000 gal., to meet the requirements of the country, which amount to 160,000,000 gal. per annum.

Condition of the Belgian Plate and Window Glass Industry

The revival of the Belgian plate and window glass industry continues in spite of the shortage of industrial fuel and certain raw materials, notably sodium sulphate, and the transportation difficulties.

The average increase in labor costs since the armistice has been 150 per cent, taking into consideration the shortening of the hours with the general introduction of the 8-hr. day. A general increase of 10 per cent was recently granted, and operatives are now claiming further advances of from 10 to 20 per cent.

At present all of the eighteen window glass plants in operation before the war are again producing; in nearly all of them, however, only one furnace is lighted, and others cannot be started until regular fuel supplies are forthcoming.

Government Chemists' Salaries

Although chemists are classified separately, as are all of the other technical groups, they receive the same salary recommendations from the Commission on Reclassification of Government Salaries which reported to Congress on March 12. The Commission has not recommended as great increases as were recommended to it by the chemical advisers from the employees themselves, but the increases, if they are approved and accepted by Congress as the basis for action, will be sufficient to reduce materially the difficulty of holding the right sort of men.

To carry out the work started it is recommended that the Civil Service Commission be greatly strengthened and its functions enlarged to include the maintenance of continual classification work and adjustments of wages to meet changing economic conditions. Many other aspects of the working conditions, vacations, retirement, etc., are covered.

Senator Jones of New Mexico, chairman of the joint Congressional Committee on the Reclassification of Salaries, commented on the report as follows:

> Generally speaking, the lower clerical services and lower grades of other services have been remunerated reasonably well. They have received, perhaps, more than is paid for similar service in private employment. In the technical branches of the service, however, the pay has been grossly inadequate. It has not been comparable at all with the salaries paid for the same service in private employment.
>
> Our report will show that there was a crying necessity for this work. The personnel in the Government service is being employed and the work is being conducted without reference to any system. There is little to prompt efficiency and literally nothing to insure a maintenance of effort. To my mind one of the most important features of the report is that part which contemplates increased pay for increased efficiency and decrease in pay when there is decrease in efficiency. If this can be put into practice, I believe it will enable the work of the Government to be carried on more effectively with fewer employees. It will remove injustice and will increase the morale in the Government service.

Production Costs in the Dye Industry

The Tariff Commission has recently issued a pamphlet (Tariff Information Series No. 15) on costs of production in the dye industry during 1918 and 1919. The report is divided into two parts: The first contains a discussion of tables that show in detail the costs of sixteen intermediates and fifteen dyes; the second compares these domestic costs with the prices at which these products sold before the war and at which they are now selling in various markets.

In view of the unstandardized and varying methods of production and of accounting in this industry, the Tariff Commission strongly emphasizes the uncertainty of conclusions drawn from this report and the possibility of error in administrative action based upon such data. The figures are, however, the most trustworthy that can be immediately secured under present conditions in the industry, and in any discussion of the cost of production, the tables given in this report must be accepted as the nearest approach to accuracy now possible.

Tables VI and VII of the report are of particular interest in that they compare American prices on about forty dyes during the period from 1917 to February, 1920, with the German prices f.o.b. warehouse in the United States in 1914 and the reparation commission's prices with the mark valued at par. Table VI gives prices in dollars per lb. while Table VII gives relative prices on the basis of 100 for the German prices of 1914. The accompanying table gives, by way of illustration, the figures for malachite green taken from these two tables.

COMPARATIVE PRICES OF MALACHITE GREEN

	Dollars per Lb.	Relative Prices
German prices, 1914	0.390	100
Tariff Commission report, 1917	6.280	1,610
Tariff Commission report, 1918	5.60	1,435
Market prices, February, 1920	3.50	898
Reparation commission, mark at par	3.2414	831

A marked decrease in the prices of the American products from 1917 on will be noted in the case of nearly all of the dyes listed. It will be noted that for the most part the German prices (reparation commission) are a little higher than domestic prices and that if they were revised with the mark valued at 20c. (the German offer to Dr. Herty), the quotations in the two countries would be surprisingly close together. Furthermore, the reparation prices do not include duties, freight charges, etc., which would have to be paid before the goods could reach the ultimate consumer in the United States. This does not mean necessarily that the American producers can successfully compete in all phases of the dye industry, because in some classes of products, such as vat and alizarine dyes, which are not shown in these tables, but which are of fundamental importance to a well-rounded industry, the foreign producers still have a competitive advantage born of long practice in complicated productive processes. Other complicating factors which make it impossible to draw general conclusions from these price comparisons are conditions of the rates of international exchange.

Pennsylvania Safety Congress

The Pennsylvania Safety Congress for 1920 will be held at Harrisburg, March 21 to 25 inclusive. This Congress is a continuation of the conferences devoted to welfare and efficiency which were held prior to the war, but which have been discontinued since 1917. Arrangements for the Congress are being made by the Department of Labor and Industry, Harrisburg, which will furnish programs and other information upon request. Some topics to be discussed are the cost of industrial accidents, relations between foremen and employees, Americanization, women in industry, rehabilitation of the industrial cripple, occupational diseases and similar subjects.

Tariff Bills Before Senate

Before this issue appears in print it is probable that the Senate Finance Committee will have reported favorably all of the tariff bills which have passed the House and are now pending before the Senate committee. The dyestuffs, laboratory glassware and magnesite bills already are on the calendar and it is probable that similar action will be taken with regard to the measures prescribing duties for tungsten and zinc.

In reporting the laboratory glassware bill, which also carries laboratory porcelain ware, optical glass, scientific and surgical instruments, the committee said:

> Your committee is satisfied from the showing made that we have the skill, the men, and the manufacturers who are willing and able to produce a better quality of articles than can be produced in any other country, and in quantities sufficient to supply all the demands of the United States, if they are properly protected.

Aluminum Rolling-Mill Practice—I Commercial Pig and Scrap

The First of a Series of Articles Discussing the Details of Rolling-Mill Practice for Aluminum, Including All Phases of Work From Pig Metal to Finished Sheet—Metal for Melting Is Considered in This Installment

By ROBERT J. ANDERSON and MARSHALL B. ANDERSON

THE practical details involved in the commercial production of aluminum sheets have not been described hitherto, so far as the writers are aware. A few papers dealing with the working and annealing of aluminum and its light alloys have appeared, to which detailed reference will be made later, but as to the rolling of substantially pure aluminum for the manufacture of sheets, very little, if anything, is on record. With the thought that a detailed discussion of the problems involved in aluminum sheet rolling may be of interest to the non-ferrous industry in general and to aluminum rolling-mill superintendents in particular, the present series of articles is offered. The scope will be mainly confined to the commercial manufacture of practically pure aluminum sheets, but a few notes on the rolling of certain light aluminum alloys will also be included.

General Considerations

Aluminum rolling, for the purpose of manufacturing sheet aluminum, differs from steel, brass and copper rolling in at least one marked essential, viz., the relatively low temperatures employed for hot work; further, all of the final reduction to gage is performed in the cold. Relatively low temperatures are employed for hot rolling, because of the relatively low melting point of the metal, i. e., 658.7 deg. C. In finishing to gage, depending upon conditions, the rolling may be done entirely without annealing between passes, or there may be some annealing done. At the present time, the most suitable rolling and annealing temperatures which should be employed for definite conditions are subjects of considerable conjecture. In fact, considerable doubt is entertained by the writers that many systematic scientific investigations on these matters have been made. However difficult the proof of that statement may be, the fact remains that very little information is available. A good field would appear to be open in aluminum rolling for the application of the methods of physical metallurgy; the use of the microscope in studying the changes brought about on annealing worked aluminum sheet should result in information of real value to those engaged in aluminum rolling. If duralumin is to be rolled in large quantities and to meet exacting specifications, no reasonable amount of control can confidently be expected without the metallographic microscope. The main immediate outlet for duralumin will be in the form of sheets, rods and tubes, and the structural changes resulting from working, heat treatment and aging can be interpreted most readily by microscopic methods in conjunction with physical tests.

In order to present a broad survey of commercial aluminum-rolling practice, together with the more important details involved, the discussion is divided into two main parts, first, the production of rolling ingots, and second, the mechanical treatment of aluminum. The various processes through which the metal passes from the time pig aluminum is unloaded from cars until the finished sheets are boxed and ready for shipment will be set forth. Unless otherwise stated, the aluminum referred to in the following paragraphs is metal containing 99 per cent Al and over (based on the difference method of analysis), with copper, silicon and iron in subordinate amounts.

Commercial Pig Aluminum

Commercial aluminum of fairly high purity is obtainable in large quantities, and such metal containing over 99 per cent Al goes into much of the present output of aluminum sheet. About 98 to 99 per cent metal is also rolled, and considerable secondary (remelt) aluminum is used for sheet manufacture. Primary or virgin aluminum is ordinarily received by the rolling mill in the form of cast pigs of various sizes and weights. Two typical commercial pigs are those known as 33-lb. (15-kg.) four-notch bars and 3-lb. (1.4-kg.) six-notch bars, but larger or smaller pigs may be furnished according to requirements.[1]

TABLE I. VARIOUS SPECIFICATIONS FOR PIG ALUMINUM

Navy Department Specifications for Ingot Aluminum

Chemical Properties: The chemical requirements shall be in accordance with the following table:

Al (Min.) Per cent	Fe (Max.) Per cent	Si (Max.) Per cent	Other impurities (Max.) Per cent	Sum of Fe and Si and other impurities. Per cent
99.40	0.60	0.60	0.10	0.60

Bureau of Aircraft Production Specification for Ingot Aluminum

Ingot aluminum shall be ordered under three grades, conforming to the following chemical requirements:

Grade	Al per cent (Min.)
Special	99.5
Standard No. 1	99.0
Standard No. 2	98.0

American Society for Testing Materials Tentative Specifications for Aluminum Ingots for Re-Melting and for Rolling

Two grades of aluminum are considered under these specifications, as follows:

A grade, containing not less than 99 per cent Al
B grade, containing not less than 98 per cent Al.

There are two well-defined grades of primary aluminum pig, viz., grade 1 and grade 2. The former is supposed to contain over 99 per cent Al, and the latter 98 to 99 per cent Al. These grades are also referred to as grades A and B, respectively. Typical specifications for aluminum pig may be cited. Table I shows the specifications of the Navy Department and the Bureau of Aircraft Production, and the tentative specifications of the American Society for Testing Materials.

[1] The nomenclature regarding forms of aluminum is rather muddled; for example, pigs are also called bars and ingots. For the sake of uniformity, metal for melting will be called pig aluminum, and metal for rolling will be termed ingot.

In connection with the extracts in Table I from the complete specifications, various instructions are given that the metal must be of uniform quality, strong, tough and sound; the specifications also state that the pig must be free from blowholes, shrinkage cracks, foreign matter and other defects. Further amplification on this subject is not considered necessary in the present article, and the writers' object in citing the above excerpts is merely for the purpose of indicating the general trend. Actually, specifications for aluminum ingot have not been entirely settled upon as yet.

The chief impurities found in the present-day commercial aluminum are copper, iron and silicon, so far as is now known, although the recent work of Rhodin[2] indicates that appreciable amounts of aluminum oxide (calculated as Al_2O_3) are usually found. Whether the quite large amounts found by Rhodin are normally present in average virgin pig aluminum is somewhat doubtful, but any difference method for aluminum based on determinations of copper, iron and silicon and omitting aluminum oxide is certainly liable to be in error. The presence of appreciable amounts of aluminum nitride, aluminum carbide and other aluminum compounds, as well as occluded particles of the reduction pot bath, is yet to be established, but apparently merits consideration. The supposition most generally held at the present time is that the normal and usual impurities in primary aluminum pig are copper, iron and silicon; these elements are usually determined in analyzing aluminum pig; the difference between 100 per cent and the sum of these elements is said to be aluminum. The writers are unable to accept this view of the matter and think that the difference represents aluminum plus aluminum oxide at least, and possibly some other compounds.[3]

As indicative of the composition of typical aluminum pig, the analyses in Table II may be consulted. With the exception of sample 10, these were all classed as grade 1. High-grade commercial metal may contain up to 99.6 per cent Al, but under the present reduction practice it is apparently not feasible to attempt any higher degree of refinement.

TABLE II. TYPICAL ANALYSES OF ALUMINUM PIG

Sample number	Percentages of Elements				
	Cu	Si	Mn	Fe	Al
1 1	0.09	0.29	nil	0.30	99.32
2	0.16	0.27	trace	0.36	99.21
3	0.12	0.34	trace	0.34	99.20
4	0.11	0.37	trace	0.32	99.20
5	0.12	0.44	trace	0.30	99.14
6	0.11	0.40	trace	0.36	99.13
7	0.18	0.40	trace	0.32	99.10
8	0.19	0.42	trace	0.31	99.08
9	0.23	0.35	nil	0.40	99.02
10	0.22	0.45	trace	0.39	98.94

Methods for Sampling Aluminum Pig

When shipments of aluminum pig are received at the rolling mill, samples for chemical analysis should be secured, and the shipments should be checked chemically on receipt. The car shipments are weighed and placed in a stock storage according to lot, and the metal is drawn out at future intervals for melting and casting into rolling ingots.

There are several methods in use for sampling shipments of pig aluminum, and these vary in accuracy with the mode of sampling as well as with the size of the shipments. For sampling carload lots or smaller lots of pig aluminum, it is necessary to select pigs at random. For larger lots, as many samples as necessary may be selected according to the judgment of the chemist, who should supervise all sampling. In any event, it is better to secure too many pigs rather than too few.

In the fabrication of sheet aluminum, where for certain grades of sheet the specifications call for all-virgin rolling ingots, it is possible to obtain a reasonable check on car shipments by analyzing samples from various casts, say the first, middle and last casts from the melting furnace charge. Of course, this will not be possible under normal conditions when scrap aluminum is charged with the virgin pig, unless the disposition of the scrap is followed; that is a difficult matter to attempt in any plant and is hardly worth while.

For 33-lb. (15-kg.) pigs, the metal should be drilled through each notch, the separate drillings well mixed, and run over with a magnet to remove any iron contamination from the drill or drill press. Sufficient of the well-mixed drillings, about 25 to 50 g., are retained for chemical analysis. Small six-notch pigs may be drilled through each notch also, in as many places as is necessary to obtain a sufficient sample. It may be advisable in cases where more accuracy is desired to melt together in a graphite crucible sufficient pieces broken from ingots, say the end and center notches, for six-notch pig; when molten, a dip sample may be taken, poured into a chill mold, and drilled in the ordinary way at numerous points. The well-mixed drillings constitute the sample. This procedure is hardly advisable except in case of dispute. Drillings should be fine, thin chips. Coarse, uneven drillings, or those which come in long curls are undesirable, since they will be non-representative in case of segregation in the pigs. Further details will not be elaborated, since this is a matter of more particular interest to chemists than mill managers.

Scrap, Briquets and Bales

A large amount of aluminum[4] is turned over annually in the form of scrap, some of which goes into melting-furnace charges for ingot production and the remainder into foundry charges for alloy castings. Roughly, the scrap aluminum produced in a rolling mill with a fabricating department may be divided into three classes, as follows:

(a) Furnace scrap, including splashings from tapping and pouring, and drippings and skimmings from crucibles.

(b) Rolling-mill scrap, made up of slab and sheet shearings; buckled slabs and sheets which have caught in the mills during rolling; and defective sheets such as those which are rejected because of occluded dross, stains on annealing, and for other reasons.

(c) Fabricating scrap, resulting from sundry fabricating processes, and including shearings, clippings and punchings from punch-press operations, chips, fine and coarse "hay" from beading and trimming operations, and so on. Melting-furnace scrap and medium and heavy rolling-mill scrap is usually returned as such to the furnace; there is little opportunity for contamination by foreign materials; they are also so massive, with the exception of shearings from light-gage sheets, as to be less liable to oxidation during melting than fine scraps.

[2] J. G. A. Rhodin, "Contributions to the Chemistry of Aluminum and Aluminum Alloys," *Trans.*, Faraday Soc., January 1919, vol. 14, pp. 134-49.

[3] There is sufficient evidence to show that other oxides may be present, but that is a matter which will be dealt with in a later paper.

[4] J. P. Dunlop, "Secondary Metals in 1917," Mineral Resources of the United States, 1917, Part I, pp. 327-29.

For economical handling, light rolling-mill scrap and fabricating scrap should be baled, and the latter possibly briquetted, although it is often charged in its original scrap condition. There is no necessity for attempting to bale large shearings, such as from slabs, plates and heavy sheets, nor do they lend themselves readily to baling. Fine fabricating scraps and long, thin shearings, such as result from re-squaring cuts on light-gage sheets, should be baled. In the case of fine "hay," it appears that briquetting might be advantageous.

A mechanical baler can form a bale of convenient weight and dimensions for charging; such a bale may have approximate dimensions of 12 x 12 x 12 in. and weigh from 15 to 35 lb. (30 cu. cm., weighing 7 to 16 kg.), the weight of a given bale being dependent upon the amount of air space.

Briquetting has been previously discussed;[5] it may, however, be advisable to point out under what plant conditions it may be economical to briquet as well as to distinguish more sharply between briquetting and baling. It is a well known fact that briquetting furnishes a metallurgical product from fine scrap which is practically equivalent to heavy scrap provided no contamination from foreign materials has arisen. However, whether a given plant will do briquetting or baling depends upon local conditions. Thus, if a plant operates a rolling mill for the production of sheets, there is obviously no need for the installation of a briquetting machine, unless large quantities of fine light scraps are purchased outside, since practically no *small* scrap results from rolling-mill operations. If most of the scrap made in the plant is medium-sized, baling will probably prove economical, provided sufficient scrap is made. Utensil-plant scrap has been successfully baled with a reduction in melting-furnace dross losses. In the event that a plant near by can do briquetting and baling, it may be advisable to send the appropriate scraps outside for treatment. Economic considerations will rule necessarily in any case. Both briquets and bales furnish good charging forms because of their convenience in handling; further, their value is increased over the value of loose scrap. Metallurgically considered, fine scraps, in the loose condition, cause high dross losses because of relative ease of oxidation, and also for the reason that these kinds of scraps are difficult of immersion beneath the surface of a molten bath. Scrap when briquetted or baled is greatly to be preferred both from the mechanical and metallurgical standpoints, but briquetting and baling can hardly be considered competitive; each has its own applications.

Part II, dealing with melting furnaces and ingot pouring, will be published in our next issue.

Movement of Tank Cars

Headquarters of the Division of Transportation of the American Petroleum Institute have been established at Room 554, 29 South La Salle St., Chicago. The organization of this department has been commenced and vigorous action is being taken toward carrying out the purposes for which it was created. Assistant directors have been appointed for field work in various territories, and everything possible will be done to accomplish results at an early date. Correspondence relative to the speeding up of the movement of tank cars should be sent to M. J. Gormley, director.

[5]A. L. Stillman, "Briquetting of Non-Ferrous Light Metal Scrap," *Trans.*, Am. Inst. Metals, 1917.

Brine Corrosion of Petroleum Equipment

By Ralph R. Mathews and Philip A. Crosby

Petroleum coming from the Healdton Field, Oklahoma, contains salt water in varying proportions, and also a small amount of sediment or silt. Most of the silt is very finely divided and when separated from the oil has a powder-like appearance. The salt water separates from the petroleum very slowly, and on standing in a tank for six months or even longer from 0.2 to 0.4 per cent is still present.

Just why the water is held in the oil so tenaciously is not exactly clear, but it appears that the finely-divided silt is in suspension in the oil and helps to support and retain the water. Due to this close association of the salt water with the petroleum, some of it travels through the pipe lines to the refineries, even though it may be in storage in the field for a considerable time. Thus the oil will probably arrive at the refinery containing 0.5 to 1.5 per cent of B. S. & W[1]. as determined by dilution, and whirling in an electric centrifuge at approximately 1,200 r.p.m. Our experience has shown this B. S. & W. is 60 to 75 per cent salt water.

To the uninitiated it no doubt seems easy to remove the salt water by washing with good, clean, warm water, or by adding a chemical which will precipitate the objectionable salts from the water and in turn from the oil. The difficulty arises here in getting an intimate mixture between the water or aqueous solution and the tiny drops of water in the oil, which probably have a protecting oil film around them. Chemicals which break down this surface tension and would thus free the drops of water have been successfully applied to the treatment of B. S. from tank bottoms, but their application to crude oil has not given the desired results. It is probable that the large volume of oil in comparison with the small amount of water is responsible for the negative results obtained. Various methods of electrical dehydration have also been applied to recovering oil from B. S. and petroleums of high water content. The reduction, however, is generally not below 1 per cent B. S. & W., thus leaving too large amount of the objectionable salt water. The centrifuge will probably reduce the B. S. & W. to 0.3 to 0.4 per cent, but its application is expensive, and there would still be enough salt water remaining to cause the trouble indicated below.

A typical analysis of the brine shows the following figures:

	G. per liter	Grains per U. S. Gal.
SiO_2	0.008	0.44
R_2O_3	0.127	7.42
$CaCO_3$	0.074	4.33
$CaSO_4$	0.011	0.64
$CaCl_2$	4.275	249.72
$MgCl_2$	1.526	89.15
NaCl	61.140	3572.20
Total solids	67.161	3923.90

The above indicates approximately a 6.5 per cent solution of sodium chloride, and special attention is directed to the content of magnesium chloride.

Observations of Corrosion

The results outlined here were obtained at a refinery where the petroleum is pumped through stills and heated to the desired temperature. The mixture

[1]B. S. & W. is an oil man's term and is interpreted as bottom settlings and water. Thus it really means the per cent of water, silt and other foreign matter in the oil.

of oil and vapors passes into an apparatus which allows the vapor to separate from the residual oil (fuel oil.) The vapor then passes through a series of dephlegmators, where it is fractionally condensed. Thus from the top of the last dephlegmator the lightest vapor passes through a condenser and the gasoline flows from there into the receiving house. Lines lead from the other dephlegmators through coolers and into the receiving house, where the necessary "cuts" are made.

The dephlegmators are arranged with water coils in the top, and after a few months service these coils began to leak. Later the tubes of the condensers started leaking water into the gasoline. Investigation showed excessive corrosion had taken place and one hole over an inch in diameter was found in a water coil when the dephlegmator top was removed.

Some of the rusty deposit found at the points of worst corrosion was removed to the laboratory and examined. It gave a slightly acid reaction and consisted largely of ferrous iron and chlorides.

Acidity of Oil Vapors

On the bottoms of the last two dephlegmators were steam lines and valves which had never been used. The lines were at the lowest points of the bottoms and any aqueous condensate would have a tendency to collect in them. There was a slight leak around the valves on these lines and a deposit showed a distinctly acid reaction and was found to consist mostly of ferrous iron and chlorides. Thus the indications pointed to corrosion by hydrochloric acid, and in order to try further to substantiate this theory a water line was tapped into the top of the next to the last dephlegmator. By means of it a small amount of water was forced down through the up-coming oil vapors. The water was trapped out in the receiving house and a sample obtained. This was examined in comparison with a sample of water taken before going through the dephlegmator and was found to have acquired an acidity equal to 8.23 grains of HCl per gal. of water.

Laboratory distillations of the oil were made, using a glass flask, and the water recovered was found to contain a small amount of hydrochloric acid. In one extreme case enough acid vapors came over during a laboratory distillation to turn blue litmus red when it was moistened and held at the mouth of the bottle containing the gasoline. The water recovered in this case was titrated, and calculation showed that the acid formation would be at the rate of 0.012 g. of HCl per liter of oil.

In view of the above evidence there seemed little doubt hydrochloric acid was responsible for the rapid corrosion, and the next step was to locate its source.

Action of Magnesium Chloride at High Temperatures

In looking for the source of the hydrochloric acid, the magnesium chloride in the salt water seemed most likely the cause. Molinari[2] states that "magnesium chloride volatilizes at a red heat and partially decomposes in the presence of minimal quantities of water, forming hydrochloric acid and magnesium oxychloride." This reaction starts at as low a temperature as 175 deg. C. If the reaction is carried to completion the ultimate products would be hydrochloric acid and magnesium oxide.

Stillman[3] says of magnesium chloride: "The latter compound, while not scale forming, is considered an active corrosive agent upon the supposition that at the temperature of 100 deg. C. and higher it is decomposed and hydrochloric acid formed and liberated."

The oil in passing through the stills is heated to approximately 260 deg. C., and at this temperature a large amount of the magnesium chloride present in the salt water in the oil is without doubt decomposed and hydrochloric acid formed. Then the acid vapors are carried with the oil vapors into the dephlegmators.

Final Observations and Conclusion

It was noted that most of the corrosion took place in the last two dephlegmators and in the condensers used with the last dephlegmator. It seems that is due to higher temperatures in the preceding dephlegmators. Thus in the next to the last dephlegmator the temperature drops to approximately 110 deg. C. and the most severe corrosion was noted on the water coils where there must have been a cooling below 100 deg. C. Some water vapor is always associated with the oil vapors, and it no doubt condenses on these water coils. The water readily collects the acid vapors and reaction starts on the metal at that point. Some of the acid vapors also carry over into the condensers, eventually causing them to give way.

We have noted this action from salt water in Healdton petroleum, but are of the opinion that petroleums from other fields could cause the same trouble, provided they carried even small amounts of salt water containing magnesium chloride.

By way of summing up, the following may be stated as covering this case in brief:

Hydrochloric acid is formed from magnesium chloride in salt water present in Healdton petroleum during distillation.

Oil vapors which contain the above acid vapor cause corrosion and produce rapid deterioration of the fractionating apparatus.

With Healdton petroleum containing 1 per cent of salt water, the amount of acid produced may be as large as 3.39 lb. of hydrochloric acid per 1,000 bbl. of oil.

Acknowledgment is made to Dr. F. W. L. Tyderman, superintendent of this refinery, for encouragement and advice in carrying out this investigation.

Roxana Petroleum Co. of Okla.,
Wood River, Ill.

New Paper Fibers

A new and very strong paper fiber has been discovered in Mexico which consists of the macerated bark of a tree called *cuazuma* or *cuahulose*. The tree is abundant in the State of Jalisco, and its bark is sometimes 20 to 30 cm. in thickness. It may be produced, it is said, at low cost.

Another promising paper material is from the leaves of a tree, *Chamserops humilis*, locally known as *doum*, which grows along the coast of Morocco in easily accessible regions. It is a dwarf palm that matures rapidly, and the annual product available is reported at about 100,000 tons. The pulp contains 75 per cent actual fibers which average 2.5 x 0.01 mm. It has satisfactory felting power, thick membrane, great tenacity, complete homogeneity, and great suppleness. The raw material may be obtained at from 3 to 5 fr. per 100 kilos.—*Le Papier*, vol. 22, p. 175 (1919.)

[2]General and Industrial Inorganic Chemistry, p. 527.

[3]Engineering Chemistry, p. 580.

A Classification of Filter Plates and Frames and Their General Usage

A Description of the Basis of Classification of Filter Plates—Flush or Recessed Types With Port or Cock Outlet Subtypes—Plain, Simple or Thorough Washing Arrangements With or Without Separate Outlets for Wash Subarrangements

By D. R. SPERRY

THERE are a great many different arrangements of filter plates and frames in use at the present day, but there has previously been no attempt to classify them scientifically. In the past the various types and arrangements have been indicated by empirical numbering or by such loose designation as "two-eyed," "three-eyed," "four-eyed," etc. The former is unscientific, because it is empirical; the latter is unscientific, because the designation is not exact, as it can be shown that the mere statement of the number of eyes which a plate has does not designate any particular type or arrangement. A two-eyed plate, for example, may be used for more than one purpose.

The object of this article is to present a classification of filter plates and frames by means of which all of the various types and arrangements which are in use at the present day can be easily enumerated. It is also desired to show in a general way what is the purpose of these various types and arrangements, so as to guide chemists, chemical engineers and others in an intelligent selection of the proper filter press for their problems. It should be understood that the classification here given does not apply to any particular make of filter press, but applies to all makes and is general.

Basis of the Classification of Filter Plates

The whole family of plates and frames used in the industries can be divided into two types—the recessed and the flush types. The recessed type plate is a plate which has a recess on each surface, usually about five-eighths of an inch deep, though in some cases thinner, while the flush plate has no recess at all, but is flush from edge to edge. Referring to the chart, Fig. 1, one will find on the left hand edge under the general heading of "Type" the words "Flush" and "Recessed." The whole family of commercial plates is included in this diagram and the plates belonging to the recessed type are all of those above the horizontal dividing line, while those belonging to the flush type are those below the horizontal line.

In practice it will be found that in addition to the two types of plates there are three different arrangements known as plain, simple washing and thorough washing. Again referring to the chart, one will find on the upper edge the word "Arrangement" and under this, the words "Plain," "Simple Washing" and "Thorough Washing." These three arrangements divide both the flush and the recessed types.

It will now be found that there are smaller subdivisions to both the "Type" and "Arrangement." Referring to the subdivisions under the "Flush" type and the "Recessed" type, these merely refer to the kind of outlet employed; that is, whether it is a cock outlet or a port outlet. This is very simple and needs no further explanation.

Referring to the subdivisions under "Arrangement," one will find under the heading of "Simple Washing" two divisions, one "Without Separate Outlet for Wash"; the other, "With Separate Outlet for Wash." The same two subdivisions will be found under "Thorough Washing." The meaning is quite clear.

It will be found that in this classification there appear certain blank spaces. These spaces, like the blank spaces appearing in the periodic classifications of the elements, may some day be filled, but at present they are not, at least as far as actual use in the industries is concerned.

It should be borne in mind that the type and arrangement of a plate has nothing whatever to do with the kind of surface on the plate nor does it have anything to do with the position in which the eyes or grommets are placed nor of the material of which the plate is constructed. The classification refers strictly to the type and arrangement and does not take into consideration such external characteristics as these things. For instance, the No. 11 plain plate, in the upper left hand corner of the diagram, would still be the No. 11 plate even if the surface was of the pyramid type and the grommet was in the center instead of in the upper left hand corner.

To recapitulate, all plates may be divided into two types, "flush," and "recess." Further, either of the two types may be divided into three general arrangements, "plain," "simple washing" or "thorough washing." This is the basis of filter-plate classification.

Usage of the Different Types of Plates

In solving a filtration problem it is always well to try tentatively the recessed type. It is always best to use the recessed type if it is applicable, because its first cost is less than the flush type due to the fact that flush type plates must invariably have frames, whereas the recessed type does not have to have frames. Suppose, for example, it is desired to clarify a certain vegetable oil. We would first investigate the possibilities of the recessed type for this purpose. We find, however, that in order to filter this particular oil it is necessary to use filter paper, and if this is carried out with the recessed type of plate, the paper will break due to the strain set up by the corners of the recess. This at once discards the possibility of using the recessed type of plate; therefore the flush type must be used, as in the flush type of plate the paper can lie flat and will not be subject to strains around the edges.

Suppose, however, that another problem occurred; namely, the filtering out of fullers earth from lard. In this case heavy canvas is used for a filtering medium and lard has no particularly deteriorating effect upon the fabric. It is therefore practical in this instance to use the recessed type of plate.

In a third case, one might have a problem in which a substance is to be filtered, the solids of which are bulky and porous; such, for example, as a mixture of mash and wort. Trying tentatively the recessed type of plate, one will find that it can not be employed in this instance due to the fact that the maximum recess which practice has shown to be possible, namely, three-quarters of an inch, will not produce a cake thick enough for this material, which will easily form a cake perhaps 3 or 4 in. thick. This at once discards the recessed type and makes the problem one involving the flush plate and frame type.

Another problem might be that of filtering a mixture of graphite water and clay such as is used in the manufacture of "lead" for lead pencils. In this particular problem it is necessary, due to the denseness of the solids, to filter a long time at a constantly rising pressure which may run to above 200 lb. per sq.in. It is desirable and indeed necessary in this case to have the cake very thin, possibly not more than three-eighths or one-half an inch. This at once throws the problem into the recessed type, as it is not practical to make a frame thin enough to produce the sized cake desired, but it is very practical to make a recessed plate with a shallow recess.

Still another problem might be the filtration of a certain aluminum salt which is strongly alkaline. Trying the recessed type for this problem, it will be found that the cloths would soon break around the edges due to the recess, as it is a fact that strong alkali has a rotting effect upon the fibers of the cloth. This discards the possibility of using the recessed type and puts the problem into the flush type, where there is little or no sag around the edges of the filtering surface.

Usage of the Different Arrangements of Plates

These five problems show in a general way how one arrives at the proper *type* of plate to use. After the type has been determined, it is next necessary to find out what arrangement is wanted. If the material to be filtered does not have to be washed, the arrangement is to be of the "plain" type. If, however, the material to be filtered has to be washed, then it must be either "simple washing" or "thorough washing." The physical and chemical characteristics determine which of these two types of washing should be employed. For example, if the material to be filtered is of a very dense nature, so dense in fact that a reasonable filling time builds up a cake on each chamber surface not thick enough to join the solids on the adjacent sides of the chambers, simple washing should be employed; that is to say, the wash water is introduced along the same channel that the material to be filtered entered. In this instance, if thorough washing is used, an excessive strain would be put upon the cloth on the surface corresponding to that surface of the plate against which the wash water is introduced, due to the fact that the cloth would be obliged to sag until it was supported by the solids deposited. In simple washing, however, this objection is entirely eliminated. Furthermore, the solids, through

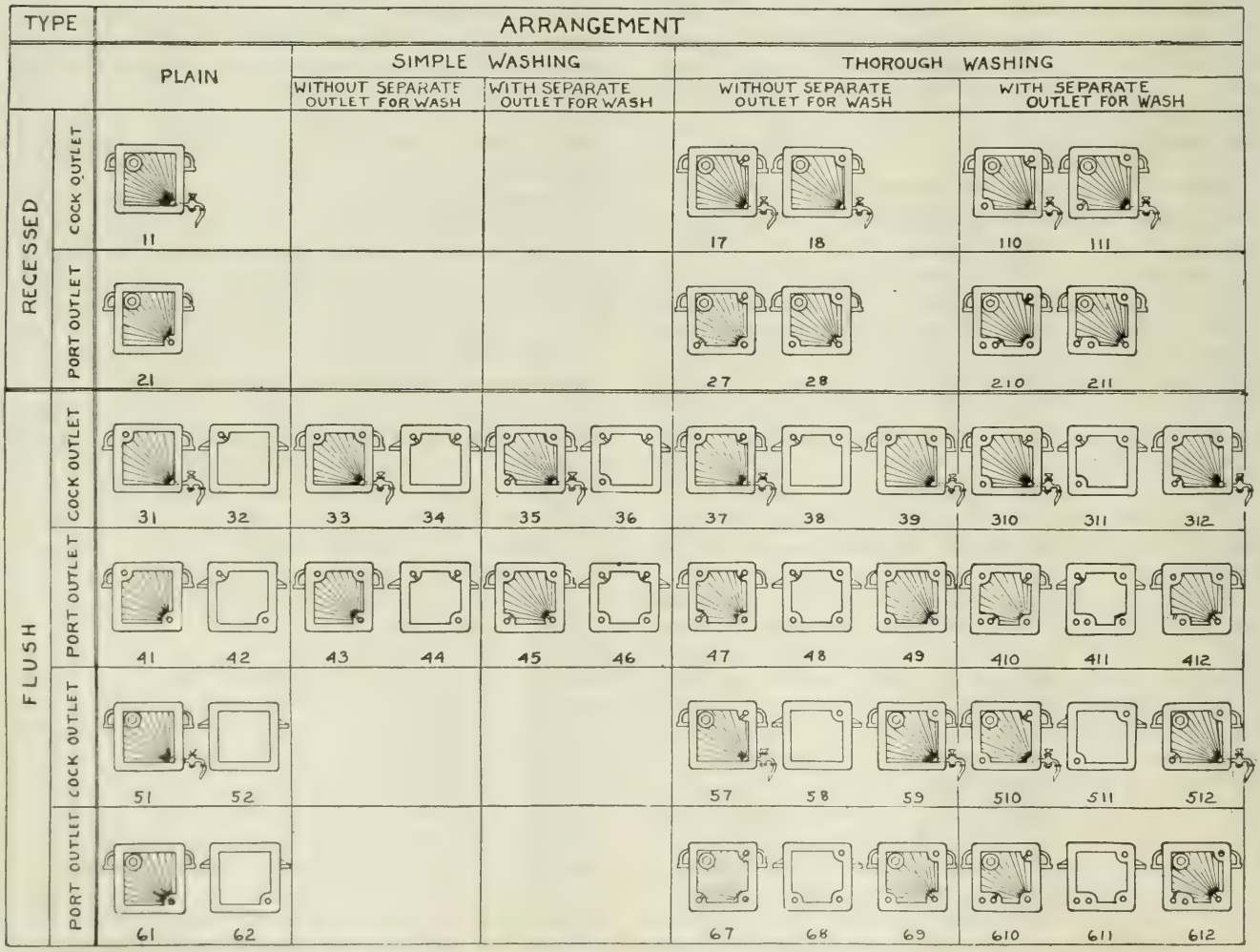


FIG. 1. CLASSIFICATION OF FILTER PLATES, TYPICAL PLATES AND FRAMES

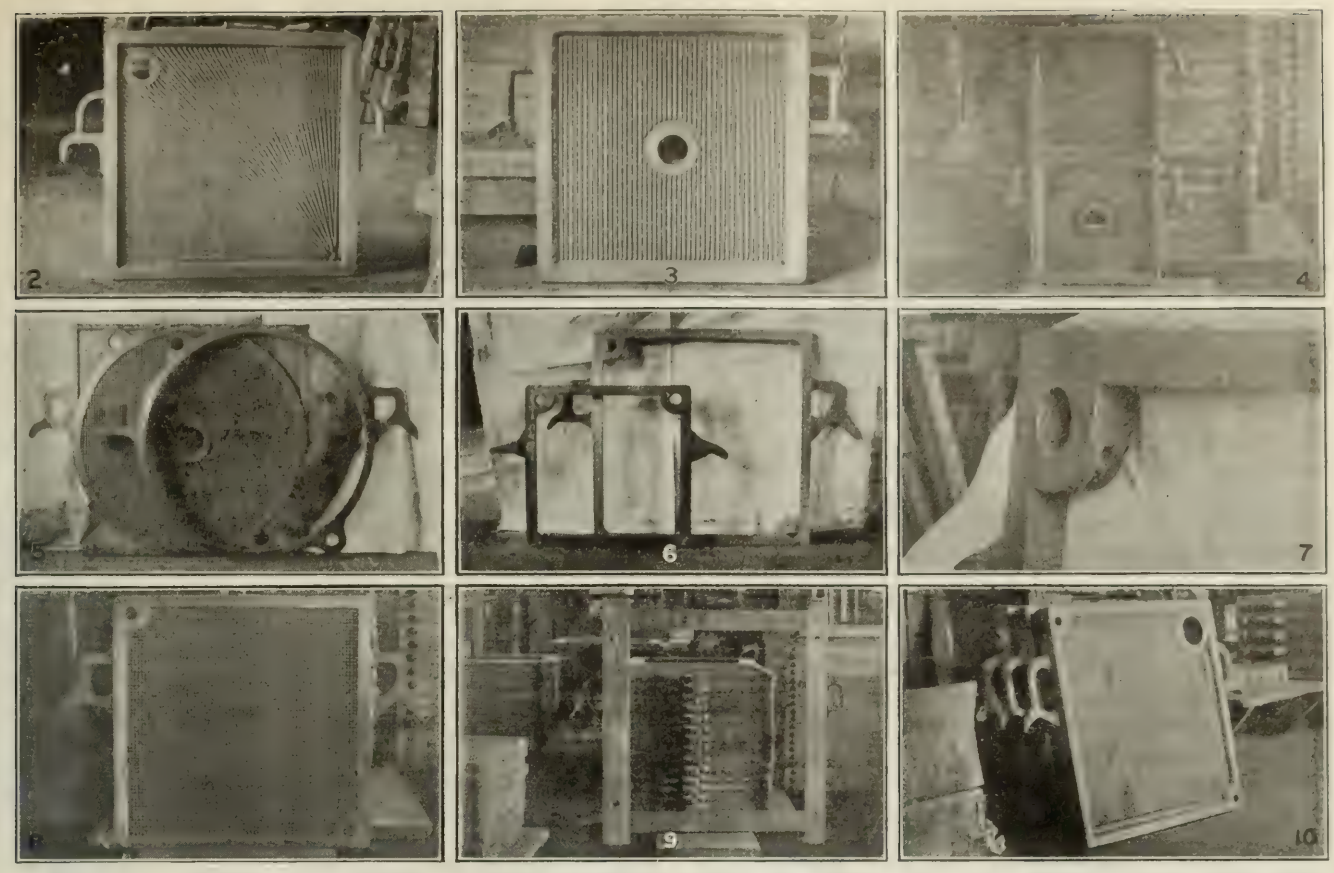


Fig. 2—No. 11 plate, radial grooved surface, corner feed. Fig. 3—No. 11 plate, parallel corrugated, center feed. Fig. 4—No. 11 plates; above, pyramid surface, center feed; below, radial grooved, corner feed. Fig. 5—No. 31 plate, No. 32 frame. Fig. 6—Small frame, No. 38; large frame, No. 32. Fig. 7—"Close-up" showing connection between eye and interior of frame. This is a feed eye; a wash eye would have no port leading to interior of frame. Fig. 8—No. 31 plate, pyramid surface. Fig. 9—No. 38, wood frame. Fig. 10—No. 11 steam-heated plate, parallel corrugated. Small eyes are for steam inlet and outlet.

which the wash water has to pass, are one-half as thick in the case of simple washing as in thorough washing, and since the solids are assumed to be very dense, this reason alone would warrant the use of simple washing.

On the other hand, suppose that the material to be filtered and washed will, in a reasonable filling time, entirely occupy the chambers of the filter press. If we were to try simple washing in this case, we could scarcely reach the solids at all but come in contact merely with those solids next to the feed port. It would therefore be necessary to use thorough washing.

Usage of Port or Cock Outlets, Subtypes of Plates

Treating now the sub-headings appearing under the words "Flush," "Recessed," "Simple Washing" and "Thorough Washing," the determination as to whether the outlet should be a cock outlet or a port outlet depends upon various things. If one were to filter a substance the liquid of which was highly volatile and valuable, such as alcohol or ether, it would be inadvisable to use a cock outlet, on account of the loss by evaporation. This would immediately demand a closed discharge so that the volatile filtrate could be conducted to a closed vessel without contact with the atmosphere. In the case, however, where there is no danger of loss by evaporation, the cock outlet is ordinarily used. The cock outlet or open discharge, as it is sometimes called, should always be employed if possible, because in case of breakage of a cloth the whole filtering operation will not be interrupted as in the case of closed discharge, but the operator merely turns off the cock which runs cloudy and goes on with the process.

Whether or not there should be a separate outlet for wash depends upon several conditions. Frequently it is desired to have a permanent wash outlet pipe connection which runs the wash water to some desired point. Oftentimes where thorough washing is employed, a valuable volatile substance may be the washing liquid instead of wash water. It may be some solvent, such as alcohol. In this instance, every other cock washing system would be out of the question owing to the loss by evaporation, and a separate outlet for the wash would be necessary.

The every other cock washing system, which is thorough washing without separate outlet for wash, is generally desirable, because in the case of a cloth giving out it can be at once detected by the eye or by chemical and physical tests; otherwise, it is not likely to be found out until considerable damage results.

Other Systems of Plates

The above classification, as already stated, covers those plates and frames most commonly used in practice in the United States. There are other systems which could be added, but owing to the fact that they are so rarely used, they are here omitted. One of these is the "three-plate system." We have not included this, as it is almost unknown in the industries and would therefore merely serve to complicate the classification.

There may be other eyes in a plate and yet those eyes would have nothing whatever to do with the type or arrangement. A case in point is that of the hollow or steam-heated plates in which there may be an eye for the entrance of the steam and an eye for the drip.

This would add two eyes, but would not in any way affect the type or arrangement of the plate. Again, it may be desired to have two separate outlets for the filtrate, thus adding another eye. This would not in any way affect the type or arrangement, but would be the same as though there were but one outlet for filtrate. A No. 11 plate with two outlets would still be a No. 11 plate; a No. 21 plate with two eyes in the lower corner, both of which are outlets for filtrate, would still be a No. 21 plate.

It will be found occasionally in practice that frames are used with recessed plates. This is not good practice and is not necessary in any event. Where this arrangement is found, it is usually due to the fact that recessed plates were originally purchased and later it was desired to increase the cake thickness and this was done by inserting No. 52 frames between the plates, or it may be that the press was made up that way originally in order to make use of certain stock material in cases where delivery is the paramount question, but in general there is no excuse whatsoever for a recessed plate with frames.

Description of the Plates

The writer has included in this article a number of illustrations showing the appearance of various typical plates and frames, the number of which is in each instance given.

Figs. 2, 3, 4 and 10 all show pictures of No. 11 plates. Here we find three different plate surfaces, radial, parallel corrugated, and pyramid; furthermore, some have the feed in the upper corner, while others have the feed in the center. Yet all are No. 11 plates. Fig. 9 is discussed later.

Fig. 5 shows a round plate and frame with grommet hole and two eyes with cock discharge. One would be inclined to regard this as belonging to the 510-11-12 series, but as a matter of fact it is a No. 31 plate and No. 32 frame. The lower eye is the feed channel; the upper eye is a circulating feed return, while the central opening is for the purpose of supporting certain mechanical features. Designating this plate as two- or three-eye would be far indeed from telling to what system it belongs.

Fig. 6 shows two frames; both have two eyes, and since they both serve entirely different systems, to call them two-eyed frames would tell very little. The small frame is a No. 38 frame; one eye is for feed, while the other is for wash water. The large frame is a No. 32 frame, as both eyes are for feed. The one feed eye ordinarily used is split into two separate eyes. Examination of these two eyes would disclose a port leading into the interior of the frame in each case (Fig. 7).

Fig. 8 is a No. 31 plate. The large frame shown in Fig. 6 is used with this plate.

Fig. 9 is a No. 38 wood frame; one would imagine that it was a No. 311 frame, but it so happens that the large eye is the feed eye, while the two smaller eyes are both wash inlets. Here the ordinary one eye used for washing is divided into two eyes.

Fig. 10 is a No. 11 steam-heated or hollow plate. Seemingly this is a No. 110 or No. 111 plate, but the two small eyes are for the purpose of conducting steam to the interior of the plates and removing the drip, and have nothing to do with type or arrangement, therefore for purposes of classification are negligible.

Batavia, Ill.

Photo-electric Spectrophotometry

In connection with the color-standardization work of the Bureau of Standards, it is desired to have available a number of independent methods of making spectrophotometric determinations, especially in the visible part of the spectrum, for it is generally admitted that the fundamental basis of color specification is spectrophotometry. To supplement the color methods at present in use at the Bureau, and especially to overcome the well-known uncertainty of measurements made in the blue and violet, a method for accurate and convenient photo-electric spectrophotometry, suitable for routine determinations, has been developed, which has proven very satisfactory as to speed of operation, ease of keeping in working condition, and reliability of measurement.

The null method used has made it possible to eliminate many errors common to photo-electric deflection methods. The only variable in the process of making a determination of the transmission at any wave length is the accurately measurable distance of a small light source from the slit of the spectrometer. Measurements of spectral transmission can be made from 380 millimicrons in the extreme violet to about 650 millimicrons in the red.

Measurements of diffuse spectral reflection relative to that of magnesium carbonate have also been made. In addition, the method is applicable to the measurement of the relative radiant power of two sources and to the measurement of fluorescence, and could be extended into the ultra-violet if quartz parts were used instead of glass.

Traveling Exhibition of Canadian Goods in France

An exchange of exhibition trains for showing in one country the products of another is a recent trade-extension project that is attracting attention in Canada. The Canadian National Railways have arranged for the transportation of exhibits of French goods through Canada, and Canadian manufacturers will be able to secure a similar exhibition of their goods on a train that will be taken through the principal cities of France.

France, it is stated, is badly in need of commodities that can be supplied by Canada, especially shoes and woolen underwear. There is an immediate need of immense quantities of such goods, which the industries of France cannot produce in sufficient volume for some time. The view is taken that it is necessary only that Canadian goods should be known in order to find a larger market in France, and the plan of a traveling exhibit has everything to recommend it.

Sizes of Feet

Commerce Reports of Feb. 11, 1920, contains the following information on "Measurements Used in Exporting Swedish Lumber":

"According to Trade Commissioner Axel H. Oxholm, 69 per cent of the lumber exported by a company in northern Sweden is cut to English feet, 7 per cent to Danish feet (1 Danish foot = 0.9711 English foot), 8 per cent to "metric feet" (1 metric foot = $\frac{1}{3}$ meter = 1.0936 English feet), 7 per cent to Spanish feet (1 Spanish foot = 1.0783 English feet), 4 per cent to Dutch feet (1 Dutch foot = 1.0768 English feet), 4 per cent to German feet (1 German foot = 1.0639 English feet), and 1 per cent to decimeters (1 decimeter = $3\frac{15}{16}$ English inches)."

PRESENT PLANT OF THE COLLINSVILLE ZINC CORPORATION

Making Lithopone at Collinsville, Ill.

Historic Zinc Smelting Plant of the Collinsville Zinc Corporation Rehabilitated for the Manufacture of Lithopone—High Price of Paint Base Interested Capital in Converting Old Industry to New Manufacture in Works Long Idle—First Unit in Successful Operation

BY CHESTER H. JONES

THE original plant on the property of the Collinsville Zinc Corporation was erected in 1873 by Dr. Octavius Lumagi at Collinsville, Ill., eleven miles east of the Pennsylvania R.R., for the purpose of utilizing as fuel the refuse slack from the coal mines in the immediate vicinity. One small set of Belgian block furnaces, a hand-operated blende-roasting furnace and a limekiln for burning zinc carbonate constituted the original works. In 1878 Otto F. Meister and Henry Wyman leased the Lumagi plant, purchasing five additional acres of land. New block furnaces were constructed and in 1890 the first Brown horseshoe roasting furnace in the world was erected by Herman Brown. This furnace has been put in operation with the remainder of the works under the present management.

Fig. 1 illustrates the original plant as installed and is a good example of the printer's art of that time in portraying industrial activity. It illustrates the ideas of other days in what was then regarded as "some project," recalling much of the romance surrounding the development of the zinc industry of America.

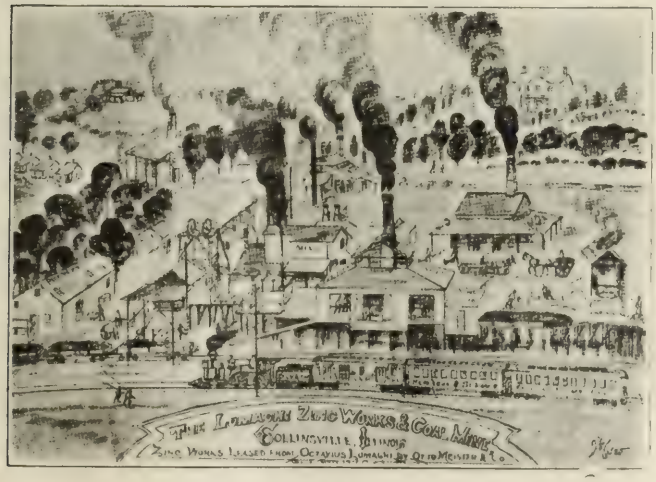


FIG. 1. THE ORIGINAL ZINC SMELTER

A touch of the personal interest of the old employee in his business is also evidenced in the return of Ben Raymond, now a successful bank director in the district, who was connected with the works as superintendent during the first period of activity. Regardless of other interests, he came back on his own initiative to start the old furnaces when the new company commenced operations.

The Collinsville Zinc Corporation secures the zinc ore from its Lost Hill mines at Moselle, Mo., which have about 300,000 tons now "in sight." The lithopone manufactured at the present works, shown at the head of this article, made from a combination of this ore with barytes, is used in manufacturing paints, enamel, rubber tires, linoleum, shade cloth, wall paper, printing inks, etc. Its production is described in the following paragraphs.

Present Plant

The plant as it exists today comprises ore and coal mills, five Brown horseshoe furnaces (sixth under construction), nine Belgian block furnaces, leaching plant, lithophone driers, and finishing plant, pottery kilns, power plant and necessary shops. The leaching and lithophone drying plants with necessary conveying equipment are additions to the zinc-smelting equipment for making lithophone and the first units with a 30-45-ton capacity of lithophone per 24 hr. are in operation. When the proposed schedule is carried out a total quantity of 300 tons per day will be produced.

Lithophone Manufacture

The zinc ore is shipped from the company's mines and unloaded from cars to the stock piles near the mill, while the barytes comes from southeastern Missouri points less than 100 miles distant. The largest barytes deposits in the United States are in this district. These

two raw materials are consumed in the ratio of 30 per cent zinc ore to 70 per cent barytes.

The zinc is fed to a baffle drier which consists of a short brick stack about 6 ft. square fired from beneath, the ore being intercepted by horizontal baffles in its downward course. It is received at the bottom by a jaw crusher (Blake) and subsequently enters corrugated rolls where it is reduced to pass 10-mesh screen, and is finally elevated to a storage bin.

It is removed from this storage by hand to narrow gage tramcars similar to those used in ore mines and is conveyed about 100 ft. across to the receiving hoppers which feed each pair of Brown furnaces.

Zinc Roasting

These furnaces have a 10-ft. hearth constructed on a circle with the inner edge of the hearth built on a 70-ft. diameter. The inner wall is shown in Fig. 2. Openings for inspection and repairs are provided on both walls with buckstays between. The post in the foreground is near the center of the circle. The ore occupies a time of 20½ hr. in passing through the length

FIG. 2. INTERIOR CIRCULAR WALL OF BROWN FURNACE

of the furnace. Capacity of each furnace is about 1,000 lb. (408 kg.) per hr. of roasted ore having a sulphur content of less than 3 per cent.

Fig. 3 shows the feed end where the hopper gate is automatically tripped to deliver ore to the hearth over the chutes, as appears to the left of the wooden post. The rabbles are operated by steel cable guided in sheave pulleys. About 3 hp. is required to drive the entire rabble mechanism, which travels through the furnace at 1½ min. per revolution. The fire stack connection is located near the feed end.

Heat is supplied from three fireplaces, two located at discharge end, farthest away from stack, and one near the feed end. This is varied on some of the furnaces by having five fireplaces, three being near discharge end and two near the stack. Powdered coal is used for fuel. Firebrick is used throughout in construction of the furnace.

Fig. 4 shows the discharge end of the horseshoe with a rabble arm emerging beneath the sheet-iron door. The door is hinged to open by pressure of the carriage. When one of these rabbles comes into the open space or end of the horseshoe, between the discharge and feed ends of the hearth, it is automatically detached from the driving cable; at this moment another carriage, which has been cooling in the space, is automatically attached and is carried into the feed end of the furnace.

While the roasted ore, consisting of ZnO and $ZnSO_4$ (the latter from residual moisture), was previously removed by hand tram, on track shown in foreground,

FIG. 3. FEED END BROWN FURNACE

Fig. 4, provision is being made to form a slurry with water and pump to the leaching plant, 150 ft. distant.

Leaching the Partly Roasted Zinc

The slurry is carried over to the leaching plant, where it is distributed to each of 6 wooden tanks, 8 ft. diameter x 10 ft. high, and provided with drop bottoms for removing sludge on completion of the lixiviation. This series of tanks is arranged in a cascade at the top of which is a larger wooden tank, lead-lined, containing a 20 per cent solution of H_2SO_4, being made by diluting chamber acid. This solution is fed to the cascade. All the tanks are heated by steam coils. The solution of zinc sulphate thus produced is pumped to six 14 ft. diameter x 10 ft. high wooden neutralizing tanks equipped with steam coils for keeping at boiling temperatures. The exact method at this point is not revealed. The neutralized zinc sulphate liquor is then ready for mixing.

Barytes Treatment

The barytes is carried from the stock piles by screw conveyor to an Allis-Chalmers No. 2 Pulverator. The section of screw conveyor feeding the pulverator is steam jacketed for drying the barytes. The pulverized material is fed to the boot of a steel elevator, where 30 per cent powdered coal is added and the mixture elevated to four steel hopper-bottomed storage bins. Tramcars convey from these bins to the Belgian block furnaces. Here the barytes ($BaSO_4$) is roasted to barium sulphide (BaS), the coal in the mix acting as a reducing agent. Detail of these furnaces will be covered further on.

The BaS thus produced is known as black ash or water-soluble barium sulphide. This is mixed in a

FIG. 4. DISCHARGE END OF BROWN FURNACE

slurry and pumped back to the leaching plant, where the solid is removed in a Cyclone classifier (about 2 ft. in diameter) and the water returned to the furnaces. Only a small amount of BaS goes into solution during transportation.

Leaching Black Ash

The black ash sludge drops from the Cyclone to the center of the first of three leachers arranged in series. These leachers are steel tanks about 15 ft. in diameter and 15 in. high. Each tank is divided by concentric steel walls so spaced as to form six annular channels of equal width between center and sides. Within each

FIG. 5. FIRST DRIER UNIT

channel a shoe or paddle is suspended from the arms slowly rotating above the tank.

Clear water flows in at the center together with the black ash as referred to above and the solution flows outward over each partition, while the solid is carried along in part so that a thorough mixing results. At the final outlet of the series of tanks practically all of the BaS is carried in clear solution. The water is heated by steam during process. This is said to give more thorough leaching results than any other method so far attempted. The clear liquor is pumped to five 10 ft. diameter x 15 ft. in height steel storage tanks and the residual sludge returned to the Belgian block furnaces.

Mixing Solutions to Produce Lithopone Liquor

The clear liquors of neutral zinc sulphate and barium sulphide are pumped from their respective storage tanks to four 8 x 10 ft. wooden tanks equipped with slowly revolving agitators and mixed in the proportion of 30 per cent zinc to 70 per cent barium content. These tanks are located in the first drier building adjoining the leaching plant.

The resulting solution is pumped to the 8 x 6 ft. Oliver filter located above the drier shown in Fig. 5. The filter delivers over the splash board shown in the upper part of the picture just to the left of the center.

The driers, of which there are two complete units located in separate buildings, are each composed of a circular brick structure about 20 ft. outside diameter and 3 ft. high. A floor of brick supported by arch construction is built 6 in. from the top to form a shallow pan over which the material is moved by rabble arms equipped with shoes as shown in Figs. 7 and 8. Heat is applied by coal fire from beneath. The revolving arms are constructed of steel I-beams and the mechanism and drive suspended from above. Hoods of sheet iron over each arm prevent the material from dropping directly on the rabble. A 10-hp. back geared motor drives the whole.

The filter is driven by a 2-hp. motor and the vacuum maintained by a 9½ x 8 in. Doak vacuum pump. A steel bin (shown in the upper right hand Fig. 5) receives the dried material from the first unit.

Belgian Block Furnaces

After the initial drying the powdered substance is trammed to the Belgian block furnaces, where it is calcined at a temperature of about 900 deg. F. (480 deg. C.), red heat, and quenched in water while hot. Proper quenching is the key to successful operation, as the reaction must not be allowed to proceed too far.

There are nine double Belgian block furnaces, each half furnace containing 128 retorts, or 256 retorts per furnace. Each retort receives about 100 lb. of material. The two fireboxes are fired by hand with ordinary stoking coal. Fig. 6 shows a section of one face of the furnace with the refractory lids in place over each retort. The sheet iron cover on the floor is removed when discharging and the material raked from the retorts falls into the quenching pit beneath.

The retorts are supported at the ends in the walls with space around each retort to permit heat to circulate unobstructed and facilitate removal of individual retorts for repairs. Each block furnace is equipped with two stacks, and two fireboxes, one set for each face. A vertical firebrick wall separates the heat chambers.

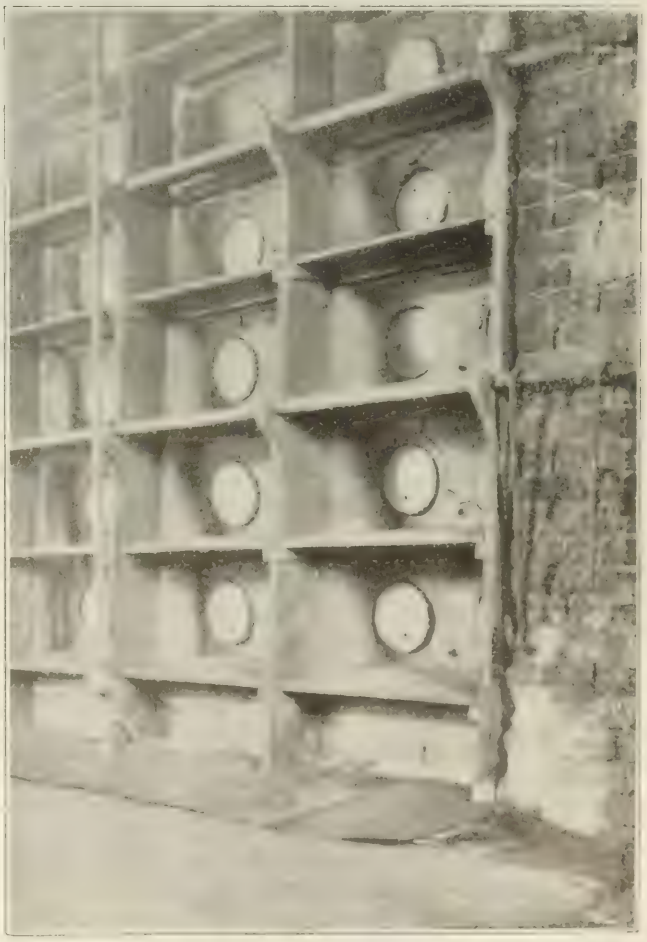


FIG. 6. SECTION OF FACE OF BELGIAN BLOCK FURNACES

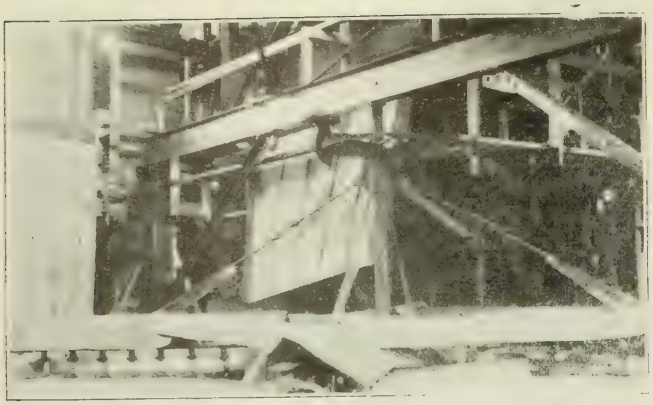


FIG. 7. SECOND DRIER IN FINISHING PLANT

The slurry formed by quenching of the calcined lithopone is pumped to the second drying unit in the finishing plant, where it is passed through an Oliver filter wheel (12 x 8 ft.), the delivery board of which is shown in the center of Fig. 7.

It will be noted that the drier is driven by chain and bevel gears. Fig. 8 shows brick construction and details of rabble plows.

After the final drying the finished material is removed from the drier bed by screw conveyor, fed to a Fuller-Lehigh mill, where it is ground to pass 300 mesh, elevated to wooden storage bins, whence it is drawn through chutes and packed in wooden barrels, lined

FIG. 8. LITHOPONE DRIER BED AND PLOWS

with paper bags, for the market. The commercial lithopone thus marketed analyzes about 30 per cent ZnS and 70 per cent $BaSO_4$.

Future

With the condition of the market such as to demand this product for paint base at high prices, this adaptation of the plant is timely. The new construction work during the coming season will call for added supplies of paint pigments.

The ultimate development of this plant to full capacity of furnaces will call for a period of construction and involve considerable additions in equipment and machinery. The work is proceeding under the direction of A. F. Versen, general manager, assisted by H. E. Gillaspy, general superintendent.

We acknowledge the many courtesies extended by Mr. Versen during the preparation of this article.

Directory of Special Libraries

The Special Libraries Association is enumerating the special library collections of the country, for the purpose of preparing an adequate directory of special libraries. A work of this nature will be as useful to librarians and investigators as a directory of manufacturers is to the purchaser of machinery or supplies. It will be a census of special information sources in the United States.

A special library has been defined as:

"A good working collection of information upon either a specific subject or field of activity; it may consist of general or even limited material serving the interests of a special clientèle; and preferably in charge of a specialist trained in the use and application of the particular material."

Any company having such library is requested to assist in the compilation of the directory by sending in the following information:

1. Name of institution or company.
2. Name by which library is known.
3. Name of librarian or custodian.
4. Can it be classified as any of the following: financial; business; legal; engineering or technical; institutional; municipal; reference; agricultural.
5. If not, how can it be classified?
6. Does it serve a special clientèle?
7. Would your librarian be willing to assist other special libraries to a reasonable extent?

The above data should be sent to William F. Jacob, chairman Library Census Committee, care of General Electric Co., Schenectady, N. Y., who will be glad to answer any question relating thereto.

California Institute of Technology

The California Institute of Technology is the new name for the larger institution developed from the Throop College of Technology at Pasadena. It has lately received $800,000 for general purposes and two endowments of $200,000 each for the support of research in physics and chemistry. In addition to this, $380,000 has been received for the construction of new buildings. An impressive architectural plan for the whole campus has been prepared by Dr. Bertram G. Goodhue, the well-known architect of New York and California.

The faculty has been strengthened in enviable measure. Dr. Arthur A. Noyes has resigned from the Massachusetts Institute of Technology and becomes director of chemical research. Dr. Robert A. Millikan of Chicago will spend one term each year and supervise research and instruction in physics. Dr. Albert A. Michelson (Nobel laureate), also of Chicago, will spend much time there engaged in research on the fundamental problem of earth tides, and Dr. Harry Bateman, formerly of Cambridge and Johns Hopkins Universities, is professor of aëronautical research and mathematical physics.

Special emphasis is placed upon the development at the Institute of the training of engineers of the creative or research type. To strengthen the courses in general culture, Alfred Noyes, the English poet, will give lectures on English literature and Paul Perigord has been appointed professor of economics.

Market for American Chemicals in Sweden

A material increase in the purchase of American drugs and chemicals in Sweden is reported by Walter H. Sholes, the American consul stationed at Gothenburg.

He reports that active introductory methods can stimulate greatly American business in that country.

Political and Commercial Control of the Nitrogen Resources of the World—II

A Description of the Commercial Aspects of Nitrogen Resources: Natural, Byproduct and Fixation Compounds, and of the Recent Developments and Changes in the Nitrogen Industry Practice*

By Chester G. Gilbert†

FREE nitrogen has no economic significance. To be available in the industrial arts it must be in a state of chemical combination. The form of compound is of secondary importance, since this may be modified more or less readily to suit the need, but its value is conditioned in terms of its availability in the form of nitrogen compounds. In consequence, the several sources are classifiable industrially under three heads:

1. Natural compounds—nitrogen occurring naturally in the form of marketable compounds.
2. Byproduct compounds—nitrogen rendered available incidentally in the course of operations otherwise directed.
3. Fixation compounds—nitrogen whose availability is dependent on special fixation treatment.

Natural Compounds

Chilean nitrate is the outstanding representative of this class. The guano industry, or what there is left of it, and a few other odds and ends of production from organic sources, belong here as well, but their combined output is relatively so small that the Chilean industry comprises what amounts to a monopoly of the natural resources. It is not operated as such, however, but by private capital, which owns and operates the oficinas, paying the Chilean Government a royalty or export tax amounting to about $11.20 per ton. British and Chilean interests share about equally in making up the far greater part of the capital invested. The balance is largely German and American. The total capitalization in 1909 amounted to approximately $134,000,000, representing an actual valuation of about $30,000,000. Various efforts on the part of the commercial interests involved to effect combinations for the purpose of stabilizing production have been attempted but have not been entirely successful, and the general tendency has all along been toward overproduction.

The operations, as already outlined on page 445, are crude and the cost of production is correspondingly high, amounting to around $25 to $30 per ton at seaboard, inclusive of the $11 export tax. The nitrate is marketed largely through commission houses. The American situation is mostly in the hands of three companies, W. R. Grace & Co., E. I. du Pont de Nemours & Co., and Wessel, Duval & Co. The magnitude of the Chilean industry as a whole and its relative importance are shown in Table I and Figs. 2, 3 and 4.[1]

Byproduct Compounds

To this class of compounds belong, with the few minor exceptions already noted, the nitrogenous products of organic derivation as a whole, and those from carboniferous sources, such as coal and oil shale. From the former source comes a miscellany of organic refuse resulting from activities dealing with animal, vegetable and fish products, and carrying nitrogen in the form of organic ammoniates commonly left as such for use in agriculture. From the latter the nitrogen recovered is all chemical nitrogen in the form of ammonia or ammonium salts, mostly ammonium sulphate.

Organic Nitrogen Supply

The organic production is impossible of definite analysis from any angle. The lack of systematically compiled records and back of that the miscellaneous largely decentralized character of the output, along with the fact that the producing costs are for the most part indistinguishable, leaves altogether too much to the imagination. Much of the supply is derived from connections of sanitation, especially of local sanitation, such as the rural practice, for which there is no measure whatever. Another prominent source of supply is represented in what is known as tankage, the refuse from animal-rendering plants; but here too the issue is lost in the scattering of the production, the indefiniteness of composition, and the fact that not all of the product is used as a source of nitrogen, some of it going into the preparation of animal food. The same is true of cottonseed meal and various other less prominent forms of organic waste resulting from industrial activities. Fish scrap and slaughter-house refuse from meat packing also contribute prominently and at the same time rather more definitely to the supply of agricultural nitrogen; but even here adequate figures are not available. The Federal Trade Commission undertook to analyze the 1913 consumption, with results given in Table II.

TABLE II—ESTIMATED CONSUMPTION OF NITROGEN IN COMMERCIAL FERTILIZERS FOR 1913

Materials	Fertilizing Substance	Tons Consumed	Content (per cent)	Units Consumed†
Nitrate of soda	Ammonia	260,000	18 0	4,680,000
Sulphate of ammonia	Ammonia	130,000	25.0	3,250,000
Cyanamide	Ammonia	15,488	18 0	278,784
High-grade tankage	Ammonia	210,000	10 5	2,205,000
Concentrated	Ammonia	18,351	14 5	266,090
Dried blood	Ammonia	40,000	17 0	680,000
Dried fish scrap	Ammonia	50,000	11.0	550,000
Cottonseed meal	Ammonia	660,000	7.5	4,950,000
Total				16,859,874

†A unit is 1 per cent of a ton, or 20 pounds.

This estimate, however, takes into account only the more strictly industrial sources, leaving rural sanitation and the like out of the reckoning.

The basis of this article by Mr. Gilbert was issued in mimeographed form for Government use as one of the Political and Commercial Geology Series prepared under the direction of J. E. Spurr, to whom book rights are reserved.

*For Part I see Chem. & Met. Eng., vol. 22, No. 10, March 10, 1920, p. 443.

†Curator of Mineral Technology, U. S. National Museum.

[1]See Chem. & Met. Eng., vol. 22, No. 10, 1920, pp. 444, 445, 446, 447.

Aside from the conversion of organic ammoniates, which is practiced on a large scale only in a few instances, notably that of the Paris system of sewage disposal, four general types of industrial operation figure more or less in the production of byproduct ammonia. They include coal distillation, bone carbonization, oil-shale distillation and blast-furnace operations. The American production, however, is all derived from the first two types. Both the others are active producers abroad, especially in Scotland, but neither of them has as yet obtained a foothold in this country. The American recovery in connection with bone carbonization is of minor consequence. Practically the whole supply comes from the gas works and byproduct coking operations. Fig. 3, in the shaded area designated "ammonium sulphate production," shows the magnitude and trend of the production from year to year since 1900.

Magnitude of Byproduct Nitrogen Compounds

The organic nitrogen recovered in all of the various byproduct connections taken together probably constitutes 40 to 50 per cent of the total supply. Coal product ammonia in this country adds another 12 to 15 per cent. So over half of our supply is of byproduct derivation. The domestic output is supplemented in the case of the organic form by considerable importations from South America, and as shown in Table I, until interfered with by the war, small amounts of ammonium sulphate were imported annually from Europe. Essentially, however, the byproduct supply is of domestic origin. Despite its magnitude, it occupies an anomalous sort of position industrially. It is recovered incidentally for what it is worth, and sold for what it will bring. The cost of production is largely charged off against the major operations with which its recovery is associated, and the returns are credited in conformance as a saving in the cost of the major operations. This is equally true whether the source be that of the domestic animal on the farm, a coke oven, or a packing house.

Controlling Factors in the Byproducts Nitrogen Supply

The industrial output is built up as a sequence to industrial concentration. This is evidenced all down the line, notably in the output of coke-oven ammonia from the steel industry and in that of organic ammoniates from the meat-packing industry. It is this influence of co-ordinated industrial concentration, along with the call for the major operations, that controls the supply of byproduct nitrogen; so the development and handling of the industrial output comes naturally to be largely in the hands of trade combinations. Thus, the coal product ammonia situation is largely at the disposal of The Barrett Co., the tankage and other animal product ammoniates gather for disposal at the hands of the packing interests, and the nitrogenous fertilizers from cottonseed are for the most part prepared and marketed by interests subsidiary to the Cotton Oil Co.

Byproduct Supply Is Not a Determining Factor in the Price of Nitrogen

The manufacturing interests involved are concerned primarily in the manufacture of other than nitrogen products. The byproduct nitrogen recovered has to compete for its market against what comes from the two other industrial classes of supply, and its price goes just low enough to enable it to do so. The limits set in the incidental character of the output leave no special incentive to carry the price competition further. Whatever additional latitude of advantage as to cost of production it possesses goes not to promoting a further reduction in the price of nitrogen but to lowering costs with reference to the major theme of production. Gas-house ammonia, for instance, does not affect the nitrogen market so much as it does the cost of gas, and the organic ammoniates recovered in connection with meat packing have not lowered fertilizer costs so much as they have kept down the cost of meat to the consumer. Thus, the byproduct class of supply, though the leading one in the point of magnitude and by far the cheapest to produce, has little to do with determining the price of nitrogen. The selling price of byproduct nitrogen is determined by the price the product from competing sources brings. In this country it is controlled by the price of Chilean nitrate, and not, as commonly imputed, by the trade combinations that develop and handle it.

Fixation Compounds

Nitrogen has five general habits of combination—that with oxygen, giving rise to nitric acid and its retinue of nitrate salts; that with hydrogen, giving ammonia and the ammonium salts; that with carbon, to form cyanogen and the cyanides; that with basic elements, yielding nitrides; and organically, in the form of organic ammoniates. Various projects have been advanced for turning these to account in the fixation of atmospheric nitrogen. For the most part they have met with little or no practical success, but there are exceptions to the rule of failure in all five directions.

Direct Oxidation—Arc Fixation

Nitrogen does not oxidize at all readily under any ordinary conditions, but its natural indisposition to combine with oxygen may be overcome by passing a mixture of the two gases through an electric arc. The atmosphere furnishes the nitrogen and oxygen ready mixed, so all that is needed in the way of raw materials is an abundant power supply. Arc fixation was developed in Norway, where the possibilities in the way of hydroelectric power give the best setting to be found anywhere in the world. Efforts to introduce it elsewhere have resulted unsatisfactorily, and arc fixation has made relatively little headway, as may be deduced from Table I and Figs. 2, 3 and 4. The reason is twofold. So far, its use of power has proved uneconomical and its product unsatisfactory. The former of these two objections depends for its force on the demand for power, but the latter is more decisive. The immediate end product is nitric acid, which is both difficult to transport and limited as to use. To be put in shape for agricultural use it must be neutralized in the form of a nitrate salt. Limestone is the only cheap neutralizing agent. This gives a salt, calcium nitrate, which absorbs moisture, cakes, and is thus unsuited to the American agricultural practice of machine drilling. An experimental plant near Seattle, Wash., aims to overcome this difficulty by turning out its arc product in the form of sodium nitrite, but the project is of no commercial significance as it stands at the present time.

Ammonia Fixation

Nitrogen is no more disposed to combine of its own accord with hydrogen to give ammonia than with oxygen to give nitric acid. In the case of the Haber process, the only synthetic ammonia process that has stood

the test of industrial application, the native indisposition to combine is overcome by subjecting a properly proportioned mixture of the two gases to heat and pressure in the presence of a catalyzer. This process was instituted in Germany shortly before the outbreak of the war, and as shown in Table I and Figs. 2, 3 and 4, has developed steadily since then. Little seems to be known as to the efficiency of the German Haber practice. Apparently careful manipulation is necessary to obtain results. This means skilled attention, which is incompatible with mechanical volume production and is thus unsuited to American practice. What aims to be an adaptation to American conditions was worked out by the General Chemical Co., and a plant with a rated capacity of 60,000 lb. of anhydrous ammonia per day was projected at Sheffield, Ala., at the instance of the Government. The plant was completed, but before it could be tuned up for actual production the war ended.

Cyanide Fixation

Nitrogen in passing through a red hot mixture of finely divided soda ash, coke and iron reacts with the sodium and carbon to give sodium cyanide. This principle of fixation is being extensively experimented with but has not been developed commercially, except in a small plant with a rated daily capacity of ten tons of sodium cyanide at Saltville, Va.

Cyanamide Fixation

Hot calcium carbide will absorb nitrogen, forming a compound of calcium, carbon and nitrogen, according to the formula $CaCN_2$, known as cyanamide. The cyanamide process, based on this reaction, has been extensively developed, far more so than any other of the various processes, as will be seen by referring to Table I and Fig. 2. Offhand, it looks to be the most adaptable and consequently the most promising of the lot commercially. In this connection, however, it is interesting to examine the several charts of its growth in the warring countries given in Fig. 2. In none of these is the showing indicative of a strong, healthy development. Worst of all is the case of Germany, with the contrast offered in the Haber and cyanamide charts. Until the war, cyanamide manufacture was unable to obtain a competitive foothold in the United States, although a small plant has been in operation at Niagara Falls in Canada for some years. The problem it has faced is similar to that already chronicled for arc fixation, in that it draws heavily on power in the preparation of the necessary carbide, and the cost of power in this country has been prohibitive. Under the stress of the war-time demand for nitrogen, however, the Government contracted for the erection of three plants—one at Muscle Shoals, Ala., one near Toledo, Ohio, and one near Cincinnati, Ohio—with a total rated capacity amounting to 220,000 tons of ammonium nitrate per year. The work on all three was well under way but none of the plants had reached the producing stage when the signing of the armistice brought the nitrate activities of the War Department to an end.

Nitride Fixation

The only process of any prominence aiming to fix nitrogen in the nitride form is one developed by the Aluminum Co. of America. This has for its working principle the fact that a mixture of alumina and carbon highly heated will absorb nitrogen by reacting to give aluminum nitride. The nitride when heated with caustic soda gives its end product in the form of pure ammonia. The outstanding difficulty encountered in applying this process commercially seems to be that of providing a furnace capable of standing the temperature requirements. At all events the process has not succeeded in making good industrially.

Bacterial Fixation

The artificial attempts at fixation have been directed almost wholly toward employing chemical principles. In view of the difficulties experienced and the uncertain value of the results as a whole, it is interesting and perhaps highly significant to reflect that after all, as indicated in Fig. 1, inorganic chemical principles seemingly have little to do with developing the natural supply, probably because of the activities of nitrifying bacteria. Little attention has been given to the possibilities in this direction. This is only natural so far as commercially actuated research is concerned, since it does not lead in the definite direction of patent rights; but the failure to institute an adequate investigation governmentally can be attributed only to lack of comprehension with reference to the scope of the nitrogen issue as brought out on pages 446 and 447. The subject has received just enough attention to show that bacterial fixation represents a tremendous field of grossly neglected possibilities.

Recent Developments and Changes in Practice

The whole matter of fixation must be regarded as in process of development. True, it was instituted about fifteen or twenty years ago and has grown to represent the largest producing source of chemical nitrogen with operations in practically all the important industrial countries in the world and with responsible financial backing. But no one can examine the charts in Fig. 2 without recognizing the premature mushroom quality of the upgrowth, induced primarily in response to the political conditions leading to and through the war. This is especially true for the American situation. When the war broke out, fixation here was confessedly still in the dependent stage of its development, unable in every effort it had made to stand alone industrially. In the main, the developments that have transpired subsequently have followed along pre-existing lines. In so far as they have done so, little actual economic significance is to be attached to them. For the rest, the new developments, all that can be said at this juncture is that they are disappointingly meager.

Military and Agricultural Nitrogen Fixation Procedure

Just one war-time achievement, the oxidation of ammonia, stands out as affording a worth that is unmistakably clear. The nitrogen situation, it will be recalled, has two aspects, the military and the agricultural. The military focus is on nitric acid and the readiest means of insuring a supply; the agricultural focus is on ammonium compounds or their equivalent in neutral nitrogen salts and the most economical means of supply. Here, then, is a parting of the ways to expediency, and it is at this juncture that with military influences to the fore the nitrogen developments of the past few years were led off on an uneconomical tangent of military control. The Bureau of Mines, however, taking up the work of others, has perfected a simple, effective means for oxidizing ammonia to nitric acid. This, beyond question, is the most important contribution of the day.

Its significance may perhaps best be brought out graphically as in the accompanying Fig. 5.

Advantages of Agricultural Nitrogen Fixation Procedure

Ammonia oxidation, it will be observed from Fig. 5, gives a means of supplying the military requirement from the direct line of agricultural efficiency. From the strictly military viewpoint, it has the objection of being a roundabout procedure. The dotted line of direct military procedure, however, has no peace-time function, and consequently cannot be maintained in time of peace in

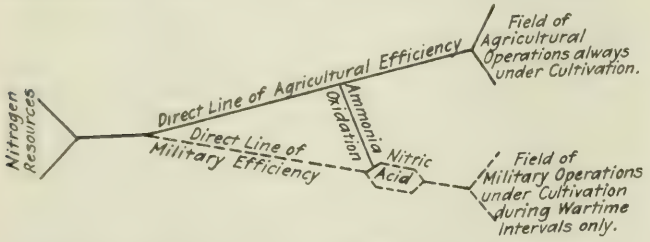

Nitrogen Resources
Direct Line of Agricultural Efficiency
Field of Agricultural Operations always under Cultivation.
Ammonia Oxidation
Nitric Acid
Direct Line of Military Efficiency
Field of Military Operations under Cultivation during Wartime Intervals only.

FIG. 5. MILITARY AND AGRICULTURAL NITROGEN FIXATION PROCEDURE

trim for war, but must instead be built up expressly to meet war-time exigencies. We have had an illustration of what this means in the way of time and money, and this one ought to suffice. The agricultural channel once built up on a basis of economic efficiency is open at all times. At the most, all that is required is to keep an eye to the emergency needs in the way of oxidation equipment, a relatively simple matter. Thus, instead of the precarious procedure of trusting to luck which characterized our pre-war attitude toward nitrogen on the one hand or of attempting the impossible in the way of maintaining a military program of industrial procedure in time of peace on the other, all that is needed is a constructive program devoted expressly to the interests of economic efficiency.

(*Part III, dealing with the nitrogen outlook and a bibliography on the general subjects of the nitrogen industry, will be published in our next issue.*)

Mineral Oil as a Factor in United States Trade

MINERAL oil has been a factor in the foreign commerce of the United States since 1862, when the first statistical record of imports and exports of this commodity appears. So rapid has been the growth of this trade that in the fiscal year ended June 30, 1919, mineral oil ranked first in order in magnitude of quantity in imports and second in exports. Its comparatively low value, however, places it fifth in value of exports and far down the list in value of imports. In 1862 exports of mineral oil, both crude and refined, were 5,829,929 gal., valued at $1,539,027. Fifty-five years later, in 1917, these exports reached the peak, aggregating 2,748,328,485 gal., valued at $230,968,940, but fell in 1919 to 2,529,064,893 gal., valued at $344,233,216, a decrease of 8 per cent in the quantity but an increase of 49 per cent in the value.

Despite the fact that the United States is the world's largest producer and exporter of mineral oils, imports have grown from a total of only 211 gal., valued at $141, in 1862 to the enormous amount of 1,978,951,092 gal., valued at $28,612,799, in 1919. When compared with 1914, the last pre-war year, this is an increase of 150.1 per cent in the quantity and of 109.4 per cent in the value.

The oil industry was begun in America in 1859, in which year the production of crude petroleum in the United States was estimated at 2,000 bbl. So rapidly did the industry grow that in 1860 production rose to 500,000 bbl., and it has climbed steadily since to the high record of 350,131,000 bbl. for the calendar year 1918. The output of the United States from 1859 to 1918, inclusive, makes a grand total of 4,602,775,000 bbl. of 42 gal.

A total production of 350,131,000 bbl., valued at $690,190,000, in 1918 places petroleum third in the value of mineral products of the United States. Bituminous coal led, with a production valued at $1,465,000,000, and pig iron was next, valued at $1,180,759,565.

Despite the fact that the production of mineral oil has increased from a little less than 266,000,000 bbl. in 1914 to more than 350,000,000 bbl. in 1918 (production figures are for calendar years), imports of mineral oils have increased steadily, reaching a total of 1,978,951,092 gal., valued at $28,612,799, in the fiscal year ended June 30, 1919, against 791,137,399 gal., valued at $13,665,940, in 1914 and 1,403,727,624 gal., valued at $21,926,370, in 1918. This is an increase of 575,000,000 gal. in 1919 over 1918. These imports are mostly crude oil and come chiefly from Mexico, with comparatively small quantities from Peru and Trinidad, all of which arrives by tank steamers. With the single exception of 45 gal. in 1916, no oil from Mexico was entered across the Mexican border during the past six years.

Exports and Prices of Mineral Oils

Although imports are mostly crude oil, more than 90 per cent of the exports of mineral oil goes out in the refined form. There has been a gradual decline in the quantity since 1917, despite which the value, reflecting the advance in price, registered an increase of more than $113,000,000 in 1919 over 1917, and the total valuation of $344,233,216 breaks all previous records. When compared with 1914 figures, exports of mineral oils show an increase of only 10.8 per cent in the quantity but an increase of 126.2 per cent in the value.

Exports of mineral oils in the fiscal year ended June 30, 1919, comprised 163,782,498 gal. of crude mineral oil, valued at $9,905,490; 898,044,039 gal. of fuel and gas oil, $49,918,288; 725,686,746 gal. of illuminating oil, $81,495,706; 273,148,541 gal. of lubricating oil, valued at $86,156,695, including 7,596,525 gal. of paraffine oil, valued at $1,173,821; 322,920,087 gal. of gasoline, $78,088,061; 145,301,861 gal. of all naphthas and other light products of distillation, $38,654,419; and 181,121 gal. of residuum, $14,557; making a grand total of 2,529,064,893 gal., valued at $344,233,216.

The average import price of crude mineral oil was 1.5c. per gal. in 1914, but fell to 1.25c. in 1919. The average export prices per gal. of the various mineral oils were as follows: Mineral oil, crude, 4.7c. in 1914 and 6c. in 1919; fuel and gas oil, 2.9c. in 1914 and 5.6c. in 1919; illuminating oil, 6.4c. in 1914 and 11.2c. in 1919; lubricating oil, 14.1c. in 1914 and 31.5c. in 1919; gasoline, 14.3c. in 1914 and 24.2c. in 1919; all other naphthas, an average of 13.8c. in 1914 and 26.6c. in 1919. All export prices show substantial increases, but the price of lubricating oil shows the heaviest advance, having more than doubled since 1914.

The Nature of the Defects Revealed by the Deep Etching of Transversely Fissured Rails*

Microscopic Studies Which Show That the "Gashes" Developed by Deep Etching of Polished Surfaces Correspond to Tightly Closed Intracrystalline Cracks — They May Be Discovered by Dipping a Magnetized Specimen Into a Suspension of Fine Iron Dust

By HENRY S. RAWDON†

THE importance of deep etching by means of concentrated acid in the study of rails showing the defects of transverse fissures has been definitely established.[1, 2] The real nature of the defects revealed has never been demonstrated with certainty, however, and in consequence various views are held as to the interpretation and value of the indications of the deep-etching test. In the different conflicting opinions expressed, the "defects" revealed in rails of this type have been attributed to possible variations in the rate of solubility of the steel in different directions, to internal stresses within the material, and to pre-existing discontinuities or separations within the metal. All of the previous investigators of this subject agree, however, that the defects are of such a nature that ordinary metallographic methods do not reveal their presence. As part of the study of railway materials authorized by Congress by special appropriation for the purpose, the Bureau of Standards has been engaged for some years in the investigation of defective rails, particular attention being paid to those showing transverse fissures. The urgent need of determining the nature of the defects in rails of this type which are revealed by deep etching has recently directed the course this investigation has followed.

FIG. 1. DEFECTS REVEALED IN TRANSVERSELY FISSURED RAILS BY DEEP ETCHING

Longitudinal section of rail No. 3 (Table I) parallel to the tread. The surface was deeply etched with hot concentrated hydrochloric acid. × 1.

As material for study, three rails which had been removed from the track because of the presence of transverse fissures were used. The three differed markedly in composition, as shown by the data summarized in Table I:

TABLE I. COMPOSITION OF RAILS USED

Rail No.	Carbon, per Cent	Manganese, per Cent	Phosphorus, per Cent	Sulphur, per Cent	Silicon, per Cent	Chromium, per Cent	Nickel, per Cent
1	0.63	0.71	0.014	0.022	0.09	0.50	1.89
2	0.62	0.91	0.020	0.036	0.01	Not detected	Not detected
3	0.90	1.22	0.094	0.022	0.14	Not detected	Not detected

Sections of the head of each of the three rails were cut parallel to the tread into a series of slices approximately ¼ in. in thickness. Each of these slices, after

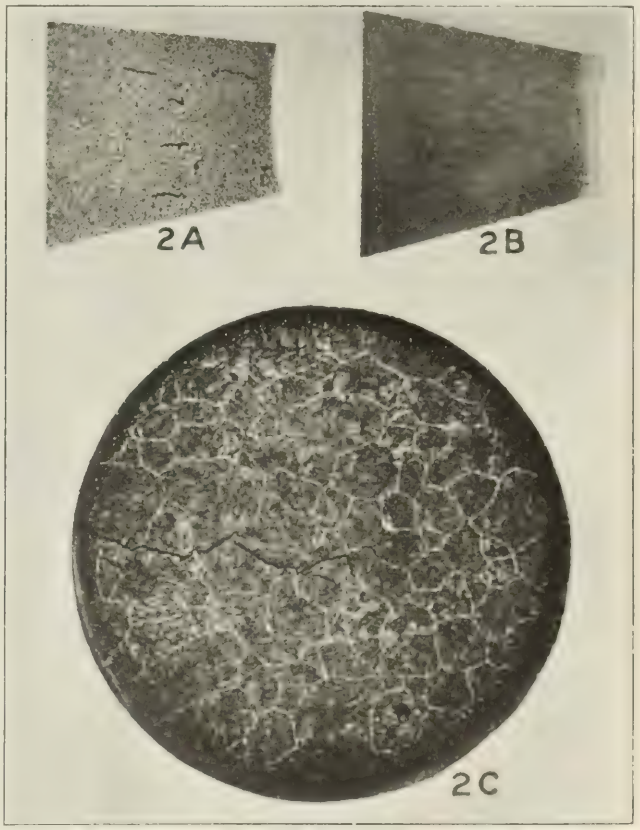


FIG. 2 DEFECTS IN GUN FORGINGS REVEALED BY DEEP ETCHING

A. Transverse radial section from a forging for a gun tube deeply etched with concentrated hydrochloric acid. × 1.

B. Same specimen as *"A"* after polishing, but before etching. The defects revealed in *"A"* are readily visible before the specimen is etched. × 1.

C. Cross-section of a 1-in. "round" trepanned out of a large bloom intended for a gun tube; etched with 2 per cent alcoholic nitric acid. The crack, which is, undoubtedly, of the same origin as the defects in *"A"* and *"B,"* probably originated at a rather high temperature. It is largely intercrystalline in its course. × 3.

*Report No. 85 to Rail Committee, Am. Ry. Engrg. Assn.

†Associate Physicist, Bureau of Standards.

[1]F. M. Waring and K. E. Hofammann, "Deep Etching of Rails and Forgings," A. S. T. M. *Proceedings*, vol 19, (1919), and discussion of same. Also *Iron Age*, vol. 104, pp. 13-16 (July 3, 1919).

[2]M. H. Wickhorst, "Transverse Fissure Rails on Atchison, Topeka & Santa Fé Railroad, Heat 41,177," Bulletin 218, Am. Ry. Engrg. Assn. August, 1919, p. 1.

grinding, was etched with hot hydrochloric acid (sp.gr. 1.19), to determine whether the defects noted by previous investigators were present or not. In each rail they were found in abundance in the central and the lower portions of the head. Fig. 1 shows a longitudinal section, parallel to the tread, cut from the lower portion of the head of rail No. 3 which has been deeply etched.

Defects similar in appearance to those seen in the etched rail sections have been noted in defective ingots and blooms of gun steel. Fig. 2a shows the defects in such material. That these defects are initially present in the material is evident from Fig. 2b, which shows the same material before etching. The nature of these

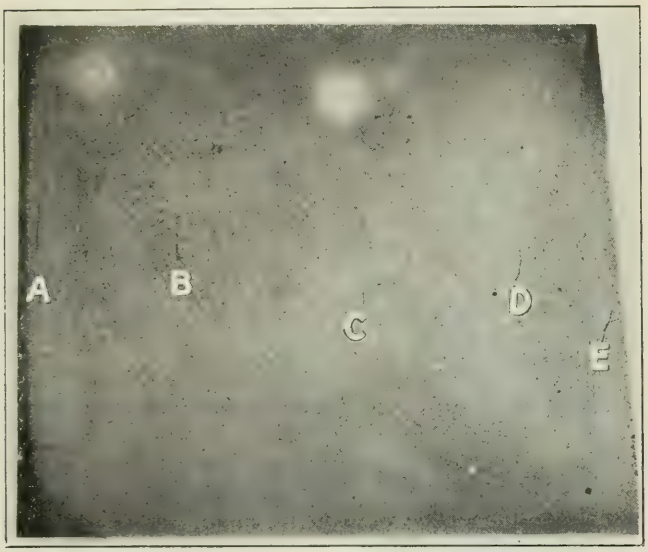


FIG. 3. DEFECTS IN TRANSVERSELY FISSURED RAILS

The specimen of Fig. 1 after polishing, but before etching, was magnetized and then immersed in a suspension of fine iron dust in kerosene. (Compare with Fig. 1.) × 1.

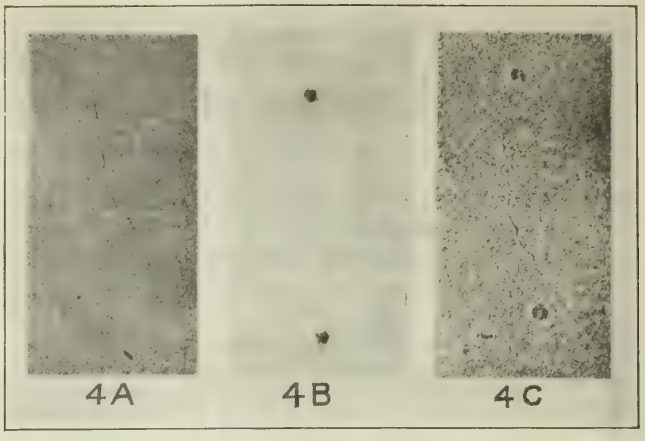


FIG. 4. INTERIOR CRACKS EXISTING IN TRANSVERSELY FISSURED RAILS

A. Crack *"B"* of Fig. 3 viewed obliquely. × 3.
B. Same specimen as *"A"*; the line of the crack shown in *"A"* was located by a punch mark at each end of the crack and the iron dust was wiped off. No crack is visible. × 3.
C. Same specimen as *"B,"* treated a second time with iron dust. (Compare with *"A."*) × 3.

"cracks" or separations is illustrated by Fig. 2c, which shows a section of a 1-in. "round" trepanned out of a defective bloom of gun steel. The defects are of the nature of cracks largely intercrystalline in their course —i.e., they extend between the grains, for the most part, rather than across them.

It might naturally be expected that the defects revealed in the rails are of the same character as those shown above in the gun steel. It is extremely difficult, however, to demonstrate the presence of any features in the unetched material corresponding to those found in the deeply etched specimen. As already stated, the usual metallographic methods are ineffective; various other means were tried, including examination by means of X-rays. Radiographic examination even of sections

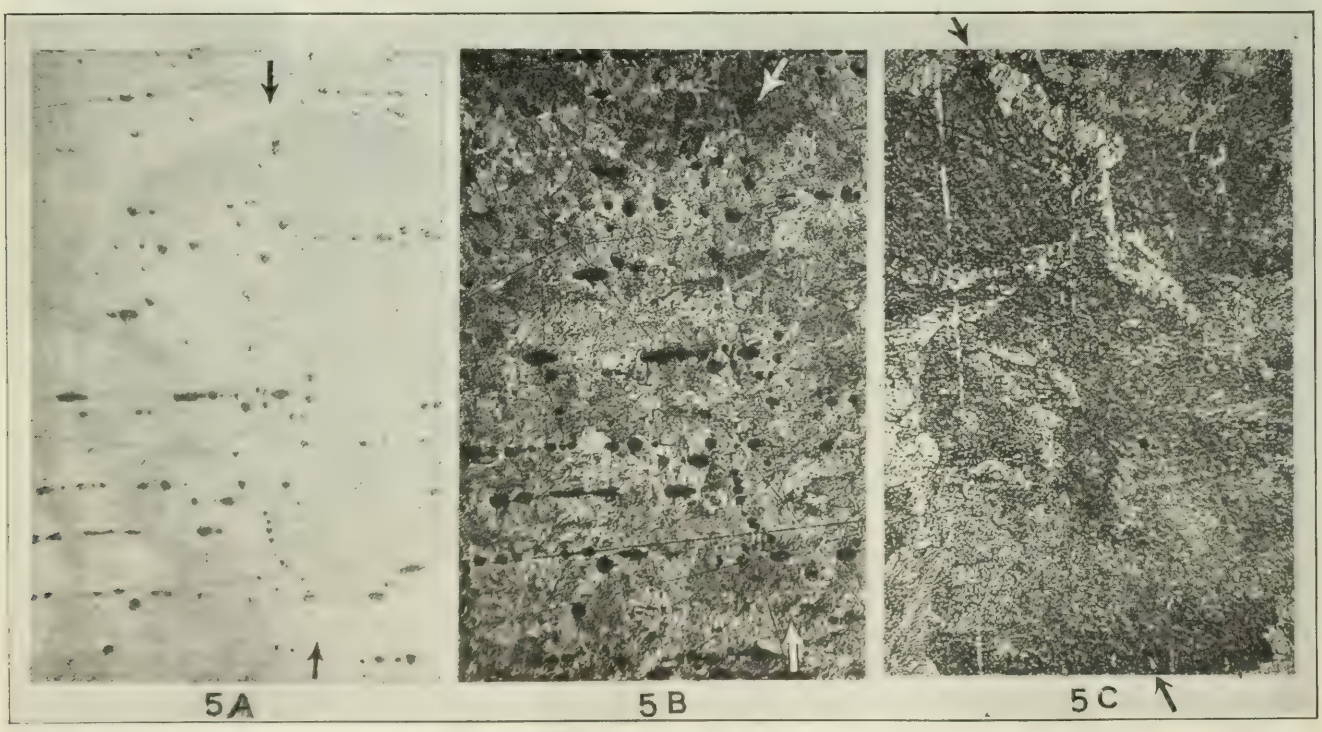


FIG. 5. MICROSCOPIC APPEARANCE OF CRACKS EXISTING IN TRANSVERSELY FISSURED RAILS

A. Crack *"B"* of Fig. 4; specimen is unetched. × 50.
B. Same specimen as *"A,"* etched with 2 per cent alcoholic nitric acid. The metal is in such intimate contact along the line of the defect that only a very faint indication of its presence could be obtained. × 50.
C. Same specimen as *"B."* × 500. Even at this magnification the course of the crack (indicated by arrows) is relatively very inconspicuous.

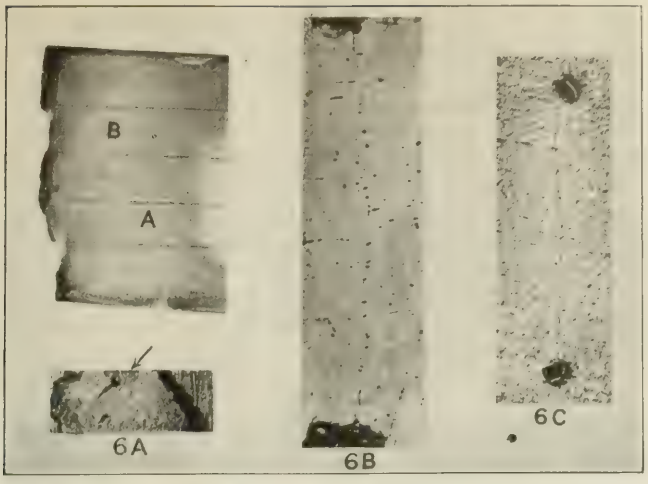


FIG. 6. NATURE OF THE INTERIOR DEFECTS REVEALED BY THE DEEP ETCHING OF RAILS CONTAINING TRANSVERSE FISSURES

Upper left—Longitudinal section of rail No. 1 (Table I) parallel to the tread. The two defects *"A"* and *"B"* were located by the magnetic method.

A. Fracture of the strip of specimen containing defect *"A."* The rail section was cut into strips as shown and fractured by a transverse break, along the line of the defect. The semi-circular area, indicated by the arrow, corresponds to the defect.

B. Defect *"A."* By means of a punch mark at each end, the crack has been opened; specimen is unetched. × 50.

C. Defect *"B."* The crack has been opened by means of punch marks as shown. Specimen was slightly etched with 2 per cent alcoholic nitric acid. × 10.

no more than ¼ in. in thickness did not reveal the presence of any unusual features.

The only method by which the defects can be located without etching the material is a magnetic one. The specimen, which must be well polished on the surface as for microscopic examinations, is magnetized and then immersed in kerosene or a similar liquid, containing very fine iron dust in suspension. "Cast-iron mud" from disks used for lapping operations is admirable for the purpose. Particles of the iron dust collect upon the polished face of the magnetized specimen and at the places where, because of a discontinuity within the metal, a change in the density of the magnetic flux occurs, orient themselves to correspond to the shape of the discontinuity. The specimens are finally washed in clean kerosene to remove as much as possible of the excess iron dust which is scattered over the surface.[3]

In Fig. 3 is shown the appearance of the specimen illustrated by Fig. 1, before etching.

It was given the treatment outlined above. It is extremely difficult to photograph the surface so as to show clearly the results of the treatment with iron dust. They are readily seen upon visual examination, much more so than might be inferred from the photograph. Comparison of Fig. 3 with Fig. 1, however, shows a very fine "crack" or discontinuity in the unetched sample corresponding to each of the defects found in the specimen after deep etching.

The appearance of the cracks located by the magnetic method is more clearly shown in Fig. 4, somewhat magnified, in which the surface was viewed obliquely. Crack *"B"* (Fig. 3) was located by means of iron dust after magnetizing the specimen. Its position was then recorded by a punch mark at each end of the crack. Fig. 4b shows the specimen after the iron dust was wiped off; no crack can be detected between the two punch marks. In Fig. 4c the same area is shown after a treatment with the iron dust. Although it is known with certainty that a discontinuity exists in the steel between the two punch marks, it is extremely difficult to find evidence of it in the microstructure even after

[3]This method was developed at the Bureau of Standards under the direction of Major W. E. Hoke for the inspection of precision length gages.

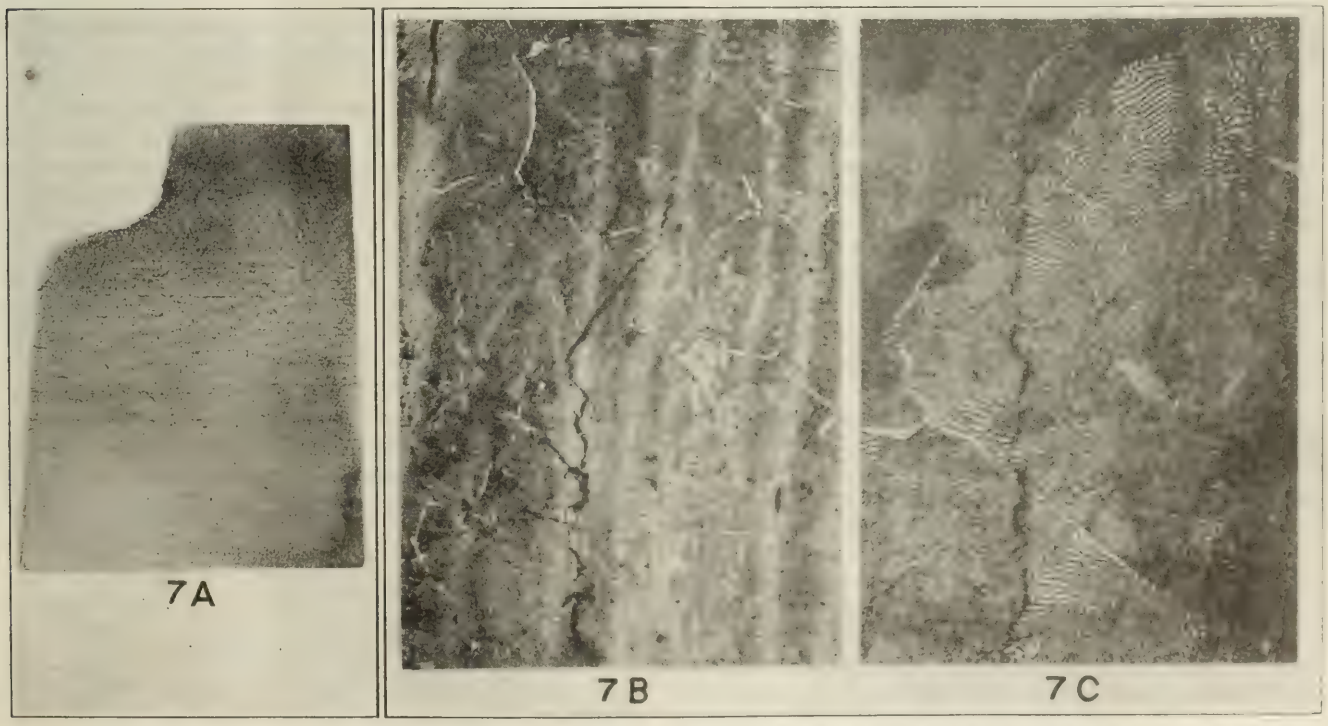


FIG. 7. MICROSCOPIC NATURE OF THE INTERIOR DEFECTS FOUND IN RAILS OF THE TRANSVERSE FISSURE TYPE

A. Longitudinal section of rail No. 2 (Table I), parallel to the tread, showing the interior cracks as they appear after slight etching with concentrated hydrochloric acid. × 1.

B. Specimen *"A"* after slight etching in concentrated hydrochloric acid to widen the crack, repolished and etched for microscopic examination. The crack is intracrystalline in its course. There is some evidence of banding due to phosphorus. Etched with 2 per cent alcoholic nitric acid. × 100.

C. Same material as *"B."* The intracrystalline nature of the crack is very evident. Etched with 2 per cent alcoholic nitric acid. × 500.

light etching. In Fig. 5 is shown the best indication found of the presence of such a crack in the area between the two punch marks. This is very faint, however, and would be regarded in the ordinary microscopic examination as of little or no significance. The faces on the opposite sides of the discontinuity or fissure are in such intimate contact that at a magnification as high as 500 diameters the course of the crack is relatively very inconspicuous, as is shown in Fig. 5c. The course of the crack which has been indicated by arrows is hardly more conspicuous than the dark boundaries of the pearlite masses which constitute the structure of the steel. The failure of the radiographic examination to reveal these defects is due to the intimate contact between the two faces of the crack; the specimen behaves as solid metal does for this reason.

In Fig. 6 is shown a slice cut from the head of rail No. 1, parallel to the tread, in which two defects have been located by means of iron dust after magnetization of the specimen. By means of punch marks close to the ends of the cracks, it was found possible to open the fissure, as is shown in Figs. 6b and 6c. The slice containing the defects was then cut, as shown by the ruled lines, and each strip broken transversely along the line of the defect. The break was localized by means of a slight sawcut on each side in line with the crack. The appearance of the fracture is shown in Fig. 6a. A definite area which is easily distinguished from the surrounding sound material corresponds to the defect previously located. The strip containing crack *"B"* showed a similar characteristic spot when broken. The area, semi-circular in Fig. 6a, is identical in appearance with the nucleus of transverse fissures and with the "gray spots" often revealed in the transverse breaks of the heads of defective rails of this kind.

The nature of these defects can best be studied in material in which the carbon content is low enough so that the grain boundaries are clearly outlined by ferrite envelopes. Rail No. 2 was found to be very suitable for this purpose. Fig. 7 shows a section of this rail after slight etching with concentrated hydrochloric acid. The interior cracks having been widened by the concentrated acid, the surface was ground down, repolished and re-etched for microscopic examination. In Figs. 7a and 7b a crack is shown passing through the grains and across the grain boundaries. The cracks are intracrystalline in their course—i.e., the break has occurred through the grains rather than between them.

Results of the Examinations

The results of the examination given above definitely warrant the conclusion that the defects ("gashes," "fissures" or "cracks") revealed in rails of the transverse fissure type by means of deep etching exist within the material previously to the etching, as discontinuities within the steel. The function of the acid used for etching is merely to widen and deepen the *pre-existing* cracks. The microscopic appearance of these cracks offers some suggestions as to their origin. The course of the crack is intracrystalline and has the general appearance of a fracture produced in normal material; there is no evidence of inherent weakness at the grain boundaries. An answer to the question as to whether the separation occurred while the metal was cold (i.e., in the track), or while hot (i.e., in the mill), does not appear to be forthcoming from the evidence offered by the examination of the fractures alone. No definite statement can be made on this point. However, the comparison of internal fractures found in ingots and blooms and hence, in all probability, produced at a rather high temperature (Fig. 2) with those found in rails which were removed from service because of transverse fissures (Fig. 7) is very suggestive.

The internal cracks shown in Fig. 2 are of the intercrystalline type. In general, this is a characteristic of fracture produced in metals at elevated temperatures. On the other hand, the cracks shown in Fig. 7c are of the intracrystalline type, a feature which, in general, is characteristic of fractures produced in metals broken at ordinary temperatures.

Summary

1. It has been definitely shown that the defects found in transversely fissured rails in abundance after deep etching exist within the metal initially—i.e., before etching. The concentrated acid merely widens and deepens these defects.

2. These defects are internal fractures, roughly circular in area, and are of the intracrystalline type of break; otherwise, the metal appears sound.

3. These defects may be revealed with certainty before etching by magnetizing the polished specimen and then immersing it in a suspension of very fine iron dust in kerosene or a similar liquid. This method appears to be the only one for determining the presence of these and similar defects with certainty without etching the piece and thus destroying the characteristic features of the defects.

Touring Exhibition for British Industry

In the interests of British commerce in overseas markets the Department of Overseas Trade is completing arrangements for a comprehensive touring exhibition with the object of showing to advantage the manufactured products of the United Kingdom.

For a start the itinerary comprises South Africa, Australia, New Zealand and Canada. The duration of the tour will be about eighteen months, and, should the venture be attended with the degree of success which is anticipated for it, similar projects to other parts of the world will receive consideration. Matters are rapidly taking shape, and in a comparatively short space of time full details of the scheme will be submitted to the manufacturers of the country. It is intended that about 500 firms shall be invited to take part in the tour, and considerable support has already been forthcoming. Only British firms may participate.

In addition to showing the goods, the question of selling them has received attention. It is hoped to work in with the staff arrangements an agency in which orders can be taken and transmitted to the manufacturer.

Chemists' Club Will Purchase German Marks

The depreciation in German marks has been a matter of misfortune to some people in this country who have had considerable sums of German money. The Chemists' Club has recently announced through its Secretary, J. R. M. Klotz, 120 Broadway, New York City, that anyone who desires to dispose of marks at the price originally paid can do so through a plan which has been devised by the Club. Parties interested should communicate with Mr. Klotz.

Need of Co-operative Educational Work in the Chemical Industry

A Plea for Co-operative National Education in the Uses of Chlorine in Our Daily Life and Examples of the Beneficial Results Already Obtained by Co-operative Propaganda in Many Other Fields of Manufactured Products

By JACOB G. COHEN

IN HIS work on Municipal Chemistry Prof. Baskerville showed, several years ago, the value that minute quantities of chlorine would have if added to the water with which streets are flushed. It has been urged by Albert H. Hooker in his work on Chloride of Lime and Sanitation. Here we have the greatest disinfectant known to man, at once cheap and available. And we have in the dust of our streets the bacilli of tuberculosis, tetanus, influenza and the germs that are said to be active in spreading coughs and colds, besides a lot more of the kind.

The Hazen theorem indicates that when an impure water supply in a community has been removed through the use of chlorine, the general death rate is reduced. It has been shown, where such change took place, that for every person thus saved from typhoid fever, three other persons are saved from death due to other causes usually not considered influenced by the character of the water supply. Infantile mortality caused by bronchitis, tuberculosis, pneumonia and other disturbances indicate a lowered vital resistance from the drinking of polluted water. An improved water supply forecasts increased health of the people of the community, a real tangible building up of bodily resistance to germ disease. Says George W. Fuller:

"Many sanitarians and medical men are clamoring stoutly for the elimination of all sewage matters from American streams. Literally this is impossible. No longer can there be streams of pristine purity in populous districts. This is one of the penalties of civilization.

"On the other hand, it may be freely stated that many streams are now polluted to a disgraceful degree. Corrections are most urgently needed.

"Fortunately there is now available by the hypochlorite method a reliable means of sterilizing or disinfecting sewage or water at a small cost. The full significance of this is not yet fully appreciated. It has much bearing on the question of sewage disposal in general, and in the duration method in particular, as related to some conditions."

Chlorine's Place in Our Daily Life

Chlorine on the farm for water and sewage infection, chlorine to banish the house-fly and the many diseases that follow in its trail, chlorine for prevention of epidemics, and use in surgery and general sanitation, it ever comes in our daily life, affairs and contacts. When the full realization of its value to all humanity comes, then will its uses become more general and its production become greater.

"We are searching for an outlet for our excess chlorine in metallurgy and in organic chemicals. If our electrolytic chlorine friends would begin telling people how they can live in a prophylactic environment, how they can feed their babies pure milk, and how they can avoid poisoning their neighbors who live lower down on the same watershed, conditions in the chlorine market would soon be such that they would no longer worry about what the Government is going to do with Edgewood."

This quotation from a paper on "Chemistry in Its Human Relations" read at a meeting in Buffalo indicates an essential need in the alkali industry. Increased number of buildings, increased surplus of elemental and manufactured materials, and a market that is glutted and sluggish from the standpoint of turnover mean that the chlorine people can take a leaf from the history and experiences of other industries that had the same situation to overcome. How they did it in a co-operative way will be briefly told in this paper, while the application of the principles to the problem of chlorine and its products will be but touched upon.

Individual vs. Mutual Interest

In the early period of American manufacture, individualism was suited to this growing stage. But the days are over when manufacturers considered that competition meant keeping to themselves everything they learned and going on their own individual paths into the markets of the country and the world. There was no regard for honorable tactics when competition was concerned, but business today has passed this stage; and for today and tomorrow and the tomorrows to come, it must be considered in its larger, greater, common grounds of mutual interest.

Industry can succeed best in this world when it renders real service, and in this opportunity for serving there will always remain individual initiative in matters of practice and competition in matters of effectiveness. This is done through the right kind of working co-operation, one which benefits the public at large by research work in facts and information gathered, and by giving the public the realization of its value through recognized media of publicity. Supplementing this general work of developmental co-operation comes creation of a code of ethics in competition, a standardization of specifications and practices in the engineering and sales management of the various companies of the industry considered with respect to the relations of any one manufacturer to all in that particular industry.

The day of organization is here, emphasized in such singularly effective manner during the period of the war—in one great industry after another the spirit of internal competition is yielding to co-operation within the ranks.

Decidedly, a condition exists in the alkali industry

which makes necessary a widening of the market. This cannot be done by one member taking away the market of another. It can be done only by a broad, effective effort to sell the American people on the uses of chlorine products, to sell more by educational efforts and thus make a better market for all. The increased volume of business will repay the small sum any one manufacturer will contribute toward such a campaign of co-operative national education.

Co-operative Advertising in the Building Materials Field

That this theoretical advantage of co-operative national education has proved successfully practical is attested by the fact that during recent years scores of industries in this country have organized for the joint promotion of their products. A glance through the leading journals shows the wide diversity and range of industries that are using this form of educational propaganda to increase the use of their product.

The Lumber Industry

The story of co-operative advertising in the lumber industry is one of continuous success. The Southern Cypress Manufacturers Association was one of the first in the field. Its annual appropriation for this purpose has been materially increased each year. In a letter from the secretary of that association, dated Sept. 27, 1917, he advises that its total revenue for promotion work during the fiscal year ended June 30, 1917, was approximately $140,000. He makes this significant statement:

"Our subscribers, or members, have felt a most decided improvement in business conditions as a result of our advertising. Cypress stands out alone of all woods as being in the most prosperous condition. During the first half of the present year, the manufacturers of all other woods suffered a decline in prices and curtailed their production."

Common Brick Manufacturers

Another association of manufacturers in the building field is that which has grown out of the demands created by the war, called the Common Brick Manufacturers Association of America. The common brick manufacturers have been asleep while the lumbermen, face brick manufacturers, the cement industry and the makers of hollow tile went after increased trade and secured it. The lumbermen went after the building business. They worked with the architect, the engineer and the contractor. They furnished plans free and even helped finance buildings. So well did the lumbermen succeed with their propaganda work that today it is estimated that fully 85 per cent of all the materials used for buildings erected in the United States was sold by the lumber dealers.

To correct this condition is the object of the plans of this co-operative association. Their work will consist of paid publicity in all of the large journals, publications, and books showing the use of brick in chimneys, garden fences and other ornamental features. It will teach the common carpenter and small contractor how to build and figure a brick house. It will prepare books and publications; it will treat the proposition of building with brick in an A B C way. The big talking point is in the fact that the price of brick has increased relatively less than that of any other building material. The brick manufacturers realize their opportunity at this time, in the fact that a brick house costs just about the same as one made of lumber and lasts a good deal longer. The association plans to follow up this opportunity in a constructive and progressive manner.

White Pine Bureau

The White Pine Bureau, composed of white pine manufacturers in the Northwest, has a large annual appropriation that it devotes to propagating the use of white pine in the building of homes. Through this campaign they have discovered the public and realized that it is the selfsame public and not the dealer or broker that is the turning factor in their interest. Their present campaign was planned for a 5-yr. period. It has been in operation so far for only three years and despite the conditions brought on during the war period they feel that their efforts were well worth while. Results of their educational work are beginning to show themselves now through increased use of their materials, and they have the satisfaction of securing wholehearted and enthusiastic co-operation from their dealers as a result of this campaign, as well as developing a new public to the use of the particular forms of building material that they manufacture.

Paint Manufacturers

The Paint Manufacturers Association of America, under the direction of its educational bureau, has completed its plans and is now at the beginning of a 5-yr. "Save the Surface" campaign which will represent a total investment of $625,000. This educational work will be carried out in the interest of all the branches of the paint and varnish industry in a purely impartial manner and no particular material will be favored or particularly recommended at any time during this campaign. The entire object is to bring home the realization that a greater use of paint materials lengthens the life of the object on which this material is used; that in saving the surface many years are added to the life and wear of the object to which it is applied. It is purely propaganda for education, and as the realization comes of the true value of paint materials, a benefit to those who have contributed to this fund will come in the increased use of their manufacture.

Portland Cement Association

Unlike the Common Brick Manufacturers Association the Portland Cement Association has been a constant user and believer of all forms of educational publicity for a good many years. This work has had much to do with the notable growth and advance of the cement industry. As indicative of the association's belief in the success of its work, its appropriation for 1917 was three times as great as the fund that was devoted to it the year previous, and that amount had increased over that of the preceding year.

Magneto Manufacturers Active

Five important manufacturers of magnetos are united to win back the market for their product. Prior to 1911 practically every automobile was equipped with magneto ignition; but due to a variety of causes the percentage of passenger machines thus equipped dropped to 18 per cent in 1918. The reason for this slump is attributed to the strong publicity for battery ignition as well as to the neglect of the magneto manufacturers

properly to acquaint the public with the merits of their product. This work, as educational work, is supplementary to the competitive publicity used by these different manufacturers in their individual campaigns.

Co-operative Association Brands

The advertisers of fruits, nuts and raisins, especially those situated on the Pacific Coast section of this country, have been regular and persistent developers of the general public opinion. Almost any national publication contains in its advertising section advertised fruits of the California Fruit Growers Association, "Sunkist," California Associated Raisin Co., "Sunmaid," Yakima Valley Fruit Growers Association, "Big Y," the Northwestern Fruit Exchange, "Skookum," California Walnut Growers Association, "Diamond Brand," Florida Citrus Exchange, "Sealdsweet."

Oregon Prune Growers

Even the humble prune will soon enter the market through being standardized, trade marked and advertised. The causes which led up to this action on the part of the Oregon prune growers are due to the ever-increasing production of the present bearing acreage, the realization and necessity for a standard product, the creation of markets to care for future surplus, the enormous prices and potential crop of California prunes which dominates the field, and the seemingly unnecessary price fluctuations. The problem, therefore, is what to do with this enormous increased production; how to find new markets; how to create a greater demand; and, of paramount importance, how to maintain prices on a stable "cost of production price" basis for every brand of prune there is. To secure these results it has been planned to spend over $200,000 within the next twelve months to acquaint the general public with its graded and branded prune.

American Cranberry Exchange

The American Cranberry Exchange is a co-operative organization of cranberry growers supported by assessments levied upon its members, which include the leading growers of fruit. It controls distribution and has created an artificial demand for cranberries, that is, created a demand other than that created by the age-old custom of serving cranberry sauce with the turkey on Thanksgiving. In this connection it is interesting to know that the general manager of the exchange in his annual report said: "With an adequate amount of publicity an artificial demand can be created sufficient to consume the largest possible crop." This is especially interesting because before the advent of any national cranberry advertising the growers experienced a number of bad years when the crop was heavy and the demand was light.

Laundry Machinery

Appreciating the fact that its success is bound up with the industry it serves, the American Laundry Machinery Co. has launched a campaign which it expects to conduct over a period of at least three years to inform the housewives of America, as simply and pleasantly as it may, the advantages of modern laundry methods over the old-time washboards and the mess and worry of wash day. The campaign also contemplates a hard and continuous drive to protect the industry and to protect as far as possible the further inroads of manufacturers of home power laundry equipment by getting before the housewives the laundries' side of the story. The campaign which has been worked out for developing a legitimate market open to the industry is largely educational. An analysis of the potential market leads the company to believe that fully one-half, or 10,000,000, of the homes in the United States can be considered as possible patrons of the laundries. Estimated surveys show that if each of these homes were to send a bundle of home work each week amounting to $2 (which is low), it would mean a total volume for the laundries each year of $1,040,000,000.

Automotive Wood Wheel Makers

The Automotive Wood Wheel Manufacturers' Association spent $70,000 in 1918, and will spend as much or more this year to put wood wheels back in the place they held before wire wheels were so widely advertised. If those manufacturers of wood wheels had begun earlier, their appropriation would have had more value. Now they have to meet opposition. Once they could have simply maintained the good will built up by years of use of wood wheels on horse-drawn vehicles.

Stone Quarry Products

The Barre Quarries and Manufacturers Association spends $75,000 annually on a product that has not one-tenth the appeal that can be made by alkali products. It has advertised for three years and the results are now beginning to show to full advantage. It pays 5 per cent of its gross income into the fund.

Tobacco Growers

The New England Tobacco Growers Association, representing the growers in the Connecticut Valley, has decided to advertise nationally in order to develop a proper appreciation for tobacco, especially wrappers, produced in that section of the country. It is reported that dealers as well as farmers are interested in this project. No amount has yet been determined, but it will be prorated according to the number of acres.

The Cooperage Industry

A fund of $300,000 for a 3-yr. educational campaign in favor of the use of slack barrels is now being raised by the Associated Cooperage Industry of America. Says F. S. Charlot, chairman of the committee:

"We think the slack barrel as a container for food products is better than some of the other containers now in use. We believe if the public could vizualize the unsanitary experiences of a sack of flour or sugar, they would prefer to go to the grocer and have that small quantity dispensed from a clean, sanitary wooden barrel that has protected the contents from contamination. If the public choose to go to their grocer and insist that the flour or sugar be dispensed that way it will eventually be done."

Spreading Gospel of "Safety First"

"Safety First" is a phrase that is familiar to everybody, but few members of the public stop to think who created the slogan and who made it possible. The answer in both cases is the National Safety Council, with headquarters in Chicago, which is spending a large sum each year to spread the gospel of accident prevention. Most of this fund goes for printed matter, because they believe their problem is entirely one of education and continued publicity. The Council was started five years ago and in that brief period it has built up an or-

ganization of 3,758 members, including 150 industries employing over 6,000,000 workmen. The Council has sought to reach these workmen and their employers with fact messages that would get co-operation from all those affected.

Labor Union to Advertise Wood Carving

An old industry, wood carving, is to be advertised by its labor union, the International Wood Carvers Association. The purpose of this publicity is to bring home to the American people the fundamental facts about hand-carved wood and to show that wood carving, into which the best efforts of skilled men have gone, is better than machine-made compo wood. The true motive is to gain the patronage of the wealthy and the artistic for the hand-carved product, that the craft may revert to its former high place among the arts.

The Canners' Campaign

A new educational campaign is now being conducted by the canners of the United States. This is contemplated to last four years and the approximate cost for this period will be about $2,000,000. The form of the campaign will be to heighten the prestige of canned goods as a steady article of diet. The maximum public good will is to be openly and candidly sought in behalf of the entire industry. The canners mean to lay their products and processes on the table and invite public inspection and examination. They want to correct the misinformed and dissipate prejudice.

It is intended that the campaign shall have the following results: A united industry, universality of food of higher standards, larger production, larger consumption, service to the public, and greater confidence of the consumers. Special committees and divisions have been appointed to take care of the different sections of the work. Surrounding them are the various subdivisions which have to do with laboratory work, legal work, finance, inspection, etc.

One part represents the educational and information section and has charge of compiling authentic information concerning all branches of activity in the industry. The second part deals with home economics and spreads the story of canned goods through schools, clubs, stores, conventions, etc., by means of addresses, lectures and demonstrations. It will also have charge of promotion, which will include personal interviews and correspondence with officials, firms, the trade and the members of the industry itself, with addresses at conventions of the industry and of the trade.

Still another section covers the actual educational work that is done by the committee in the way of general publicity, together with investigative work among canners, consumers, dietitians, physicians, pure food reports, food law officials and many other classes. No effort will be spared to show the housewife the healthfulness and safety of canned goods and the care and study given their proper production. It is believed their consumption will be vastly increased.

In Union There Is Strength

These are the illustrations of manufacturers, all of them in competing lines, who are willing to forget fear and jealousy and work together for the common good. They are merging their various individual educational efforts into a common hold to develop and enlarge the market for their product. These men are competitors and will remain so, but they are proceeding on the theory that the more information and the more propaganda they conduct on their particular products, the better it is going to be for everybody in the industry. Manufacturers when disposed to shy at co-operative efforts in the way of marketing and advertising can well afford to learn a lesson from the labor unions. Statisticians tell us that organized labor comprises only about 7 per cent of the country's population. Despite the small proportion, note the way the labor unions win out time and again. They win because they adopt a policy and then go through with it. Whatever may be the criticism of their methods, it must be admitted that they stand together for their common cause.

Business Expansion and Market Saturation

In considering the trade in chemicals, the amount of the trade should not be regarded as a fixed volume of business, but one capable of unlimited expansion, bounded only by the character of the business administration and the study of business conditions, trade opportunities, sales, etc. The limit is reached only when the market has topped the saturation point. Has this point been reached in the use of chlorine for water treatment and disinfection purposes? A paralleling of towns using chlorine products for this purpose with those that do not would bring forth the comparison. As an illustration of a similar condition, though in a dissimilar field, Chairman Hurley of the Shipping Board relates an incident in his own business when he centered a lot of energy on a special sales campaign.

Money was spent in advertising and saleswork, new territory was entered and new customers secured. Results exceeded his expectations. He increased his output, distribution and profits and at the same time reduced his manufacturing and selling costs.

None of his competitors lost any business, however. In fact, by his educational work they gained many new dealers and consumers. He said that it is as if some one suggested that new railroad lines of freight cars to carry goods might take business away from somebody, for we all understand that trade is something to be expanded, something that grows by opening up new territory, by finding new uses, spreading new ideas. It will grow through intensive development, as is done on other products, through advertising, sales, organization and co-operative work generally, whereby business will be created by cultivating the natural desire of every human being for a better standard of living.

Conclusion

Co-operative educational propaganda has tremendous possibilities. It makes a broader and wider market for the entire products and industry through an increase in demand; stabilizes and steadies the market, and makes it less affected by trade depressions and other similar conditions; creates a market for general production before it tries to sell the particular commodity. It lessens the bitterness of competition and advertises the health and strength of the entire industry.

There is opportunity at the present time for co-operative educational work on the greater use of alkali products. To lower the death rate, to make living conditions better and more pleasant, to benefit all mankind —this is the opportunity and the work that is to be done, done in the same way and in the same manner that the various individual industries of this group have been built up, and the results can be considered certain of success.

Industrial Alcohol Under the New Law and Regulations

An Interpretation of the Industrial Aspects of the National Prohibition Act and Regulations 60 and 61—Authorized Uses of Intoxicating Liquors—Procedures—Tax-Free and Completely and Specially Denatured Alcohol—Formulas and Applications

By BURNELL R. TUNISON

BECAUSE of the general misconceptions on the part of the public, and of chemists and manufacturers in particular, concerning the recent national prohibition act and the regulations recently promulgated by the Internal Revenue Bureau for carrying out the provisions of this act, it seems advisable at this time to attempt to explain the essential features of this act and these regulations and indicate in a general way the fundamental changes which will take place due to their operation.

Most people imagine that the national prohibition act has but one aim to accomplish; namely, to prohibit the use of alcohol as an intoxicating beverage. This was the primary consideration, but it may be seen from the title of the act itself that Congress had another aim of almost equal importance. Congress, after mature deliberation and after the passage of most of the features involved in the act itself, decided to call the act as follows:

> An act to prohibit intoxicating beverages, and to regulate the manufacture, production, use and sale of high-proof spirits for other than beverage purposes and to insure an ample supply of alcohol and promote its use in scientific research, and in the development of fuel, dye and other lawful industries.

Dual Purpose of the Act

It will be noted that one of the purposes of the act is to insure an ample supply of alcohol and promote its use in the lawful industries.

In order to carry out the provisions of this act the United States Treasury Department, through the Bureau of Internal Revenue, has issued regulations. These have been issued in two parts: Regulations 60 relating to the manufacture, sale, barter, transportation, importation, exportation, delivery, furnishing, purchase, possession and use of intoxicating liquor; and regulations 61 relating to the production, tax payment, etc., of industrial alcohol and to the manufacture, sale, and use of denatured alcohol.

Most people think that the above-mentioned regulations 60 concern that alcohol which may be used as beverage and that regulations 61 concern all alcohol which is used industrially. It is the writer's opinion that this should be the case, but unfortunately this is not the arrangement made by the powers at Washington. Regulations 60 concern intoxicating liquors, in which the Government has included all pure alcohol used industrially upon which tax is paid. Thus manufacturers of pharmaceuticals or chemical manufacturers who are producing lawful goods which are unfit for beverage purposes and who because of the nature of their product and process cannot use alcohol denatured under formulas prescribed by Government regulations are therefore forced to obtain their alcohol under regulations 60, pay a tax of $4.18 per gal. and be subjected to all the restrictions, red tape, delays, etc., as though they were users of whiskey. Why should these manufacturers be subject to whiskey regulations and taxes any more than a hospital, or college, or a manufacturer of varnish? This red tape is so extensive and the delays which accompany it are so great as to be next to impossible for the busy manufacturer. If any possible substitutes for this alcohol can be discovered, even though they are inferior to alcohol, they will undoubtedly be used.

Authorized Uses of Intoxicating Liquors

Regulations 60 provide that intoxicating liquors may be manufactured, sold, bartered, transported, imported, exported, delivered, furnished, purchased and possessed, and used for *non-beverage* purposes as indicated below, under the conditions and requirements of the regulations.

1. Manufacture of medicinal preparations in accordance with formulas prescribed by the U. S. Pharmacopeia, National Formulary, or the American Institute of Homeopathy, which are unfit for beverage purposes and in the manufacture of other patented, patent, proprietary and other medicines which are unfit for beverage purposes and certain medicinal preparations which are fit for beverage purposes.

   Such preparations must contain no more alcohol than is necessary for the purpose of extraction, solution, or preservation and must contain in each fluid ounce a dose as a whole or in compatible combination of one or more agents of recognized therapeutic value and contain no agents either chemically or physiologically incompatible with the active medicinal agents upon which the medicinal claims are based.

2. By retail druggists or pharmacists in the compounding of medicinal preparations unfit for use for beverage purposes on physicians' prescriptions, and for dispensing as such for medicinal purposes upon physicians' prescriptions.

3. By physicians in the practice of their profession.

4. By persons conducting hospitals and sanatoriums for medicinal, scientific, and manufacturing purposes.

5. (Potable distilled spirits only.) In manufacturing and industrial establishments for first-aid treatment.

6. (Rum only.) In the manufacture of denatured rum as provided by regulations 30.

7. In the manufacture of denatured alcohol as provided by regulations 61.

8. In the manufacture of toilet and antiseptic preparations and solutions that are unfit for use for beverage purposes.

9. In the manufacturing of flavoring extracts and sirups that are unfit for use as beverages or for intoxicating-beverage purposes.

10. For medication by druggists or pharmacists.

11. For laboratory purposes and in general manufacturing and technical processes.

12. By dentists and veterinarians in the course of their practice.

13. (Tax-free alcohol.) By the United States or any governmental agency thereof, or by the several states and territories or any municipal subdivision thereof, or by the District of Columbia, or for the use of any scientific university or college of learning, any laboratory for use exclusively in scientific research, or for use in any hospital or sanatorium.

14. For conversion into beverages containing less than one-half of one per centum of alcohol by volume, as provided by the regulations.
15. For sacramental purposes or like religious rites, as provided in the regulations.
16. In the manufacture of beverages containing less than one-half of one per centum of alcohol by volume under the procedure outlined in the regulations. Provided, however, that intoxicating liquors produced for this purpose may not be exported.
17. In the manufacture of other alcoholic medicinal preparations which are unfit for beverage purposes according to the standards prescribed in the regulations.
18. By retail druggists or pharmacists in the compounding of medicinal preparations unfit for use as beverages on physicians' certificates and for dispensing as such for medicinal purposes upon physicians' prescriptions.
19. By persons conducting hospitals and sanatoriums, for medicinal purposes.
20. By physicians for administering to patients in the practice of their profession.
21. In the production of vinegar as provided in the regulations.

Procedure Necessary in Order to Use Tax-Paid Alcohol

In brief the procedure necessary for a manufacturer to obtain pure alcohol for industrial purposes is as follows:

1. Application must be made to the Federal prohibition director in the state in which the manufacturer desires to use the alcohol (form 1,404 in triplicate). This application after being approved by the director is forwarded to the Federal prohibition commissioner, who may approve the application and issue the permit (form 1,405) to use non-beverage alcohol. Every permit clearly and specifically designates and limits the acts that are permitted and the time when, and the place where such acts may be permitted. It is necessary to make application for each individual purchase, be it for one 10-gal. can or a carload, and have these permits renewed in accordance with the regulations.

2. A bond must accompany the above application (form 1,408 or form 1,409 in duplicate) to insure compliance with the provisions of the act and the regulations. The basis of the penal sum of the bond is $4.20 per proof gallon of distilled spirits. The penal sum of the bond is fixed at approximately twice the sum of the United States internal revenue tax on the alcohol involved. The rate of tax on distilled spirits for non-beverage purposes is fixed by section 600a of the revenue act of 1918, approved Feb. 24, 1919, at $2.20 on each proof gallon [which is equivalent to $4.18 on each wine gallon (231 cu.in.) of 95 per cent alcohol] or wine gallon when below proof, and a proportionate tax at a like rate on all fractional parts of such proof or wine gallon. In no case the penal sum of any bond can be less than $1,000 nor more than $100,000. The bond must be recommended by the Federal prohibition director and referred to the Federal prohibition commissioner. The bond must then be approved by the Federal prohibition commissioner before the manufacturer can obtain a permit to purchase alcohol.

3. After the above permit and bond have been approved it is necessary to make application to the Federal prohibition director for a permit to purchase non-beverage alcohol. Application for permit to purchase must be made on form 1,410 (in triplicate—where transportation is involved four or more copies must be provided). The application must be sworn to before a notary or other person authorized to administer oath, and when approved by the Federal prohibition director becomes a permit. The applicant must describe in particular alcohol to be received by him and must in all cases give the quantity in wine gallons, also in proof gallons, of each kind of liquor on hand at the date of application, and previously received by him during the current calendar year and also since the first day of the quarterly period. Each application must show the name and address of the vendor from whom he proposes to buy, the number of the permit to use alcohol held by the applicant and the address of the premises where the alcohol is to be used. The applicant must be certain that his bond covers the quantity of alcohol outstanding as a debit against the bond, at all times. The permit when approved is forwarded to the vendor who is to furnish the alcohol. It is then possible for the vendor to ship the alcohol to the manufacturer. The vendor must keep careful records, fill out and return a copy of the permit to the director and make reports of all such sales within a specified time. The vendor must send a copy of form 1,410 to the vendee, who must retain it as a permanent record of all such transactions. These permits to purchase for the purpose of manufacturing or selling expire in ninety days after date of approval. Other permits to purchase expire in thirty days.

It is necessary to obtain such a permit for every shipment and the amount required or authorized on each permit must be shipped at one time.

After going through the above procedure the manufacturer may use the alcohol obtained. It is obvious that all this procedure will do very well to cover the purchase of a bottle of whiskey, but it is a real hardship for the persons who purchase alcohol in quantities for lawful manufacturing purposes. In order to carry out these regulations the new office of Federal prohibition director has been created. The Collectors of Internal Revenue, who have had the handling of the tax-paid alcohol regulations, have been relieved of this duty. This new office is not familiar with the handling of this business, it has no uniform methods of procedure, and it is not too much to expect that the user of tax-paid alcohol will suffer long delays in addition to those necessarily experienced due to the Post Office Department in forwarding permits, bonds, etc., from place to place.

Tax-Free Alcohol

Pure ethyl alcohol may be withdrawn free of tax for export under regulations, provided this alcohol is to be used for non-beverage purposes. A permit to export such alcohol may be obtained by making application to the Federal prohibition director (form 1,404 in triplicate) who may approve the application and forward it to the Federal prohibition commissioner, who may approve and issue the permit (form 1,405). Alcohol may then be exported, under further regulations.

Pure undenatured alcohol may be obtained tax free for use under Section 11 of Title III of the national prohibition act, which provides as follows:

> Alcohol may be withdrawn under regulations from any industrial plant or bonded warehouse tax free, by the United States or any governmental agency thereof, or by the several states and territories, or any municipal subdivision thereof, or by the District of Columbia, or for the use of any scientific university or college of learning, any laboratory for use exclusively in scientific research or for use in any hospital or sanatorium.

But any person permitted to obtain alcohol tax free, except the United States and the several states and territories and subdivisions thereof, and the District of

Columbia, must first apply for and secure a permit to purchase the same and give the bonds prescribed for in the case of tax-paid alcohol previously described, but alcohol for use by the United States and the states, territories and subdivisions thereof, and the District of Columbia may be purchased and withdrawn subject only to such regulations as may be prescribed.

Under the provisions of law above referred to the privilege of withdrawing alcohol in bond, free of tax, is held to apply to all scientific or educational institutions incorporated or organized under any Federal, state, or territorial law, or any colleges of learning which have a recognized curriculum and confer degrees after specified periods of attendance at classes or research work, upon proper showing of the facts, any laboratory for use exclusively in scientific research, or to any permanently established hospital or sanatorium in good standing, whether operated for profit or not.

Alcohol withdrawn as above provided may be used in the case of hospitals or sanatoriums only for medicinal, mechanical, and scientific purposes and in the treatment of patients. Scientific or educational institutions or colleges of learning must use such alcohol only for mechanical and scientific purposes, and any laboratory withdrawing alcohol free of tax must use same exclusively in scientific research. The use of the alcohol and resulting products is confined strictly to the premises of the institution withdrawing the alcohol, and in no case is the alcohol to be used in the preparation of food products for use in the institution or elsewhere, nor can products for sale be made from the alcohol withdrawn as above provided.

From the above it may be seen that colleges, universities, hospitals and sanatoriums may obtain tax-free alcohol.

Any laboratory may obtain tax-free alcohol for use exclusively in scientific research.

Procedure to Use Tax-Free Alcohol

Where it is desired to withdraw alcohol, tax free, as above indicated, it is necessary to proceed as follows:

1. An application (form 1,447 in quadruplicate) must be made to the Commissioner of Internal Revenue for a permit to use such alcohol. This application when approved by the Commissioner constitutes the permit.

2. At the time of filing the above application the applicant should give bond (form 1,448 in duplicate) in a sum sufficient to cover double the tax at the non-beverage rate on all alcohol at any time on hand, in transit, or unaccounted for, but at no time may the bond be for less than $1,000.

3. Make application to the proper Collector of Internal Revenue for a withdrawal permit (form 1,449). The United States or any governmental agency thereof must make application direct to the Commissioner of Internal Revenue (form 1,444). Applications by any state or territory or by the District of Columbia must be made to the proper Internal Revenue Collector (form 1,445). This latter procedure also applies to any municipal subdivision of any state or territory, which in addition is required to file the regulation bond for twice the sum of the non-beverage tax. A permit (form 1,450) will be issued which permits obtaining alcohol free of tax for the year, and for the amount covered by the penal sum of the bond.

It is necessary for institutions securing such tax-free alcohol to make a monthly statement (form 1,451) of the amount of alcohol received, on hand, used, etc.

Denatured Alcohol

Alcohol when suitably denatured was first allowed tax free under the act of June 7, 1906, which provides in part:

> That from and after Jan. 1, 1907, domestic alcohol of such degree of proof as may be prescribed by the Commissioner of Internal Revenue, and approved by the Secretary of the Treasury, may be withdrawn from bond without the payment of internal-revenue tax, for use in the arts and industries and for fuel, light and power provided said alcohol shall have been mixed in the presence and under the direction of an authorized Government officer, after withdrawal from the distillery warehouse, with methyl alcohol or other denaturing material or materials, or admixture of the same, suitable to the use for which the alcohol is withdrawn, but which destroys its character as a beverage and renders it unfit for liquid medicinal purposes: such denaturing to be done upon the application of any registered distillery in denaturing bonded warehouses specially designated or set apart for denaturing purposes only, and under conditions prescribed by the Commissioner of Internal Revenue with the approval of the Secretary of the Treasury.

The amendatory act of March 2, 1907, permitted the use of denatured alcohol in the manufacture of ether and chloroform and other definite chemical substances where the alcohol is changed into other chemical substance and does not appear in the finished product as alcohol.

Prior to the enactment of the national prohibition act the internal revenue tax on distilled spirits (ethyl alcohol, whiskey, brandy, rum, gin, etc.) was $6.40 per proof gallon—50 per cent alcohol by volume—when used for beverage purposes, and $2.20 per such proof gallon when used for non-beverage purposes. Ethyl alcohol was then tax free only when withdrawn from bonded warehouse exclusively for export, or by the United States Government or scientific universities and colleges of learning, or for use in the arts and industries and for fuel, light and power when denatured "with methyl alcohol or other denaturing material or materials, or admixture of the same suitable to the use for which the alcohol is withdrawn but which destroys its character as a beverage and renders it unfit for liquid medicinal purposes." (The quotation is from the original denatured alcohol act of June 7, 1906.)

The national prohibition act under Title III not only extended the use of tax-free ethyl alcohol to "the several states and territories or any municipal subdivision thereof or by the District of Columbia, or any laboratory for use exclusively in scientific research, or for use in any hospital or sanatorium," but said act furthermore provided that alcohol shall also be tax free when denatured "by the admixture of such denaturing materials as shall render the alcohol or any compound in which it is authorized to be used unfit for use as an intoxicating beverage," thus eliminating the restriction against the use of such tax-free denatured alcohol for "liquid medicinal purposes," contained in the aforesaid act of June 7, 1906, and reconciling the definition of denatured alcohol with that established for intoxicating liquor in Title II of the national prohibition act. This act under Title III provides that "alcohol lawfully denatured may, under regulations, be sold free of tax either for domestic use or export."

"Intoxicating liquor" is defined in the national prohibition act to mean practically all substances "containing one-half of one per centum or more of alcohol by volume which are fit for use for beverage purposes," and as the Government is itself fixing standards under such definition, it follows that a manufacturer requiring al-

cohol for non-beverage purposes, i.e., in the production of commodities which are not fit for use for beverage purposes, is lawfully entitled to tax-free alcohol denatured in accordance with formulas suitable for his needs. Expressed differently, lawful products must be made "unfit for use as an intoxicating beverage," and *ipso facto*, they come within the class of industries in which tax-free denatured alcohol may be used under Title III of said act. This construction is sound in principle both from the legal and economic standpoints and, when effectuated by regulations of the Internal Revenue Bureau, will not only remove the present unfair and discriminatory tax upon an essential raw material when used in the manufacture of pharmaceuticals and other articles which are equally important to national welfare as those which now enjoy tax-free alcohol, but will have a salutary effect upon the "H. C. of L." by reducing the price of medicines and other necessaries of life and otherwise placing United States chemical industries upon a plane of efficiency which will enable them to compete successfully with foreign goods in the markets of the world.

Completely Denatured Alcohol

In order to carry out the provisions of the act the Internal Revenue Bureau has authorized the following completely denatured alcohol formulas:

1. This formula, which consisted of 100 parts of ethyl alcohol and 10 parts of methyl alcohol and ½ part benzine, has been suspended.
2. To every 100 parts by volume of ethyl alcohol there shall be added 2 parts by volume of approved wood alcohol and one-half of 1 part by volume of approved pyridine bases.
3. To every 100 parts by volume of ethyl alcohol add 5 parts by volume sulphuric ether, 2 parts by volume benzine, and 1 part by volume pyridine.
4. To every 100 parts by volume of ethyl alcohol there shall be added: 2.5 parts by volume of approved benzol, 0.5 part by volume of nitrobenzol, 0.2 part by volume of approved pine oil (steam distilled).
5. To every 100 parts by volume of ethyl alcohol there shall be added: 2 parts by volume of approved wood alcohol, ¼ part by volume of approved pyridine bases, ½ part by volume of approved benzine (kerosene).

The denaturing materials used are subject to regulation and their specifications may be found in regulations 61, p. 97 et seq.

Alcohol when denatured as above may be used without restriction or regulation except as to marking of containers and is not subject to tax.

Specially Denatured Alcohol

A manufacturer desiring to use specially denatured alcohol for manufacturing purposes must file an application for a permit (form 1,479 in duplicate). The application must contain a description of the location and construction of the storeroom or storerooms in which the manufacturer proposes to store the alcohol, also an explanation in detail as to how the alcohol is to be used. A bond must be filed to insure compliance with regulations, the bonds being not less than $500 nor more than $100,000, in accordance with the schedule shown in Table II.

The formulas of specially denatured alcohol which have been authorized up to the present are as shown in Table I.

TABLE I. AUTHORIZED FORMULAS OF SPECIALLY DENATURED ALCOHOL

(The ethyl alcohol used in these formulas is of 190 deg. proof, or 95 per cent).

(1) 100 gal. ethyl alcohol.
5 gal. methyl (wood) alcohol.

(2) 100 gal. ethyl alcohol.
7 lb. camphor.
5 lb. methyl alcohol (refined).

(2a) 100 gal. ethyl alcohol.
2 gal. methyl alcohol.
2 gal. benzol.

(2b) 100 gal. ethyl alcohol.
½ gal. benzol.

(3) 100 gal. ethyl alcohol.
5 gal. following mixture: 5 gal. methyl alcohol (refined), 1 gal. castor oil, ½ gal. of 36 deg. Bé. caustic soda lye.

(3a) 100 gal. ethyl alcohol.
5 gal. methyl alcohol (refined).

(3b) 100 gal. ethyl alcohol.
1 gal. liquid pine tar.

(4) 100 gal. ethyl alcohol.
1 gal. following solution: 5 gal. aqueous solution containing 40 per cent nicotine; 0.4 lb. acid yellow dye (fast yellow Y); 0.4 lb. tetrazo brilliant blue, 12 B, conc.; water to make 100 gal.

(4) 100 gal. ethyl alcohol.
1 gal. following solution: 5 gal. aqueous solution containing 40 per cent nicotine; 3.6 oz., more or less, of methylene blue; water to make 100 gal.
(This is an alternative for formula 4 above.)

(5) 100 gal. ethyl alcohol.
65 lb. sulphuric ether.
3 lb. cadmium iodide.
3 lb. ammonium iodide.

(6) 100 gal. ethyl alcohol.
3 gal. methyl alcohol (refined).
½ gal. pyridine bases.

(6a) 100 gal. ethyl alcohol.
15 gal. condensed fumes, recovered in the process of manufacture. (Fulminate of mercury.)

(6b) 100 gal. ethyl alcohol.
½ gal. pyridine bases.

(7) Revoked (formula 1 substituted).

(8) 100 gal. ethyl alcohol.
1 gal. pyridine bases.
1 gal. benzol.

(9) 100 gal. ethyl alcohol.
10 gal. acetone.
2 gal. petroleum naphtha.

(10) 100 gal. ethyl alcohol.
2 gal. methyl alcohol.
2 gal. benzol.

(11) 100 gal. ethyl alcohol.
100 lb. sulphuric ether.
10 lb. cadmium iodide.

(12) 100 gal. ethyl alcohol.
1 gal. pyridine bases.
2 gal. benzol.

(12a) 100 gal. ethyl alcohol.
5 gal. benzol.

(13) 100 gal. ethyl alcohol.
5 gal. sulphuric acid.
5 gal. sulphuric ether.

(13a) 100 gal. ethyl alcohol.
10 gal. sulphuric ether.

(14) 100 gal. ethyl alcohol.
5 gal. methyl alcohol (refined).
10 lb. anhydrous zinc chloride.

(15) 100 gal. ethyl alcohol.
3 gal. sulphuric acid.
1 gal. kerosene.

(16) 100 gal. ethyl alcohol.
5 gal. methyl alcohol (refined).
2 gal. benzol.

(17) 100 gal. ethyl alcohol.
5/100 gal. (6¼ fluid oz.) animal oil (Dipple's oil).

(18) 100 gal. ethyl alcohol.
100 gal. vinegar (not less than 9 per cent acetic acid).

(19) 100 gal. ethyl alcohol.
100 gal. ethyl ether.

(20) 100 gal. ethyl alcohol.
5 gal. crude chloroform.

(21) 100 gal. ethyl alcohol.
100 gal. solution containing not less than 4½ per cent acetic acid.

(22) 100 gal. ethyl alcohol.
10 gal. solution of formaldehyde.

(23) 100 gal. ethyl alcohol.
10 gal. acetone.
2 gal. benzol.

(24) 100 gal. ethyl alcohol.
29 gal. sulphuric acid.

(25) 100 gal. ethyl alcohol.
25 lb. iodine.

(26) 100 gal. ethyl alcohol.
5 gal. aniline oil.

(27) 100 gal. ethyl alcohol.
1 gal. oil rosemary.
30 lb. camphor.

(27a) 100 gal. ethyl alcohol.
35 lb. camphor.
1 gal. oil cloves.

(28) 100 gal. ethyl alcohol.
10 gal. benzol.

(29) 100 gal. ethyl alcohol.
5 gal. alcoholic solution acetaldehyde.

(30) 100 gal. ethyl alcohol.
10 gal. methyl alcohol (refined).

(31) 100 gal. ethyl alcohol.
100 lb. soap.
100 lb. glycerine.

(31a) 100 gal. ethyl alcohol.
100 lb. glycerine.
20 lb. hard soap.

(31b) 100 gal. ethyl alcohol.
5½ gal. oil peppermint.
1¼ gal. eucalyptol.
4 lb. menthol crystals.

(32) 100 gal. ethyl alcohol.
5 gal. sulphuric ether.

(33) 100 gal. ethyl alcohol.
30 lb. methyl violet.

TABLE II. RATIO OF THE PENAL SUM OF THE BOND

Less than 100 wine gallons	$500
100 to 200 wine gallons	1,000
201 to 425 wine gallons	2,000
426 to 650 wine gallons	3,000
651 to 900 wine gallons	4,000
901 to 1,100 wine gallons	5,000
1,101 to 2,200 wine gallons	10,000
2,201 to 3,250 wine gallons	15,000
3,251 to 4,400 wine gallons	20,000
4,401 to 5,250 wine gallons	25,000
5,251 to 6,600 wine gallons	30,000
6,601 to 7,750 wine galons	35,000
7,751 to 8,900 wine gallons	40,000
8,901 to 10,000 wine gallons	45,000
10,001 to 11,000 wine gallons	50,000
11,001 to 12,000 wine gallons	55,000
12,001 to 13,000 wine gallons	60,000
13,001 to 14,250 wine gallons	65,000
14,251 to 15,400 wine gallons	70,000
15,401 to 16,500 wine gallons	75,000
16,501 to 17,800 wine gallons	80,000
17,801 to 18,800 wine gallons	85,000
18,801 to 20,000 wine gallons	90,000
20,001 to 21,000 wine gallons	95,000
More than 21,000 wine gallons	100,000

To the user of large quantities of specially denatured alcohol the new schedule represents quite an advantage over the old regulations in that if the manufacturer files a bond for $100,000 he can use any quantity of alcohol he may desire.

Another decided improvement in the present regulations over the old is in the fact that it is now not necessary to renew the withdrawal permits. Manufacturers found under the old regulations that the delays necessary in sending the withdrawal permits from place to place and the delays in renewing withdrawal permits constituted a serious handicap in the continuity of their plant operation. Under regulations 61 once the permit is given it stands until revoked or surrendered.

The formulas of specially denatured alcohol given in Table I have been authorized for use in various products and industries as indicated in Table III.

TABLE III. PRODUCTS AND INDUSTRIES AUTHORIZED TO USE SPECIALLY DENATURED ALCOHOL

FORMULA 1

Acetaldehyde.
Acetphenetidine.
Acetic ether.
Aconite.
Adeps lanæ.
Alkaloids and alkaloidal salts.
Aletrin.
Aloin.
Antipyrin.
Apocynin.
Arbutin.
Asclepiadin.
Avenin.
Artificial flowers.
Ammunition.
Atophan.
Aspirin.
Acetanilid.
Artificial feathers.
Baptisin.
Barometer and thermometer tubes.
Benzoic acid.
Benzaldehyde.
Beta naphthol.
Beta naphthol benzoate.
Brushes.
Benzidine.
Beta-naphthol salicylate.
Benzyl cyanide.
Benzon.
Chelonin.
Cimicifugin.
Collodion.
Collodion corn remedy.
Concentrations (nonliquid).
Confectioner's colors.
Coumarin.
Cutlery.
Cocoa butter.
Composition billiard and pocket balls.
Chloroform.
Compasses.
Creosote carbonate.
Colors and bronze powders.
Chloral hydrate.
Camphor, synthetic.
Cements.
Dental alloy.
Dandelion and digitalis. (Resin of, solid and powdered extracts of.)
Disinfectant germicide.
Door checks.
Dyestuffs.
Dimethylglyoxime.
Dinitro toluene.
Digestive ferments.
Diethylaniline.
Ethyl acetate.
Ethyl propionate.
Ethyl butyrate.
Essential oil orris.
Ethyl chloride.
Embalming fluid.
Eosine.
Ethyl bromide.
Ether.
Ethyl aniline.
Enamel.
Extracting glycerine from distillery slop.
Filaments for incandescent lamps.
Formaldazone.
Fertilizers.
Fulminate of mercury.
Formaldehyde.
Gaduol.
Gelatine capsules.
Gentian (solid extract).
Glycerophosphates.
Guaiacol.
Guaiacol carbonate.
Gum and pyroxylin solutions.
Gallocyanine.
Gas mantles.
Hats.
Heliotropin.
Hydrastis (alkaloid of).
Hexachlorbenzol.
Inks.
Inulin and iriscin.
Imitation leather.
Isinglass.
Imitation ivory goods.
Jalapin (nonliquid concentration of).
Jewelry and watches.
Japans.
Lacquers, pastes, and varnishes from soluble cotton.
Leather substitutes.
Leather-goods finish.
Lacquers.
Liquor cresolis compound.
Mandrake (powdered and solid extract of).
Mirrors.
Moldings and picture frames.
Monobromated camphor.
Moth repellant.
Mica insulators.
Mucilage, paste, and glue.
Motor fuel.
Nonscatterable glass.
Nitroso betanaphthol.
Orthotoluolsulphamide.
Oils, greases, lubricants, and soluble thread-cutting oils.
Oleoresins.
Paints.
Phenolphthalein.
Phytolacin (concentration of).
Photographic dry plates and films.
Print paper and enlargements.
Postal-card colors.
Polish preparations for metals and furniture.
Pepsin and similar products.
Potassium hydroxide.
Podophyllin resin and similar products.
Powdered drugs and extracts.
Photographic engravings.
Phenyl cinchoninic acid.
Pyroxylin cements.
Refining mineral oils.
Refining precious metals.
Resin of scammony.
Resorcin.
Salol.
Santonine and strychnine.
Solid extracts.
Soaps (transparent and liquid).
Shellac varnish.
Shoe polish.
Silverware and bronze.
Smokeless powder.
Surgical ligatures.
Soldering flux.
Sodium benzoate.
Sulphonic acid and paraffine.
Salicylic aldehyde.
Solution and solvent of nitrocellulose.
Solidified alcohol.
Salophen.
Saponin.
Salicylic acid.
Saccharine.
Shellac thinner.
Stains.
Sterilizing solution for corks.
Silk fabrics.
Synthetic mustard oil.
Shampoo, liquid.
Shampoo, jelly.
Stencil paper.
Tannic acid.
Tinfoil and bottle caps.
Terpin hydrate.
Textile cleansing soap.
Toluidine.
Transparent paper.
Transparent soap for waterproofing cement.
Trinitrotoluol.
Theobromine.
Thermostatic devices.
Varnish remover.
Viburnum (concentration).
Water colors.
Wood finish.
Wool fat.
Washing lenses.
Wood filler.
Watches.

OTHER FORMULAS

(2) Pyraline and similar products.
(2a) Celluloid; pyraline and similar products.
(2b) Acetic ether; acetyphenetidine (conditional); dyes, diethyl barbituric acid (barbital); ethyl sulphate (for use in manufacture of acetphenetidine); phenacetine; pyroxline plastics; ketone; Michelers; sulphuric ether (in connection with the production of powder); synthetic camphor; trinitrotoluol; viscaloid; white petroleum oils; ethyl sulphate.
(3) Transparent soap; shampoo; shampoo jelly.
(3a) Cutting oils; shampoo; shampoo jelly; transparent soap.
(3b) Liquid soap; shampoo; shampoo jelly.
(4) Cigars; cigarettes; smoking, chewing tobacco; deodorants.
(5) Photo enlargements; photoprints; photo-engravings; photographic collodion.
(6) Fulminate of mercury.
(6a) Fulminate of mercury.
(6b) Acetphenetidine; chloral hydrate; dichlorethane; ethyl acetate; ethyl butyrate; ethyl chloride; parafulminate of mercury; paraphenetidine; acetic ether; ethyl bromide.
(7) Revoked.
(8) Ethyl chloride; fine chemicals; sulphonmethane; dyes.
(9) Monobromated camphor; purification of rubber; santonine; strychnine; tannic acid.
(10) Ethyl acetate (conditional), lacquers, pastes and varnishes from soluble cotton.
(11) Photographic collodion; photo-engraving; photoprints.
(12) Imitation leather (see also formula 12a); soluble cotton.
(12a) Acetphenetidine; barbital; hydrazoanisol; imitation leather; milk protein; paranitrophenatol; refining potassium and sodium hydrate; saponification of the waxes of acid-fast bacteria; smokeless powder; terpin hydrate; trinitrotoluol; benzoic acid ethyl ester; dye intermediates; imitation rubber.
(13) Sulphuric ether. (See also formula 13a).
(13a) Celery oil; certified food colors; dry extracts for food products; ethereal oil; protargentum; sodium ethyl sulphate; sulphuric ether.
(14) Ethyl chloride. (See also formula 1 and 8.)
(15) Ethyl bromide; ethyl chloride; nitrous ether; pure acetic ether.
(16) B-naphthol; byproducts from distillery slop; glycerophosphates; lacquers for food containers; phenal cinchonic acid; acetanilid; acid salicylic; acetphenetidine; ammonium; benzonaphthol; betanaphthol benzoate; codeine; diacetylmorphine; ethyl morphine; homatropin; morphine; salicylate cocaine; sodium, strontium; salol. (See also formula 1.)
(17) Acetphenetidine; chloral hydrate; dichlorethane; ethyl acetate; ethyl chloride; ethylene gas; paraphenetidine.
(18) Acetate of lime; acetone; vinegar.
(19) Artificial silk; backing of films; byproducts from distillery slop. (See also formula 16.) Collodion; ethyl acetate; iodizers; solvent for nitrocellulose; photofilms; photo engravings.
(20) Chloroform (conditional).
(21) Acetate of lime (conditional).
(22) For preserving formaldehyde, U. S. P.
(23) Liniment for external use only.
(24) Phenacetin; ethyl acetate (conditional); ethyl butyrate; ethyl propionate; ethyl valerate.
(25) Tincture of iodine, U. S. P.; tr. iodi Fortier, N. F.; tr. iodine Churchill's; tr. iodine 3½ per cent.
(26) Ethylaniline and diethylaniline.
(27) Soap liniment, U. S. P.; chloroform liniment, U. S. P.; liquid and green soap, in accordance with U. S. P. except as to content of camphor and oil of rosemary.
(28) Motor fuel (conditional).
(29) Aldehydes (conditional); glacial acetic acid (conditional).
(30) Chemical and physical laboratory purposes, only in accordance with the provisions of T. D. 2793 (no recovery for re-use); photo dry plates; manufacturing vegetable oils; varnish; white petroleum oils (conditional).
(31) Tooth paste.
(31a) Tooth paste.
(31b) Tooth paste.
(32) Ethylene (conditional).
(33) Meat branding inks (conditional).

The term methanol is now used to indicate methyl alcohol.

The types and quality of the denaturing materials used in the preparation of the formulas given are controlled by the United States Internal Revenue Bureau and details as to their specifications may be found in regulations 61, pp. 97-104.

The following table giving the specific gravities and the weight of 1 gal. of the specially denatured alcohols has been found of considerable value to manufacturers:

SPECIFIC GRAVITY AND WEIGHT OF 1 GALLON OF SPECIALLY DENATURED ALCOHOL

(Weight of 1 gallon water at 15.6 deg. C., 8.32823 lb.)

Specified Formula No.	Weight of 1 Gal. at 15.6° C.	Specific Gravity at 15.6° C.	Specified Formula No.	Weight of 1 Gal. at 15.6° C.	Specific Gravity at 15.6° C.	Specified Formula No.	Weight of 1 Gal. at 15.6° C.	Specific Gravity at 15.6° C.
	Pounds			Pounds			Pounds	
1.....	6.7793	0.8140	10.....	6.7775	0.8138	21.....	7.8238	0.9394
2.....	6.7731	0.8132	11.....	6.6928	0.8036	22.....	7.0062	0.8412
2a.....	6.7757	0.8135	12.....	6.7937	0.8157	23.....	6.7963	0.8160
2b.....	6.7705	0.8129	12a.....	6.7910	0.8154	24.....	9.0304	1.0843
3.....	6.7771	0.8137	13.....	7.2725	0.8732	25.....	7.0633	0.8481
3a.....	6.7735	0.8133	13a.....	6.6993	0.8044	26.....	6.8539	0.8229
3b.....	6.7487	0.8103	14.....	7.0671	0.8485	27.....	6.8435	0.8217
4 (alt.)..	6.7803	0.8141	15.....	7.1202	0.8549	28.....	6.8186	0.8187
5.....	6.7105	0.8057	16.....	6.7884	0.8151	29.....	6.7810	0.8142
6.....	6.7662	0.8124	17.....	6.7645	0.8122	30.....	6.7498	0.8105
6b.....	6.7796	0.8140	18.....	7.8154	0.9384	31b.....	6.8112	0.8178
8.....	6.7883	0.8150	19.....	6.4745	0.7774	32.....	6.7224	0.8072
9.....	6.7445	0.8098	20.....	7.0149	0.8423			

The Commissioner of Internal Revenue will consider any formula for special denaturation that may be submitted by any manufacturer in any art or industry and will determine (1) whether or not the manufacture in which it is proposed to use the alcohol belongs to a class in which tax-free alcohol withdrawn under the provisions of the law can be used; (2) whether or not it is practicable to permit the use of the proposed denaturant and at the same time properly safeguard the revenue. But one special denaturant will be authorized for the same class of industries, unless it shall be shown that there is good reason for additional special denaturants.

The Commissioner will announce from time to time the formulas of denaturants that will be permitted in the several classes of industries in which tax-free alcohol can be used.

Conclusions

Users of alcohol should keep in mind that five different formulas (four now that formula 1 is suspended) for completely denatured alcohol have been authorized, which alcohol may be sold, distributed and used without any restriction, regulation or taxes. Formulas for many specially denatured alcohols have been authorized, which formulas are of such a nature as to be suitable for most industries; these alcohols being free of tax but distributed and used under regulation. To those who must use pure ethyl alcohol there are two possibilities. 1. If they desire the alcohol for scientific research only (and a few other cases as mentioned) it may be obtained free of tax, but is subject to Government regulation. The other case is that of manufacturers who may obtain alcohol for non-beverage purposes under Government regulation and pay a tax of $4.18 per gallon of 95 per cent alcohol.

385 Edgecombe Avenue,
New York, N. Y.

Blast Roasting at Port Pirie*

By Gilbert Rigg
Metallurgist, Associated Smelters Proprietary, Ltd.

THE introduction of granulated slag into the roaster charge when dealing with Broken Hill leady concentrates has been found to have certain advantages apart from the economy in the use of ironstone, which the slag largely replaces. This practice has been developed at the Port Pirie smelters during the past eight months.

The concentrates used at Port Pirie are divided into two classes, according to their mode of origin; concentrates from the jigs and tables, and slime concentrates from the flotation plants. The following analyses illustrate the composition of the two classes:

	Concentrate Per cent	Slime Per cent		Concentrate Per cent	Slime Per cent
Pb	63.0	57.0	CaO	1.5	1.5
Zn	7.0	11.0	Al_2O_3	1.5	1.0
S	14.5	18.0	SiO_2	5.0	3.5
FeO, MnO	6.0	5.5			

A certain amount of oxidized ore is used, and is usually referred to as siliceous ore. The following is an analysis:

	Per cent		Per cent
Pb	20.0	CaO	2.0
Zn	4.5	Al_2O_3	8.0
FeO, MnO	15.0	SiO_2	40.0

In order to make clear the nature of the present innovation, some account of the roasting practice in general is essential. Roasting is done in two stages, a preliminary or "A" roast on a D. & L. machine, followed by a crushing of the A-sinter, and a final or "B" roast of the A-sinter on Dwight & Lloyd machines or Huntington-Heberlein pots. In both cases the charge is the same and was, until the introduction of granulated blast-furnace slag, substantially as follows:

	Per cent		Per cent
Concentrates	49.0	Limestone	6.0
Slime concentrates	18.5	Ironstone	14.5
Siliceous ore	12.0		

Blast-Roasting Charge

This charge varied a little in accordance with small variations in the composition of the concentrates.

Originally, the fluxes were crushed through a ½-in. screen. Experience has shown that this was much too coarse. The notion that coarse pieces in a charge undergoing blast roasting do open up the charge to the passage of the blast is to some extent true. But, on the other hand, such opening up is local, and encourages the blast to pass through the charge at favored spots, while the denser parts of the charge go short. Other factors also militate against this practice. The concentrates, especially the slime concentrates, are finely divided, and, regarded as a uniformly distributed material, would no doubt effectively block the passage of the blast. Such materials, however, have the advantages of their defects. Finely-divided substances, when mixed damp, have a strong tendency to cohere into large and porous aggregates, and in consequence present a relatively coarse structure. The presence of coarse pieces of ironstone and limestone interferes with this process by mechanically breaking down the aggregates during mixing.

Again, seeing that the blast-roasting charge only sinters and never enters the molten condition, pieces of limestone iron ¼ in. to ½ in. diameter are attacked only at the surface. They are, however, largely burned to lime, which slakes when the sinter is

*From the *Industrial Australian and Mining Standard*, vol. 62, p. 597 (1919).

exposed to the air, and causes it to crumble and become unsuitable for the blast furnace.

Moreover, the sinter coming from the D. & L. machines on which the final or "B" roast is performed is found to contain the coarser pieces of ironstone in an unaltered condition. The coarse unassimilated material helps to weaken the sinter. The recognition of these facts led the author to use the fluxes in much finer form than before.

In the neighborhood of the limestone quarries on Wardang Island, Spencer's Gulf, are sand dunes composed of disintegrated limestone of the same composition as the solid limestone of which the island is composed. This sand will pass a 40-mesh screen. Substituted for the crushed limestone, it was found to work perfectly. The elimination of sulphur was good, and the final sinter was free from lime as such, and more resistant to exposure.

Ironstone screened through $\frac{1}{8}$ in. gave good results in substantially smaller amount than had been used previously, and owing to the denser character of the charge, it gave a stronger sinter, and, while roasting, gave less trouble through blow-holes and dust losses than previously.

A similar line of action in regard to the crushing of the "A" sinter before passing to the "B" machine or H-H pots was attended with similar results.

The D. & L. sinter derived from this charge averages about as follows:

	Per cent		Per cent
Pb	44 to 45	MnO	3 to 4
Zn	5 to 6	CaO	4 to 5
SiO_2	9 to 10	S	2 to 3
FeO	16 to 18		

On the blast furnaces this sinter gave satisfactory results, the only addition made on the furnace being a little limestone.

Composition of the Slag

The composition of the slag corresponding to this sinter is as follows:

	Per cent		Per cent
SiO_2	21.0	ZnO	13.5
FeO	33.5	Pb	2.0
MnO	4.5		Oz.
CaO	14.0	Ag	0.75

The composition of this slag is unusual, and defies any attempt to figure out a silicate formula from it. It runs very fluid and separates well. Microscopical examination of thin slices shows that it is composed of two major constituents. The ground-mass is colorless, in thin section, and resembles fayalite, and is probably a lime-ferrous orthosilicate. Scattered through this is a black to dark brown constituent, with indications of octahedral crystallization; also green octahedral crystals referred to gahnite are present. Frequently the silicate crystals are full of parallel rods, arranged like the teeth of a comb, and suggesting a constituent which separated from the silicate at the moment of freezing of the latter. The slag is decidedly magnetic, the powder being appreciably attracted by a permanent magnet.

Unfortunately time has not yet been available for the final working out and diagnosis of these sections. Arrangements have now been made for a thorough investigation of the problem. In the meantime the following working hypothesis has been adopted:

The silicate ground-mass is an orthosilicate of CaO, MgO, FeO and ZnO. The black to brown mineral is a ferrite ($ROFe_2O_3$), mainly a ferrite of Zn, possibly also a ferrite of lime and manganese, or, in other words, a franklinite. These two constituents exist in the molten slag in a state of mutual solution. In addition, it appears that ZnO is also present dissolved in the slag. The orientation of the rods referred to corresponds to the crystallographic structures of the silicate base, and, as suggested, they appear to have separated out at the freezing point of the latter.

Structure of the Slag

The structure of this slag is of considerable interest, both scientific and technical, and it is expected that its final elucidation will not now be long delayed. Meanwhile, there is some evidence is favor of the foregoing hypothesis. In the first place ferric oxide is present in the slag. Its quantitative estimation is rendered very difficult owing to the presence of 3 per cent of sulphur in the latter, which reduces the Fe to the ferrous state when the slag is treated with acid, but its presence has been qualitatively established. The formation of magnetite under blast-furnace conditions when Fe is present and SiO_2 is deficient is well known. The color and high opacity of the dark constituent and the magnetic character of the slag lend color to the view that a molecule of the construction $ROFe_2O_3$ is present.

Again, experiments on the use of a reverberatory matte settler yielded large masses of magnetic material which formed on the hearth and side walls and choked up the furnace unless the temperature was maintained high enough to prevent the separation. Incidentally, no matte separated at this temperature either.

Influence of Adding Slag to Charge

Accepting this hypothesis provisionally, the next question that arose was, what would be the behavior of the ferrite if added to the roaster charge as a substitute for ironstone; in other words, if instead of using new ironstone blast-furnace slag was returned to the furnace. There were several cogent reasons for doing this if possible. In the first place, there is good ground for believing that in the roasting charge ferric oxide serves as a carrier of oxygen to adjacent sulphides. This can only take place if the Fe is absorbed into the sinter. It has already been shown that ironstone in pieces too coarse for this absorption come through the process unchanged, and can be discarded from the charge without injury. The Fe in the slag is already in finely-divided form, and the slag is very easily taken up by the sinter. Further, it was thought that the addition of slag would tend to strengthen the sinter which erred on the side of fragility.

The Zn content of the sinter would naturally be increased by addition of zinc-bearing slag to the charge, and in consequence the blast-furnace slag likewise, and the interesting question arose whether a Zn content could be tolerated in the slag which would make it commercially feasible to treat the latter for recovery of Zn. As regards this amount of Zn upsetting the running of the blast furnaces, this was felt to depend mainly on how completely the sulphur was eliminated from the sinter. With sulphur well below 3 per cent, troubles due to Zn largely disappear. These latter are mainly due to zinky matte and to accretion, in which ZnS plays an important part.

Finally, the economy which would accrue from a reduction in the amount of ironstone required, and the cost of crushing it, were attractive.

Trials with crushed slag had been made some time previously with unsatisfactory results. Granulated slag being available, it was decided to utilize the slag in this form. It seemed to be in an ideal condition for this purpose. It consists of a mass of porous disintegrated grains, the great majority passing readily through a 4-mesh screen and yet free from powder, such as is produced in crushing. Such a material would give the maximum of useful surface and porosity.

Large-Scale Operation

After some preliminary small-scale experiments, which were highly encouraging, the substitution of granulated slag for ironstone was put to work on the entire plant, turning out about 400 tons of lead per day. The following charge was used:

	Per cent	Per cent		Per cent	Per cent
Concentrates	40.0	49.0	Limestone sand	8.3	6.0
Slime concentrates	25.5	18.5	Ironstone	4.5	14.5
Siliceous ore	10.0	12.0	Slag	10.0	

For the sake of comparison, the composition of the original charge without slag is given in the second column. It will be noted that the percentage of slime concentrates has been increased in the new charge, this class of concentrate being more difficult to desulphurize than the coarse concentrate under ordinary conditions.

Average figures for the D. & L. sinter from this charge were:

	Per cent		Per cent
Pb	44 to 45	MnO	3 to 4
Zn	7 to 8	CaO	5 to 6
SiO_2	11 to 12	S	2 to 3
FeO	11 to 13		

This sinter was of good grade and worked well on the blast furnaces. The ZnO content of the blast-furnace slag was 17 per cent and gave no trouble.

Increasing the Lead Content

After running some weeks on this charge, it was decided to try increasing the proportion of concentrates in order to improve the Pb content of the sinter. A supply of siliceous ore not being available at this time, the deficiency in silica was made up by increasing the amount of slag, and adding a silica sand carrying 85 per cent SiO_2. The charge had the following composition:

	Per cent		Per cent
Concentrates	47.0	Ironstone	4.0
Slime concentrates	27.5	Slag	12.5
Limestone sand	7.0	Sand (SiO_2)	2.0

The charge sintered well, the sinter having the following composition:

	D. & L. Per cent	H. & H. Per cent		D. & L. Per cent	H. & H. Per cent
Pb	47.5	48.5	MnO	3.0	3.0
Zn	7.5	7.5	CaO	6.0	5.5
SiO_2	8.0	8.5	S	2.8	2.7
FeO	13.0	14.0			

Both D. & L. and H. & H. sinter were made from the same charge mixture, the small differences shown being due to slight variations in the constituents. The increased Pb tenor is noticeable. Up to 50 per cent of Pb has been carried without trouble, although before the introduction of the granulated slag 44 to 45 per cent Pb was the limit at which satisfactory sintering practice could be maintained. The equality in S content of both classes of sinter is also of interest, as prior to the introduction of slag the H. & H. sinter usually ran distinctly higher in S than the D. & L.

This sinter ran well in the blast furnaces, the slag having the following composition:

	Per cent		Per cent
SiO_2	20.7	CaO	12.0
FeO	29.8	ZnO	18.7
MnO	4.8		

The FeO content is 29.8 per cent, as against 33.5 per cent when slag is not used. No Zn troubles were met with.

The next charge run had the following composition:

	Per cent		Per cent
Concentrates	47.0	Ironstone	2.0
Slime concentrates	27.5	Slag	15.0
Limestone sand	7.0	Sand (SiO_2)	1.5

This also sintered well. The composition of the blast-furnace slag was:

	Per cent		Per cent
SiO_2	24.2	CaO	11.0
FeO	25.6	ZnO	20.0
MnO	5.3		

This slag ran well, and no Zn troubles were present.

In the foregoing slag analysis the Fe is expressed as FeO, as it also is in the sinters, but part of the Fe is present as Fe_2O_3 in both cases.

No additions of limestone or any other fluxes have been made to the blast furnaces since the slag-sinter was used, the charge consisting of sinter, slag-shells and coke only. The Pb and Ag contents of the slag average 1 per cent and 0.5 oz., respectively.

The use of granulated slag as a constituent of the roaster charge has now been proved. Its advantages may be summed up as follows:

(1) Better sinter physically, both D. & L. and H. & H.

(2) Economy in the use of ironstone.

(3) Economy in crushing ironstone.

(4) Higher Pb content of sinter, and consequent reduction in cost per unit of Pb roasted.

(5) Higher ZnO content of slag, which brings its recovery within the limits of commercial practice.

The new slag, while apparently of the same type as the old, differs markedly from it in its higher SiO_2, lower FeO and higher ZnO content. Its further investigation, both from a theoretical and practical standpoint, promises interesting results.

Melbourne, Australia.

Industrial Uses of the Prickly Pear

The prickly pear, more particularly *Opuntia inermis*, or pest pear, is a kind of cactus which already covers about 22,000,000 acres in Australia and is spreading at the rate of a million acres per year. As a reserve food for cattle it has some value, but it is not a well-balanced ration and needs mixing. In Ceylon, India and South Africa it is used as a fertilizer, the broken parts being buried in wide trenches 18 in. deep. This involves considerable labor. The fruits have been used for the manufacture of alcohol in Spain and Sicily, but the enterprise was not commercially successful. For 1 gal. of alcohol 140 lb. of fruit is needed, and to make the enterprise successful ten tons of fruit to the acre would be required and a method of mechanical harvesting not yet invented. As paper-making material the yield of pulp is slight, while the fibers are short and lack felting qualities.

Arsenic pentoxide and arsenic chloride are used for exterminating the plants, and it is found that the cochineal insect has almost exterminated the true pear in India and Ceylon. This plant (*Opuntia monacentha*) is, however, not a serious pest, and the insects will attack no other. Research is in process to discover the action of insects and fungi upon the offending plant.

Synopsis of Recent Chemical and Metallurgical Literature

Improved Methods of Ore Dressing Graphite Ores.—The *Canadian Mining Journal* for Jan. 16, 1920, contains an article by CHARLES SPEARMAN giving a general outline of ore-dressing methods for graphite ores. In the separation and concentration of graphite from its gangue, the ideal condition is attained when the flake, as a whole, is completely separated from the accompanying gangue and recovered, without material modification to its physical condition, as a concentrated product. The separation is a step in the operation not easily accomplished commercially, but the recovery of the naked flake by concentration is relatively a simple matter; in fact, the treatment of graphite ore is more of a problem in ore dressing than it is one of concentration.

It is advantageous to effect the complete separation of the flake from the gangue previous to concentration. The widespread practice of refining or finishing concentrates necessitates an auxiliary ore-dressing unit.

Prior to the commercial application of flotation to graphite ore, the usual ore-dressing plant was crude and inefficient and it is doubtful if any of them were operated at a profit. The ore was first dried "bone dry" in kilns and crushed in rolls, the drying operation being necessary to prevent "pancaking" of the ore on the face of the rolls. After crushing, the product was delivered to a set of "heavy-duty" rolls for further comminution and then delivered to a series of finer rolls, usually of the flour mill type. The product of the fine rolls was screened between sets with the object of removing the flake graphite as oversize. Some mills of this type were equipped with as many as ten sets of rolls and screens, with the result that most of the flake was completely disintegrated before reaching the final screen.

The screens removed the oversize, which consisted of naked flake, flake with adhering gangue, mica and free gangue. The oversize was refined or finished in auxiliary units, which consisted of fine rolls and French buhr stones which disintegrated the brittle gangue and incidentally the graphite flakes. The product of this operation was screened to remove the undersize, the oversize being commercial flake. Quite often dry tables were included in the circuit in order to relieve the burden on the screens and rolls and to recover additional flake. The dust-laden atmosphere attending these operations is a very serious objection.

The commercial product resulting from this method of concentration is thin, flattened and polished flakes, in which the physical structure of the original flakes is rendered discontinuous due to the action of the rolls. And the ordinary handling of this product results in an abnormal quantity of the lower grade flake.

Recent practice in the separation of the flake from the accompanying gangue is less complicated than the method described and is more efficient in that it produces a higher grade product at a lower cost.

The drying of the ore is eliminated and after preliminary crushing the ore is fed to a ball mill and ground wet. The load and feed of the mill is so adjusted as to insure a free discharge and to exclude the liberated flake from the zone of disintegration as soon as possible. This action is sometimes accelerated by the addition of oil to the feed to the ball mill, which then acts on the principle of the Macquestin tube section. The pulp from the ball mill is fed to a mixer and then to an Alderson hydraulic classifier, from which most of the gangue-bound flake is returned as oversize to the mill for retreatment, while the free flake for the most part follows the undersize to a Spearman flotation concentrator.

After concentration the flake is dried and graded, and the portion containing adhering gangue is retreated the same as the classifier oversize. The low-grade product is about 3 to 10 per cent of the concentrate. The remainder of the flake after the removal of the dust is No. 1 crucible stock.

The flake resulting from the improved method of concentration may be described as coherent, thick, "bold" and "rugged," that is, having rough edges and surfaces. It is much higher in carbon and has a higher specific gravity than flake from the roll treatment. This is due to the fact that powdered gangue is impressed into the relatively non-coherent mass of minute flakes which constitute the product of roll treatment.

The special advantages of the wet method of separation applied to graphite ore are lower cost of installation and operation, greater quantity of a high-grade product, better grade, and smaller quantity of low-grade product, the elimination of the dust nuisance and simplicity of operation.

Manufacture of Carbon Electrodes.—The increasing demand for electrodes during the latter part of the war period resulted in the erection of a new plant at Niagara Falls, which has now been finished as the Republic Carbon Co. A description of this thoroughly modern plant will be found in the Jan. 15, 1920, issue of *Iron Age*.[1]

The raw materials used are: Anthracite, coke, petroleum coke, retort carbon, hard and soft pitch, tar and oil. After preliminary crushing, the coal or cokes are calcined in specially designed electric furnaces, and transferred by belt conveyors to the grinding building, which is equipped with a Raymond mill and Sturtevant and other types of crushers. By means of blowing and elevating conveyors, the finely ground raw materials are delivered at the top of the mixer building. After screening, the materials pass to a series of storage tanks, from which they may be fed as required to weighing cars which dump into the mixing machines. Here the binders are added and the mass is thoroughly kneaded and then molded into lumps resembling a large cheese. The plastic mass is extended through dies of various shapes in a 3,000-ton hydraulic press.

The last stage in the manufacture is the baking and annealing of the electrodes. In the baking building, there are 28 producer gas-fired baking furnaces operating on the ring principle. The green electrodes are placed in saggers, using coke, coal or sand as packing material. These are then placed in the various compartments of the furnaces and buried in some insulating and protective material. Pyrometric control lating and protective material.

Pyrometric control regulates both the baking and the annealing.

[1] "New Plant for Making Carbon Electrodes," *Iron Age*, vol. 105, p. 188, Jan. 15, 1920.

Recent Chemical and Metallurgical Patents

Australian Patents

Complete specifications of Australian patents may be obtained from the Government Printer, Melbourne, one shilling each.

Desulphurizing Ore.—To dispense with hand or mechanical rabbling during desulphurizing of, say, zinc sulphide, the ore is caused to descend in a finely-divided state through an upcurrent of pre-heated air in a narrow zigzag passage formed by inclined shelves within a vertical furnace. The air required for roasting is pre-heated by the hot combustion gases leaving the furnace and is forced through pipes into the lower part of the zigzag passages. The roasted ore falls into chambers, from which it is removed by screw conveyors. A series of pokeholes is arranged in the front wall of the furnace to maintain a free passage for the falling ore. (Australian Pat. 9,269, G. RIGG, Victoria. Nov. 25, 1919.)

Manufacturing Oil Pastes.—To obviate drying the material when preparing oil pastes, such as white lead, from lead precipitates, the precipitate is subjected to the action of sodium biborate or other boracic acid salts in the proportion of not more than eighteen grains or less than seven grains to one pound of wet precipitate. The required quantity of oil is then added, and the mass subjected to mechanical working and mixing, the water being expelled and the oil combining with the precipitate. (Australian Pat. 9,458, H. P. FLETCHER, N. S. W. Dec. 2, 1919.)

Glue and Gelatine.—To produce glue and gelatine from the pith of horns and the bones of cattle, these materials are subjected to a solution consisting of one part hydrochloric acid and eight parts of water for a period of five days. This step is repeated till the material has been treated with five solutions. After being washed for two periods of 24 hr. in two separate baths of cold water, the material undergoes two applications, each of 24 hr. duration, of a solution of 100 lb. lime to 100 gal. of water. Two further washings of cold water are given and the material is then dried and boiled for 12 to 18 hr. The thin liquid, which is skimmed off and dried, comprises pure gelatine, while the thick liquid contains the glue. Sulphuric acid may be used in addition to, or instead of, hydrochloric acid. (Australian Pat. 10,447, J. TURNER, Victoria. Nov. 25, 1919.)

Treatment of Battery Separators.—To render wood suitable for separating positive and negative elements in storage cells, the strips are boiled for an hour in a solution of 4 oz. of washing soda to a gallon of water and after cooling are placed in a dilute solution of sulphuric acid of 1.150 sp. gr. for one hour and finally washed. (Australian Pat. 10,120, L. ROWSON, New Zealand. Nov. 18, 1919.)

Recovery of Metallic Zinc.—To keep within predetermined limits the accumulation of impurities in a cyclic process for the electrodeposition of zinc from solutions obtained by the leaching of wasted ores with sulphuric acid (spent electrolyte), a certain proportion of the zinc-bearing solution is withdrawn from each cycle and an equivalent amount of water is added. The deflected solution is treated with zinc dust in the presence of a soluble arsenic compound for the precipitation of the cobalt, and the manganese is eliminated by electrolytic oxidation and by treatment with suitable oxidizing agents. The purified zinc sulphate solution is then mixed with barium sulphide for the manufacture of lithopone in the ordinary way. (Australian Pat. 9,442. H. W. GEPP, Victoria, assigned to Electrolytic Zinc Co. of Australia Proprietary, Ltd. Dec. 16, 1919.)

Ore Roasting.—To sulphatize zinc sulphide ore preparatory to leaching with sulphuric acid, the ore is subjected to multi-stage roasting. In the first stage the ore is roasted at a high temperature with a controlled supply of air for partial elimination of the sulphur and to insure a sufficient concentration of the sulphur dioxide for the production of sulphuric acid. In the second the ore is roasted at a lower temperature, preferably 725 deg. C., with excess of air. The iron oxide content of the ore functions as a catalyst converting the sulphur dioxide into the trioxide which is absorbed by the zinc oxide to form sulphate. Alternatively, a more or less complete elimination of the sulphur may be effected in the first stage, and in the second stage, unroasted sulphide may be added to the first calcine. (Australian Pat. 9,224. ELECTROLYTIC ZINC CO. OF AUSTRALASIA PROPRIETARY, LTD., assignee of H. W. Gepp, Victoria. Nov. 18, 1919.)

American Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Benzaldehyde From Toluene by Catalytic Oxidation.—Toluene vapor mixed with air, oxygen or ozone and a certain amount of diluent gases or steam is passed over molybdenum oxide, MoO_3 contained in a tube heated to 500 deg. C. Benzaldehyde is formed according to the reaction:

$$C_6H_5CH_3 + O_2 = C_6H_5CHO + H_2O$$

(1,321,959; JOHN M. WEISS and CHARLES R. DOWNS, assignors to The Barrett Co.; Nov. 18, 1919.)

Sulphonation With Sulphur Trioxide.—By sulphonating aromatic hydrocarbons in the vapor phase with SO_3 from the contact chambers, the formation of water as a byproduct and the presence of excess sulphuric acid in the sulphonic acid are avoided. The rapidity and degree of sulphonation depend upon many factors, such as temperature, time of contact, concentration of SO_3 in gaseous mixture, the particular hydrocarbon used, and the pressure. The sulphonic acid formed may be treated directly with sodium hydroxide for the purpose of replacing the HSO_3 group by hydroxyl. (1,321,994; CHARLES R. DOWNS, assignor to The Barrett Co.; Nov. 18, 1919.)

Chlorinated Pyroxylin.—The inflammability of pyroxylin may be reduced in the following manner, according to ALEXANDER SCHWARCMAN, of Buffalo, N. Y. Commercial pyroxylin is dissolved in CH_3OH containing 5 per cent acetone. This solution is diluted with CCl_4 and treated with chlorine in the presence of a carrier such as $ZnCl_2$ or $SnCl_2$ until from 5 to 8 per cent by weight of chlorine has been absorbed by the pyroxylin. The solvents are removed by evaporation and the chlorinated pyroxylin washed, neutralized and dried in the usual manner. (1,323,792; assigned to Spencer, Kellogg & Sons, Inc.; Dec. 2, 1919.)

Personal

JAY A. CARPENTER, metallurgical engineer, has removed his office from Tonopah, Nev., to 1006 South Hill Street, Los Angeles, Cal., where he has a laboratory for ore testing.

FRANK L. DRIVER, president of the Driver-Harris Co,. Harrison, N. J., left on March 6 for a two months' trip through England and France.

A. E. DRUCKER has been appointed professor of metallurgy at the Wisconsin State School of Mines.

L. W. EMERSON has joined the engineering staff of the Chile Exploration Co., and will be at its New York City office, 120 Broadway.

H. F. FISH, formerly in the research department of the Great Western Sugar Co., Denver, Col., has been appointed special research assistant in the joint investigation of the fatigue of metals, by the board of trustees of the University of Illinois. Mr. Fish will be located at Champaign, Ill.

ADOLPH HARVITT, who has been on the research staff of the Davison Chemical Co., Baltimore, Md., sailed for Japan on business connected with the foreign shipments of the company.

J. D. JONES, who since last September has been general superintendent of the Algoma Steel Works, Sault Ste. Marie, Canada, has now been appointed general manager in succession to Captain David Kyle, deceased.

HAROLD E. KETCHUM, for the past three years vice-president in charge of construction for the American Nitrogen Products Co., Seattle, Wash., has been made general manager of the Francis A. Vaughn Manufacturing Co., Milwaukee, Wis., manufacturer of tools and construction equipment. During his connection with the American Nitrogen Products Co. Mr. Ketchum built and equipped the factory at La Grande, Wash., for the production of sodium nitrite, using surface power from Tacoma. He also built a factory for the production of concentrated nitric acid and sodium nitrate at Vancouver, B. C., using surface power in the British Columbia Electric Co. Both of these factories are equipped with the Wielgolaski long-arc furnace.

H. A. LINCH of the engineering staff of the Dorr Co. is on his way to South America. He expects to be gone several months and will visit Peru, Chile and Bolivia. His South American address will be Hotel Londres, Antofogasta, Chile.

ERIC A. LOF of the power and mining engineering department of the General Electric Co., Schenectady, N. Y., sailed for Norway March 11.

W. MOTHERWELL, recently from Broken Hill, Australia, is conducting flotation tests at the 85 Mine, Valedon, N. M.

Judge JOHN BARTON PAYNE of Chicago, chairman of the United States Shipping Board, was selected by President Wilson to succeed Franklin K. Lane as Secretary of the Interior. He assumed his duties March 1.

A. R. STEVENSON has severed his connections with Schaar & Co. and is now with the Deegan Supply Co., Chicago, Ill.

MAXIMILIAN TOCH of New York City has been appointed adjunct professor of industrial chemistry in Cooper Union, New York, and will co-operate in the development of a new 4-yr. day course in industrial chemistry to be started in September.

HARRY VIVIAN has been appointed chief engineer of the Calumet & Hecla and subsidiary companies, succeeding the late Edward S. Grierson.

S. S. VOORHEES, chemist, Bureau of Standards, was operated on for acute appendicitis March 1. His continued improvement is confidently expected.

GEORGE WEINTRAUB, formerly chief chemist of the Rare Metals Co., Perth Amboy, N. J., is now metallurgical chemist of the Standard Chemical Co., Canonsburg, Pa.

FRANK R. WICKS has opened an office and testing laboratory at 1006 South Hill Street, Los Angeles, Cal.

Obituary

Captain DAVID KYLE, vice-president and director of the Algoma Steel Corporation, died of pneumonia following influenza.

EDWARD S. GRIERSON, chief engineer for the Calumet & Hecla Mining Co., died recently at his home in Calumet, Mich., following a long illness from pernicious anæmia.

Dr. FRANCIS C. PHILLIPS, who was in charge of the chemistry department, University of Pittsburgh, where he was professor of chemistry for forty years, died at his home in Pittsburgh, Pa., on Feb. 16, of influenza and pneumonia.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 15.—A number of minor changes will be noted in the metal market. In an attempt to enliven the apathetic copper market, producers have offered spot for 18⅝c.

		Cents per Lb.
Copper, electrolytic		19.00
Aluminum, 98 to 99 per cent.		31@32
Antimony, wholesale lots		11.25
Nickel, ordinary		43.00
Nickel, electrolytic		45.00
Tin, Straits, spot		63.00
Lead, New York, spot		9.50
Lead, E. St. Louis, spot		9.25
Zinc, spot, New York		9.05
Zinc, spot, E. St. Louis		8.75

OTHER METALS'

Silver	oz.	$1.21
Cadmium	lb.	1.50
Cobalt	lb.	1.50
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	89.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	28.50
Low brass rods	29.50
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	32.00

SCRAP METALS

	Cents per Lb.
Aluminum, cast scrap	22½@23½
Aluminum, sheet scrap	22 @22½
Aluminum clippings	25½@26½
Copper, heavy machinery comp	15 @15½
Copper, heavy and wire	13½@14½
Copper, light and bottoms	12 @12½
Copper, heavy cut and crucible	15 @15½
Brass, heavy	7 @ 7½
Brass, casting	10 @10½
Brass, light	5½@ 6½
No. 1 clean brass turnings	7½@ 7½
No. 1 comp. turnings	11½@11½
Lead, tea	5½@ 5½
Lead, heavy	7 @ 7½
Zinc, scrap	4½@ 4½

The Iron and Steel Market

Pittsburgh, Pa., March 12, 1920.

There is additional information that production has been increasing and is greatly exceeding both the predictions made by producers and the expectations entertained by consumers two or three months ago. The monthly report of the American Iron and Steel Institute, in which there was a hiatus for the months of September to December inclusive, states that in February 2,865,124 gross tons of ingots were produced by thirty companies which in 1918 contributed 84.03 per cent to the country's total. Counting the number of working days in the month and year and allowing for production by the capacity not reporting, this indicates that in February ingots were produced at the rate of 44,200,000 tons per annum, against a rate of 40,-

650,000 tons for January and an average during the last three months of the old year of somewhat less than 30,000,000 tons. Eventually the steel mills may show an ability to produce more steel than would be expected of them, judged by their output in 1916 plus allowances for new construction since, but on that basis indicated capacity is now in the neighborhood of 50,000,000 tons of ingots per annum. On this basis, the rate of production rose from about 45 per cent on Oct. 1 to about 75 per cent on Dec. 31, averaging about 58 per cent for the three months. By the Institute reports the average was 81 per cent in January and 88 per cent in February, suggesting a March rate of about 95 per cent, having regard to the facts that March is almost invariably a favorable month for production and that the transportation difficulties that interfered with production in February are disappearing. Thus there would be 88 per cent for this quarter, against 58 per cent for last quarter, an improvement of 52 per cent, with still better prospects for the second quarter of the year.

Indicated Output of Steel Larger Than Anticipated

These are much larger outputs than consumers of steel have been expecting. At some times it might be of little consequence to the market observer that consumers of steel misjudged the situation and prospects, but, considering what consumers have been doing in the past three months, bidding up prices on themselves and becoming more anxious to buy as producers were reserved about selling when they wished to catch up with their overdue deliveries, it is a very important thing, marketwise, if consumers were acting upon incorrect premises, yet there can scarcely be a doubt that such has been the case.

The runaway in steel prices has probably gone altogether as far as it is to go, and it now appears that it has affected early deliveries chiefly. The United States Steel Corporation is still on the basis of March 21 or Industrial Board prices. Several large and conservative independents will not, according to the present outlook, quote above 3c. for bars, 3.10c. for shapes and 3.25c. for plates to their regular customers for third quarter deliveries, these prices being $13, $13 and $12 respectively above the Steel Corporation prices, while they are the prices to which these independents gradually mounted in the past few weeks as they closed with their customers for second quarter. The opening for third quarter will probably occur within about thirty days. The Steel Corporation is already largely sold beyond that quarter. The smaller independents, who do simply a prompt business, securing delivery premiums when they can, are not yet thinking of third quarter at all, but as the weeks pass will probably secure smaller and smaller premiums. In sheets the top point for small lots for early delivery seems to have been passed about a fortnight ago, with a 10c. basis for common black as the limit, comparing with 4.35c. in the Industrial Board price schedule.

The bi-monthly settlement of the sliding wage scale of the mills controlled by the Amalgamated Association showed 4.65c. for 26, 27 and 28 gage sheets and $7.40 for tin plate, as average invoice prices of shipments from the selected mills during January and February. The showing in tin plate is not representative of the industry as a whole, it chancing that the selected mills have been doing a premium business when many others have not, except in selling export tin plate at above the regular $7 market price. The Steel Corporation is, of course, not represented at all in these settlements.

Pig Iron

The pig-iron market appears to have passed the crest in its great upward movement. Apart from the recent decline of $1.50 in basic iron, the market for extended deliveries is not lower in the Central West, though there have been slight declines at Buffalo and Philadelphia. The market, however, has been dull and almost stagnant, and the common opinion is that the next general price movement will be downward. An important fact is that the premium on prompt foundry iron, once amounting to several dollars a ton, has disappeared entirely. There is no precedent for pig iron being at a high price and at the same time showing no premium for prompt delivery. The valley market remains at $42 for bessemer, $41.50 for basic, $42 for foundry and $43.25 for malleable, prompt or forward, freight to Pittsburgh being $1.40.

Ferro-Alloys

Prompt ferromanganese is a trifle easier, carloads standing at about $200, while later deliveries, to July 1, bring prices on a scale down to about $170 for June. Second half remains at $160, delivered. English has been quoted at $150, c.i.f., but it is uncertain whether purchases could now be made at the figure. Electrolytic ferrosilicon is $80@$81, delivered, for 50 per cent and $140 for 75 per cent. Bessemer ferrosilicon is quoted at $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. Jackson or New Straitsville, Ohio. Electrolytic ferrosilicon, 12 to 14 per cent, is now competitive with the blast-furnace ferrosilicon in the case of a number of consumers, and is reported to have sold as low as $65, delivered.

Chemical and Allied Industrial Markets

New York, March 12, 1920.

Owing to the present high prices and small spot stocks, trading has not been very heavy. Foreign demand is still strong on some of the leading items and it is reported that Europe is destitute of some of these more active materials. The present scale of prices is due to remain until producers can catch up with their contracts and the pressure of the transportation problem can be relieved.

General Chemicals

Sodium nitrite is the outstanding item on the list this week. Last week's quotation of 15@17c. per lb. jumped to 65@68c. This rise was occasioned by the depletion of spot stocks, which have been steadily decreasing during the past few weeks. At present this item is unobtainable in any quantity here in the East, but relief is expected from the West and from shipments from abroad. *Nickel salt, single,* has tightened up slightly and at present is quoted at 16@17c. per lb., while the *double* holds firm at 14c. *Salt cake* has been exceptionally active during the week and with present low supply of spot material the low price came up from $18 to $21 per ton. *Ammonia* products are still scarce; quotations remain firm at last week's price, *aqua,* 26 deg., being sold at 8¾@10¾c. per lb. *White granular sal ammoniac* is still firm at 15@16c. per lb. with very little material obtainable at this price. *Methyl alcohol,* wood, is unobtainable in the market at present. Some small quantities are being transferred to old customers but at extreme prices. In sympathy with alcohol, *formaldehyde* remains scarce and prohibitive in price, 85c.@$1 per lb. being asked. *Barium chloride* is still firm at $140@$150 per ton, with no material changing hands even at this level. Producers are completely sold out and it seems to be the opinion of a good many that this condition will prevail for some time.

Coal-Tar Products

There has been no change of importance in this market during the past week. Spot stocks on most of the items remain small and previous price levels are holding firm. Producers are for the most part sold up on contract for periods ranging from three to six months. The future of the spot market, because of this condition, does not look especially bright. All *aniline* products are still practically unobtainable, the most important of these being *dimethylaniline,* which is quoted nominally at 90c.@$1.50, with no material to offer at the top price. *Naphthalene, crushed,* holds firm at 6@8c. per lb., while *flake* is quoted at 7@8c. and the *balls* 8½@10c. per lb. It is the opinion of one large producer that there will be an increase in price during the last half as indicated by decreasing surplus stocks on hand at present.

Naval Stores

This market is firmer in prices than it has been for the past few weeks, due entirely to scarcity of supplies. Foreign buyers have not come back in the market with the usual demand owing to a continued unfavorable rate of exchange. *Turpentine* advanced to $2.05 per gal., against $1.93 of

last week. This strengthening is due to scarcity in the Southern market, which has had the effect of tightening New York prices. All grades of the *rosins* are decidedly firmer. B-D grades are listed at $18@$18.75, against a low mark of $17 for last week, while E-I advanced to $18.90@$19.25 and K-H $19.35@$20 per 280 lb. There is no immediate relief in sight until the new crop arrives and in the meantime the large spring paint demand threatens to send prices still higher.

Crude Rubber

Para grades are still on the decline, *upriver* fine going down to 40½@42c., coarse 30½@32c. and *caucho ball* 31@32¾c. per lb. *Plantations* had a rise on the strength of the jump in exchange with some slight activity on the part of buyers.

Vegetable Oils

This market remained firm throughout the week with some slight fluctuation on *cottonseed*, crude, f.o.b. mill, which finished up at 17½@18c. per lb. There is an impending shortage in the *linseed* branch which threatens to be serious unless the crushers can be relieved by Argentine seed. Quotations are slightly firmer in tone, *raw*, carlots, being listed at $1.79, and *boiled*, carlots, $1.82 per gal.

Miscellaneous Materials

A continued active market for the past few months on *feldspar* combined with a series of unfortunate conditions, the latest being the severe weather which interfered with surface mining, has seriously crippled this industry. One large producer is refusing to consider any more contracts for the present even at the Government price of $18 per ton. The nominal quotation of $13.50@$18 per ton, ground grade, f.o.b. Tennessee and New York State remains firm, although there has been no business, on a large scale, reported at these prices.

The *shellac* market is somewhat easier owing to the increase in sterling. Orange fine is still quoted nominally at $1.45 per lb. while superfine is listed at $1.50@$1.60 per lb.

No. 1 crucible flake *graphite* dropped 50 per cent following the armistice and has never recovered. The prices quoted in the table may be regarded as delivered prices, approximately the same throughout the country. There are graphite mines in Texas, Alabama, Pennsylvania, etc. In Alabama there are twenty to thirty mines producing No. 1 flake, but only four or five of them are in operation, owing to reduced demand occasioned by the cessation of war. Those companies which have developed or are developing a market for other than crucible graphite stand a better chance for permanency.

Chicago, March 10, 1920.

Apparent apathy on the part of buyers marks trading in all lines, caused probably by the fact that price levels seem too high to justify buying beyond actual current needs. But few price changes of moment are recorded. Continued demand in excess of supply causes pine-tar products to continue their upward trend and a suddenly developed shortage in supply of *sodium nitrite* has provoked a spectacular boost. In general it may be said that, with most materials, production is rather less than normal demand and prices are firm with an upward tendency in most cases.

Chicago's growing importance in the *naval stores* industry is indicated by the recent increase in office space and storage capacity made by the General Naval Stores Co. at this point. Their capacity for business will be trebled by the enlargement.

Heavy Chemicals

Continuous demand by the dye industry coupled with shortage in production and a minimum of imports has forced *sodium nitrite* up to unreasonable levels. From a price of 18c. per lb. in carlots two weeks ago, 50c. is now easily obtained for the small lots available. Some sales were made at an even higher figure and it appears that 50c. will be the minimum for some time to come. *Alkali* products continue their upward trend, as spot stocks are low and export demand is still heavy. *Caustic soda*, solid, is quoted at $5 cwt., f.o.b. works. The same figure is named for goods from Chicago stock, but supplies are so low as to render this figure practically nominal. *Bleaching powder* is held at $3.25 per cwt. at the works, 25c. per cwt. more being asked for small lots for local delivery. Scarcity of *soda ash* has forced the figure up to $2.50@$2.65 per cwt. for spots, with but little less asked on contract. *Sal soda* is also up to $1.40 per cwt. in carloads.

Conditions remain the same as for the past six weeks in *alcohol, ethyl*, 190 proof, being quoted at $5.50@$5.70 in barrels, *methyl*, 97 per cent, at $2.40@$2.60 per gal. and *denatured*, 180 proof, at 78@83c. Spot stocks are almost out of existence and these quotations in most instances are purely nominal. The same is true as concerns *formaldehyde*, what little trading occurred ranging from 60@80c. with the most recent offer being made at 70c. New interest is being shown in *blue vitriol* (copper sulphate), producers showing no anxiety to close at the current figure of $9 per cwt. in carlots. *Chlorine* in cylinders holds at 9c. per lb. in spite of light demand, heavy withdrawals on contracts leading to the expectation of a better selling market. *Sodium bichromate* is easier, current transactions in small lots going at 39c. per lb. f.o.b. Chicago. A shortage has recently developed in *white sal ammoniac*, present market being 20c. per lb. for spots.

Acids, as for some time past, show but little activity, prices holding firm without change. The only exception is in *boric*, which steady demand has forced up to $16 per cwt. in cars for immediate delivery.

Coal-Tar Products

Supply conditions are steadily improving and as a result most prices should soon recede. This does not mean the market is weak. Rather, better supply and lower prices will make trading more active, buyers having stayed out of the market as much as possible during the recently prevailing poor buying conditions. Quotations of 30c. per gal. is still asked for *benzol* for spot shipment, 27c. for contract. *Toluol* is quoted at 28c. in carload quantities. Stocks of *anilines* are still seriously depleted, the *oil* being quoted at 35c. per lb. and *salts* at 50c. for immediate delivery. *Dimethylaniline, diphenylamine and paranitraniline*, being completely off the market, are not quotable. *Salicylic acid* has advanced, with present quotations 50c. per lb. for technical grade and 60c. for U. S. P. *Benzoic* remains unchanged at 75c. for technical and 90c. for U. S. P.

Vegetable Oils

Practical cessation of export trade has caused accumulation of excess stocks in all lines and induced a falling market. Plentiful supply with demand poor, is the case on every item. *Cocoanut oil* is off 2c., *manila*, in sellers' tanks, f.o.b. coast, being quoted at 17c.; refined, in barrels, at 20c. f.o.b. Chicago. *Prime corn oil*, in tanks, is bringing 15c. f.o.b. Chicago, with no inquiries being made for inferior grades. *Cottonseed oil* is very weak, carload quotation on crude being 15½@16c. and on *prime summer yellow*, 18@19c. delivered. Refined, in barrels, is going slowly on the local market at 23c.

A peculiar twist has developed in the *linseed oil* market. At the same time the wholesale market shows a cut from $1.75 per gal. to $1.65 per gal. for carlots, jobbers have raised their price on less than 5-bbl. lots 2c. per gal., $2.05 being the present price. It does not seem that this high price on small quantities can be maintained very long. *Soya bean oil* shares in the general decline, quotations now being, for tanks, f.o.b. coast, 16c.; for barrels, immediate delivery in Chicago, 17½@18c. and for refined, in barrels, Chicago, 19½@20c.

Flotation Oils—Naval Stores

The impending new crop causes buyers to be cautious and demand correspondingly light, but prices continue to ascend. *Turpentine* is now quoted at $2.30 in cars at Chicago, $2.42 being asked for barrels. This is an advance of 21c. in two weeks. *Pine oil* is also a little higher, $1.60 being asked for the small quantity of .933 pure steam distilled available and $1.55 for the destructively distilled. *Rosin* shows some additional strength, today's Chicago quotation on F grade being $19.75 per cwt., with other grades in proportion. *Pine tar oil* is held at 40c., under excellent demand.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 – 12.50	13.50 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	–	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09½
Oxalic, crystals	lb.	.35 – .40	.43 – .45
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	–
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	–
Sulphuric, 60 deg., drums	ton	–	–
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	–
Sulphuric, 66 deg., drums	ton	–	–
Sulphuric, 66 deg., carboys	ton	–	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P	lb.	–	1.35 – 1.45
Tannic (tech.)	lb.	–	.42 – .55
Tartaric, crystals	lb.	–	.69 – .74
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
*Alcohol, Ethyl	gal.	4.80 – 5.50	6.00 – 7.00
*Alcohol, Methyl	gal.	2.35 – 2.75	–
*Alcohol, denatured, 188 proof	gal.	–	.72 – .78
*Alcohol, denatured, 190 proof	gal.	–	.70 – .74
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac)	lb.	.15 – .16	.17 – .19
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	–
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	–
Barium chloride	ton	140.00–150.00	160.00 – 170.00
Barium dioxide (peroxide)	lb.	.26 – .27	.28 – .30
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.85 – .95	–
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	–	.04¾ .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	3.50 – 3.75	4.00 – 4.50
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.	–	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.80 – 1.05
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	–	2.00 – 2.05
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Formaldehyde, 40 per cent (nominal)	lb.	–	.85 – 1.00
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.10 – 4.30
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	–	.13 – .17
Lead nitrate, crystals	lb.	–	.70 – .80
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	–	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	3.40 – 3.55	3.60 – 3.75
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.16 – .17	.17½ –
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	–	.60 – .65
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .37
Potassium bitartrate (cream of Tartar)	lb.	–	.56 – .60
Potassium bromide, granular	lb.	–	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 –
Potassium hydroxide (caustic potash)	lb.	.25 – .32	.35 – .42
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	.34 – .36	.40 – .70
Potassium sulphate	ton	$225.00 –	–
Rochelle salts (see sodium potas. tartrate)		–	–
Salammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)		–	–
Salt cake	ton	21.00 – 22.00	–
Silver cyanide (nominal)	oz.	–	1.25 –
Silver nitrate (nominal)	oz.	–	.81⅝ – .82½
Soda ash, light	100 lb.	2.50 – 2.60	– 3.00
Soda ash, dense	100 lb.	2.70 – 2.75	– 3.10
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.05½ – .06½	.07 – .07½
Sodium borate (borax)	lb.	.08½ – .08¾	– .09
Sodium carbonate (sal soda)	100 lb.	1.35 – 1.40	1.50 – 1.75
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	5.00 – 6.00	6.10 – 6.25
Sodium hyposulphite	lb.	–	.03¾ – .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	–	.65 – .68
Sodium peroxide, powdered	lb.	–	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02¼
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	–	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½	.46 – .50
Tin oxide	lb.	.50 – .60	.65 –
Zinc carbonate, precipitate	lb.	–	.20 –
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 –
Zinc dust	lb.	.11¼ – .12½	.13 – .15
Zinc oxide, dry American	lb.	–	.09½ – .12
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

*Nominal quotations.

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.35
Benzidine, sulphate	lb.	1.00 —	1.15
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.29
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.55
Beta naphthol, sublimed	lb.	.65 —	.80
Beta naphthol, tech.	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.70
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline (nominal)	lb.	.95 —	1.50
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.55 —	.65
H-acid	lb.	1.60 —	1.75
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.75 —	1.25
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.12 —	.18
Paranitraniline	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.15 —	3.00
Paratoluidine	lb.	1.75 —	2.50
Phthalic anhydride	lb.	.60 —	.70
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	3.75 —	4.50
Resorcin, pure	lb.	6.50 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.43 —	.45
Salicylic acid, U. S. P.	lb.	.55 —	.60
Salol	lb.	.90 —	1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.22	—	$0 27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.42	—	$0.45
Beeswax, refined, yellow	lb.	.47	—	.48
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1. (nominal)	lb.	.80	—	.88
Carnauba, No. 2, regular (nominal)	lb.	.65	—	.78
Carnauba, No. 3, North Country (nominal)	lb.	.46	—	.48
Japan	lb.	.17	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.10½
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.11	—	.11¼
Paraffine waxes, refined, 133-135 m.p.	lb.	.....	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.....	—	.14
Stearic acid, single pressed	lb.	.23	—	.26
Stearic acid, double pressed	lb.	.28	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.45
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.40
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.48
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.70
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.60
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$18.00	—	$18.75
Rosin E-I	280 lb.	18.90	—	19.25
Rosin K-N	280 lb.	19.35	—	20.00
Rosin W. G.-W. W.	280 lb.	21.50	—	24.75
Wood rosin, bbl.	280 lb.	15.50	—	17.50
Spirits of turpentine	gal.	.....	—	2.05
Wood turpentine, steam dist.	gal.	.....	—	1.93
Wood turpentine, dest. dist.	gal.	.....	—	1.85
Pine tar pitch, bbl.	200 lb.	8.50	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	14.75
Retort tar, bbl.	500 lb.	15.00	—	15.25
Rosin oil, first run	gal.	.93	—	.95
Rosin oil, second run	gal.	.96	—	.97
Rosin oil, third run	gal.	1.10	—	1.15
Rosin oil, fourth run	gal.	.....	—	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33¾
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30¼
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½	—	$0.42
Upriver coarse	lb.	.30½	—	.32
Upriver caucho ball	lb.	.31	—	.32¼
Plantation—First latex crepe	lb.	.48½	—	50
Ribbed smoked sheets	lb.	.48	—	.48¾
Brown crepe, thin, clean	lb.	.45	—	....
Amber crepe No. 1	lb.	.46	—	47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.23
China wood oil, in bbls.	lb.	.23½	—	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18	—	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½	—	.23½
Corn oil, crude, in bbls.	lb.	.17	—	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½	—	.18
Cottonseed oil, summer yellow	lb.	.18½	—	.19½
Cottonseed oil, winter yellow	lb.	.22	—	.24
Linseed oil, raw, car lots	gal.	1.79	—	
Linseed oil, raw, tank cars	gal.	1.72	—	
Linseed oil, boiled, car lots	gal.	1.82	—	
Olive oil, commercial	gal.	2.50	—	3.00
Palm, Lagos	lb.	.16	—	.16½
Palm, bright red	lb.	.15½	—	.17½
Palm, Niger	lb.	.15	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22½	—	.24
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal.	1.70	—	
Rapeseed oil, blown, in bbls.	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½	—	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.16¾	—	.20

FISH

Winter pressed Menhaden	gal.	$1.15	—	....
Yellow bleached Menhaden	gal.	1.20	—	....
White bleached Menhaden	gal.	1.22	—	....
Blown Menhaden	gal.	1.28	—	....

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.04½	—	.05½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.35	—	.36
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar (nominal)	ton	13.50	—	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	52.00	—	57.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	.07½
Graphite, crucible, 86% carbon content	lb.	.....	—	.08
Graphite, crucible, 87% carbon content	lb.	.....	—	.07
Graphite, crucible, 88% carbon content	lb.	.....	—	.08½
Graphite, crucible, 89% carbon content	lb.	.....	—	.08½
Graphite, crucible, 90% carbon content	lb.	.....	—	.09
Graphite, crucible, 91% carbon content	lb.	.....	—	.08½
Graphite, crucible, 92% carbon content	lb.	.....	—	.09½
Graphite, crucible, plus 92%	lb.	.....	—	.12
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, orange, fine	nominal lb.	1.45	—	
Shellac, orange, superfine	lb.	1.50	—	1.60
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	20.00	—	60.00
Talc, imported	ton	60.00	—	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fire clay	1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	45-50 at Mt. Union, Penn

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.22
Ferro-manganese, 70-80% Mn	gross ton	160.00	—	175.00
Spiegeleisen, 16-20% Mn	gross ton	50.00	—	65.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25	—	2.75
Ferro-silicon, 50%	gross ton	85.00	—	95.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb	.90	—	1.10
Ferro-uranium, 35-50%	lb	7.00	—	
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.50

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.60	—	$0.85
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton		—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.25	—	6.75
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	
Pyrites, foreign, lump	unit	.17	—	
Pyrites, foreign, fine	unit	17	—	
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	
Rutile, 95% TiO_2	lb.	.11	—	
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	
Monazite, per unit of ThO_2	unit	42.00	—	

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

HUMBOLDT—The Silver Belt Mining Co. plans to install a 50-ton flotation mill at its silver mine. Ben Rybon, Prescott, gen. mgr.

KOFA—The New King of Arizona Mining Co., Los Angeles, Cal., plans to construct a 20-ton stamp mill with cyanide equipment at its gold mine, here. W. J. Johnson, mgr.

MAYER—The Peck Consolidated Mining Co. plans to construct a 100-ton cyanide plant. A. Anderson, supt.

TUBAC—R. R. Mason, Patagonia, plans to install a 50-ton flotation concentration mill, in connection with the Royal Blue Mine, near here.

TUCSON—The Midland Copper Co. plans to install a 100-ton flotation mill on its North Star property. E. G. Bush, pres.

TUCSON—The Mineral Hill Consolidated Copper Co. plans to install a 300-ton flotation mill at its copper mine. F. G. Farish, genl. mgr.

TUCSON—The Silver Peak Mining Co. plans to install a stamp and concentrating mill at its silver mine. Paul Von Feldt, supt.

California

BIGGS—The city voted $45,000 bonds to improve the sewer system, including the construction of a sewage disposal plant.

EL MONTE—B. B. Moore, city clk., will receive bids until March 18 for the construction of a sewer system and a circular septic tank, Imhoff type, for the city. Estimated cost, over $10,000. Olmsted & Gillelen, Hollingsworth Bldg., Los Angeles, engrs.

TURLOCK—The city trustees are having plans prepared for the construction of a sewage disposal plant. Estimated cost, $10,000. A. M. Jensen, Fresno, consult. engr.

Connecticut

MERIDEN—The Miller Bros. Cutlery Co., 464 Pratt St., will soon award the contract for the construction of a 4-story, 50x90-ft. addition to present plant on Pratt St. Estimated cost, $50,000. W. T. Arnold, 105 Elm St., archt.

Illinois

CHICAGO—Darling & Co., 4201 South Ashland Ave., have awarded the contract for the construction of three buildings, including a 5-story, 97x100-ft. distillation plant, etc., to Stresenreuter Bros., 3020 South Halstead St. Estimated cost $225,000.

Iowa

CENTERVILLE—The city will soon award the contract for the construction of a sewage disposal plant, etc. R. O. Stephenson, city clk. M. G. Hall, engr.

Maine

ROCKLAND—The Rockland & Rockport Lime Corp. plans to rebuild lime plant which was recently destroyed by fire, entailing a loss of about $100,000.

Michigan

GREENVILLE—The Moore Plow & Implement Co. is in the market for gray iron foundry and pattern shop equipment.

HOWELL—The Howell Electric Motors Co. is in the market for brass foundry equipment.

Minnesota

ELLSWORTH—E. A. Meester, village recdr., will receive bids until March 26 for the construction of sanitary sewers, disposal works, including a disposal tank, sludge bed, etc. Estimated cost, $40,000. Druar & Smith, Globe Bldg., St. Paul, engrs.

New Jersey

HARRISON—Driver Harris Co., Middlesex St., is constructing a 3-story, 52x100-ft. building including an office, spooling and testing room, etc. G. A. Rickert, adv. mgr.

New Mexico

GAGE—Norman Welch, supt., plans to install a 50-ton concentration mill to handle fluorspar, in connection with its fluorspar mine here.

New York

BROOKLYN — Devoe - Reynolds, 460 Smith St., is having plans prepared for the construction of a 6-story, 55x175-ft. paint factory at Smith and Hamilton Sts., and is in the market for chemicals for the manufacture of paint. Fred A. Phelps, Union Bldg., Newark, N. J., archt.

PENN YAN—The city held an election March 16 to vote on $5,750 bonds to repair sewage disposal system.

SCHENECTADY—The General Electric Co., River Rd., plans to construct a 1-story, 206x600-ft. punch press shop on Central Ave. Estimated cost, $700,000.

North Dakota

CANDO—The town plans to construct a sewage disposal plant. Estimated cost, $60,000. Atkinson and Hall, Devils Lake, engrs.

MINOT—The city has awarded the contract for the construction of a sewer system and sewage disposal plant, to G. W. Kewper, Minot. Estimated cost, $205,000.

Ohio

AKRON—The S. & O. Engraving Co., 330 South High St., is having plans prepared for the construction of a 2-story, 40x150-ft. office and laboratory building on High St. Harpster & Bliss, Nantucket Bldg., archts. Mayer & Valentine, Bangor Bldg., Cleveland, engrs.

CINCINNATI — The Standard Silicate Co. has purchased a 24-acre site on Paddock Rd. and plans to construct a factory on same. Estimated cost, $750,000.

CLEVELAND—The Buckeye Brass Co., 6410 Hawthorne Ave., has awarded the contract for the construction of a 1-story, 30x110-ft. foundry, 75x75-ft. furnace room and an 18x35-ft. wash-room on Ashland Rd., to Gometz & Neshkes, 2361 East 61st St. Estimated cost, $75,000.

NEW PHILADELPHIA—The Weiss McClung Co. plans to build a 1- and 3-story factory for the manufacture of rubber. Estimated cost, $300,000. W. F. Ferguson Co., 1900 Euclid Ave., Cleveland, engr.

Oklahoma

RED FORK—The Sunlight Carbon Co. has purchased an 8-acre site near here and plans to build a carbon factory for the manufacture of lamps, dry cells, lamp black, etc., on same. Estimated cost, $100,000.

Pennsylvania

MILLERSBURG—The Alvord Reamer & Tool Co. has awarded the contract for the construction of a 40x60-ft. addition to plant, to H. Helwig, Millersburg. Address W. S. Umberger.

PHILADELPHIA—The Trenton Crockery Co., 106 North 2nd St., has awarded the contract for altering the 5-story, 120x195-ft. factory, to Smith-Hardican, 1606 Cherry St. Estimated cost, $10,000.

West Virginia

WESTMORELAND (Huntington P. O.) —The West Virginia Glass Co., Huntington, plans to build two additional units to its plant, here.

Wisconsin

MANITOWOC — The Aluminum Goods Mfg. Co., 15th and Franklin Sts., had preliminary plans prepared for the construction of a 2-story, 60x350-ft. rolling mill on Main St. Estimated cost, $500,000. Lockwood, Greene & Co., South Dearborn St., Chicago, engrs.

Ontario

SAULT STE. MARIE—The Natl. Electric Products Ltd., 83 Church St., Toronto, plans to build a 1-story factory for the manufacture of liquid oxygen. Estimated cost, $25,000.

SUDBURY—The High School Bd. is having plans prepared for the construction of a 2- or 3-story high school. Equipment for chemical and physical laboratories will be installed in same. Estimated cost, $200,000. P. J. O'Gorman, archt.

WOODSTOCK—John Morrison, city clk., will receive bids until March 24 for the construction of a 1,500,000-gal. sewage disposal plant, Imhoff style, etc. F. J. Ure & Son, engrs.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 P.M., Dr. R. B. Moore, chief chemist, U. S. Bureau of Mines (*Lantern*); "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 P.M., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern*).

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE PENNSYLVANIA SAFETY CONGRESS for 1920 will be held at Harrisburg, Pa., March 21 to 25 inclusive.

THE SOCIETY OF INDUSTRIAL ENGINEERS will hold its national spring convention March 24 to 26 at the Bellevue-Stratford Hotel, Philadelphia.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Associate Editor
WALLACE SAVAGE, Assistant Editor

ALAN G. WIKOFF, Assistant Editor
L. W. CHAPMAN, Western Editor
CHESTER H. JONES, Industrial Editor
J. S. NEGRU, Managing Editor

Volume 22 — New York, March 24, 1920 — *Number* 12

Are Executives to Join The Labor Turnover?

INDUSTRIAL unrest is ordinarily thought of as being perpetually epidemic in the "submerged tenth," and sporadic among laborers, mechanics and craftsmen. We hear much about this unrest—the former class furnishes fields where the police department's bomb-squad works, while organized labor furnishes the ever-present strikes and endless negotiations which receive such wide publicity.

Only since the profiteer has waxed fat has it dawned upon many that uneasiness is spreading wide among the men who wear white collars and work with their heads or nerves rather than their muscles. Only recently has it been recognized that a ferment is working among those conservative citizens who are often likened by the orator to the ballast of the ship of state, or other important, nice-sounding things. Whereas it was easy to see that large horizontal increases in wages had wiped out the differential which attracted the best workmen to the places demanding the most skill, effort and trust, it has only recently dawned upon many employers that there is a tremendous turnover in their staffs of clerks, technical men and unorganized skilled artisans. They seem to be driven from one place to another, more or less against their instincts, but really driven in the hope that their salary may somehow become larger so as more nearly to cover their necessities and leave a little for play and thrift.

But now it is going even higher up. As but one instance, general foremen in railway shops have had their salaries raised up to $300 a month, yet master mechanics, with very much greater responsibilities, still get unchanged their $325—by no means enough for a good executive under the present range in prices. More than a few of the faithful superintendents are wondering whether a period of service extending over their whole working years, a time in which they gave ungrudgingly the best there was in them to the untold profit of their employing corporation, is going to leave them poor at the finish. A director or manager is indeed blind if he can view the spectacle of common labor receiving two to three times what it got before the war, and the prices of all commodities correspondingly up, and yet assume that the wholly unusual men who are responsible for the success of the business are not going to be restive under the same old salary plus a 10 per cent bonus and with an occasional bouquet.

Under such circumstances nothing less is to be expected than that the most energetic men will leave their old positions and join the restive ranks which form the labor turnover. Expensive as the turnover is among the working force, it must be ruinous if it gets to the executives. BABSON, the statistician, was timely in his recent warning to stand-pat business to 'ware the new concern, which is recruiting talent among those who have already made good elsewhere. While we believe (more from that hope which springs eternal than from hard experience with the price-boosting activities of those who sell things) that the peak of high prices has passed, still that is no reason for further delaying that impluse to raise the salaries to where they were before the war. Then watch the efficiency curve!

Do We Need Immigration?

AGENCIES that are engaged in studying the labor problem in the United States are making public facts and figures that must give pause to executives in those industries in which a steady and uniform supply of labor is a vital factor. The chemical industries are not so much dependent on labor, perhaps, as are the metal industries, and yet when there is an actual shortage of manpower in the country as a whole, all industry must be affected. It requires no fine calculation to prove that there is an actual shortage of manpower in the United States, to say nothing of having a reserve that can be called upon in emergency. The steel industry, the railways, the telephone companies, the mills, factories and mines of the country are suffering from an acute shortage of workers; and to a large extent that shortage is in labor that formerly was supplied by immigrants from foreign countries. Nor is the shortage in unskilled labor alone, as a glance at the "help wanted" advertisements in the daily papers will attest. One authority has estimated that $30,000,000 was spent in 1919 for such advertisements in the United States alone—an eloquent testimonial to the competitive conditions that drove employers to extremity in hiring their neighbors' employees.

Labor leaders may assert that this is a desirable condition as far as the worker is concerned, for now there are more jobs than workmen. For general prosperity and healthful industry, however, the doctrine is as fallacious as the converse that there should be a great excess of laborers so that industry might bid the labor market down. Somewhere between lies the happy medium, with a sufficient reserve in manpower to meet emergencies. All of the capital in the country is not always profitably employed; no more is all of the labor likely to be. It is equally fallacious to assume that production is the only item to be considered, for while a labor shortage may enhance the value of a job, the market for the product is diminished by the reduced number of consumers. To put it concretely, if the labor resources of the United States have been reduced in recent years by 4,000,000 immigrants who normally would have come to this country if the

war had not intervened, we are not only short of their productive effort in industry but we lack the market for the consumption of commodities that those 4,000,000 men and their 2,000,000 women and children would have required. Add to this definite shortage of labor the loss in production due to strikes and the slackening in the productive effort of the average workman, and we have all the elements of a situation calling for study and an intelligent solution.

How shall we escape from this *cul de sac*? The Inter-Racial Council which has been recently organized, representing more than 450 industrial establishments, is of the opinion that the only way out is to adopt a plan of systematic and regulated immigration. They believe that immigration is more of an industrial problem than one of politics, and that a study should be made of its ethnical phases in order to encourage immigration of those races most easily assimilated and best adapted to our industrial needs. Their remedy comprises three elements: selection of immigration at the source, supervision of its distribution on its arrival, and adequate steps to assimilate and Americanize immigrants instead of leaving them to shift for themselves.

The program appeals to us as worthy of support. At present there is little discrimination in regard to the first two items. Immigrants come from practically the four quarters of the globe, and few are denied entrance. In the past the stream of immigration has flowed into this country at a few ports, and like the delta of a great river has spread out over a comparatively small and already congested area. As for assimilation and Americanization, the efforts have been largely local and in some cases spasmodic, although all that has been done is praiseworthy. What is needed is a co-ordinated plan that will consider the type and quality of the immigrant, his place in this country after he arrives, and finally a definite effort to accustom him to our institutions and make an American out of him. Immigration is needed to avert a continuous shortage of manpower, but it must be regulated and not be allowed to proceed promiscuously.

Why Not Export Helium?

IT HAS been proposed, apparently in all seriousness, that we should establish an embargo upon the export of helium from the United States, in order to prevent foreign powers from accumulating a reserve supply for balloon-gas uses. We doubt very much whether this particular embargo will be given much serious consideration, but the principle involved in such matters should engage our most careful and serious attention.

Any natural resource of limited quantity that would be quickly exhausted and our own supplies thereby curtailed through export should be considered as being in a different class from materials such as helium which are being wasted unless developed and used currently. Helium is procured exclusively from the natural-gas supplies which are being developed and used for domestic or industrial purposes without regard to the helium content. If by maintaining a foreign market in such material we are enabled to exploit profitably this resource and develop the art of its recovery and handling to a satisfactory commercial state, we are attaining a very desirable position. Moreover, this development and industrial advantage would be fostered largely at the expense of the foreign purchaser, and thus our industrial independence would be established with small cost to us.

There is little need to fear that helium or any other similar commodity difficult to store can be accumulated for use to our subsequent detriment. It does not lend itself to storage in quantity except at prohibitive expense. Thus, it is reasonable to assume that not more than a current supply will be maintained by purchasers abroad.

On the other hand, we should not be content to sell all of this material abroad, for if we do we may find ourselves in the unenviable position of knowing how to prepare a material but not knowing how to use it effectively. We should certainly hope to continue in this country a reasonable amount of industrial application in aircraft work and any other lines that may find this gas commercially applicable, so that we may keep pace with foreign development. Beyond this, however, we see no reason why the greatest facility for exporting such a commodity should not be afforded our industries.

The principles thus discussed apply in many other cases, though perhaps not as fully or as strikingly as to helium. It is worth while, therefore, to stop long enough in our consideration of international relations regarding each mineral or other natural resource, and think clearly as to whether or not continued production for export as well as continued development of the arts or application are receiving proper encouragement within as well as without our boundaries.

Empirical Equations in Engineering Calculations

MOST, if not all, the formulas of physics and physical chemistry are in the primitive stages of a process of evolution. For example, take as a typical case the gas laws of BOYLE (MARIOTTE) and CHARLES GAY-LUSSAC), which form the very foundation of the study of not only gas phases but solutes as well. Later AMAGAT made a classical investigation in which he demonstrated that BOYLE'S premise that PV is constant for any given temperature is very inaccurate. Some time prior to AMAGAT'S publication of his nitrogen, hydrogen, ethylene and carbon dioxide $PV:P$ charts, VAN DER WAALS deduced a new gas equation, containing correction constants characteristic of individual gases. The generality of the VAN DER WAALS equation is only apparent and, not having great mathematical flexibility, it has not proved adaptable to a wide range of determined results in calculations to which it has been applied. While CLAUSIUS, DIETERICI and several others have devised more flexible mathematical equations, they have not solved the problem satisfactorily for the very simple reason that the premises they make are inaccurate, incomplete, or both.

In the case of steam, REGNAULT, BROCH, PEABODY, HENNING and many others have devised or revised the various empirical steam equations in PT that have been proposed since 1847. All these have, however, been too complicated to get into current engineering use. This, of course, is due to the fact that both the steam charts and tables are much more convenient.

There are cases in engineering where tables cannot be satisfactorily devised and empirical equations must be used. An excellent illustration is afforded of this

in the investigation of heat conductivity by GEORGE A. RICHTER, to whose paper on Double Pipe Heat Interchangers, published in this issue, the attention of the reader is directed. Mr. RICHTER has demonstrated the importance of film velocity, which has hitherto not been considered a factor of much weight. Problems of design require reliable guides in the form of tables, charts or equations of direct and specific applicability. To get this, theory has to take orders from an empirical superior. Deductions must be made on assumptions that have proved to be workable both forward and backward. Good empirical equations have an excellent qualification for workaday use by being based on data rather than a skeleton of simplified assumptions. The engineer is tending to make more use of them in his calculations and in time should derive better general equations than have hitherto been in vogue in theoretical science.

How Is an Invention Invented?

LAYING down rules whereby an invention may be conceived is as hopeless a task as demonstrating by pure reason the existence (or non-existence) of GOD, Immortality, or the Infinite—which if we wanted to digress might all be argued to be the same thing. Pursuing the original thought, however, scientists are generally as different in their mental processes from inventors as philosophers are from theologians in this principal respect: Scientists and philosophers reach their conclusions by a skillfully constructed train of thoughts proceeding from cause to effect, while inventors and theologians arrive at their destination by an exercise of intuition.

This is probably most apparent in various aspects of religion. The Infinite evidently cannot be comprehended by the finite mind; It must be accepted meekly as an act of faith. Intuition may not so clearly be the main characteristic of an inventor. But if a scientist (bred in the bone) and an inventor (by divine right) both start from a certain point and travel in a certain direction they will proceed side by side closely in step until they reach a wide chasm, across which lies their goal. On the edge of this abyss the scientist sits down and starts to think. The inventor, however, lifts his eyes from the abyss, and seeing his destination on the far side, arrives there with one stupendous leap. That is to say, his leap is long enough if he is a successful inventor; others land just short of the farther bank and drop into oblivion!

And a curious thing about it is, that after the scientist sits and ponders and builds a substantial bridge of thought across the gap, he ultimately arrives at the same destination. But it is sometimes a long and discouraging task interrupted by as many false starts and failures as bridging the St. Lawrence. Meantime, if he ask his inventor friend how he did it, the inventor (almost prophet) speciously exhibits a phantom bridge as unsubstantial as a monkey-span across the great gray-green, greasy Limpopo. And the surest way for scientist and inventor to become estranged is for the former to point out the perfectly obvious faulty links and actual gaps in the chain of argument. As a parting shot, the prophet will exclaim against the obtuseness of men who are not awed by the unusual, saying: "Why are you so blind that you can't see it is thus and so?" Trying to justify a fact is so obviously foolish when you know it exists!

Therefore it is rather futile to give instructions to inventors who will find those real epoch-making things yet hidden far out into the dark unknown. But as a matter of fact, only an infinitesimal number of inventions belong to this class. The rest are merely adaptations of known principles, or an arrival at a given point in well-mapped territory by a less devious route. With such utilitarian things most modern seekers are concerned.

Perhaps the principal rule to adopt would be: Don't become discouraged because others have tried and failed. A sufficiently minute search through the literature would doubtless reveal at least one reason why any given scheme would be almost foolish. One or more men may have actually recorded failures in attempting the same path you plan to follow. But it would be as bad to turn back because some one else had not successfully traveled the route as it would to abandon the expedition in discouragement on arriving at the first obstacle. Still, don't become discouraged at the wrecks along the way!

A case in point is the recent development of a commercial process for electrolytic white lead by KREJCI and his associates. Electrolytic white lead is no new thing, as the *Transactions* of the American Electrochemical Society will bear witness. It had never been taken beyond the experimental stage, however, for a variety of reasons, but good practical technology (otherwise known as common sense) eventually solved the larger applications. Yet these men are frank enough to say that had they known of the failures of the earlier experimenters *before* their successful attempt instead of after, it is doubtful whether the trial would have been made.

A second rule follows from the principal one. If you are acquainted with the former work, and can see that it has all split upon one rock, rearrange the attack so as to turn the obstacle into a pronounced advantage.

The late WILLIAM THUM was fond of pointing out how this was accomplished in his now almost universally-used process for parting gold and silver. In all former experimentation it had been found impossible to refine gold bullion successfully in a tank, because the silver deposited from nitric acid solution would always (no matter what dodges were tried) deposit in a discontinuous mass of needles, which played havoc with electrical conditions and would not adhere to the vertical anodes. Yet, and it seems so simple that it took one of those flashes of genius to discover it, if the bottom of the tank were made the anode, the insurmountable difficulty of a non-coherent deposit became the chief advantage. Thus, in placing the impure cathode bars horizontally in the tanks, the loose crystals of pure silver collecting in quantity under the diaphragm at the bottom of the tank could be shoveled out quite easily.

Another simple illustration of the second point which comes to mind is concerned with matte casting. Those lead-plant men, who are used to casting matte buttons, know the difficulty and expense involved in breaking up the thick, tough slabs, to say nothing of the explosion risk when a partially-solidified mass breaks in handling. Yet if the liquid matte be purposely bled from the interior of such a button, the remaining shell will be safe to handle and will break with the utmost ease into the correct-sized material for re-charging.

Instances might be uselessly multiplied. After all is said and done, inspiration cannot be explained! But in directing it, the best captain is sound theoretical groundwork, and the best lieutenant is wholesome common sense.

Readers' Views and Comments

A Study of the Lime-Soda Ash Water-Softening Process

To the Editor of Chemical & Metallurgical Engineering

SIR:—Having spent several years specializing on the purification of water for industrial purposes, the writer found the article by Max H. Herrle and Francis M. Gleeson, "A Study of the Lime-Soda Ash Water-Softening Process" (appearing in the Feb. 11, 1920, issue of CHEMICAL & METALLURGICAL ENGINEERING), quite interesting from a strictly laboratory standpoint, since they embody certain experiments the writer has never duplicated.

It would appear quite doubtful, however, if the authors of this article have any wide experience or knowledge of conditions met with in the evaporation of water for steam; for the reason that they fall into errors in drawing conclusions which indicate that the article is the product of analytical chemists without engineering experience.

In the first place, they divide the subject of water purification into three classes—distillation, filtration, and chemical purification by precipitation. Did they, in elaborating on these three classes, allow filtration and chemical purification by precipitation great enough latitude, this would be correct, but they limit filtration to the removal of suspended matter, and chemical purification to the use of some form of the lime-soda ash, the caustic soda, or the lime-barium water softener.

This excludes two widely used and well recognized methods of water purification—the zeolite method of water softening, and the use of boiler compounds.

Strictly speaking, the zeolite method of water softening is a filtration method, and for the benefit of Messrs. Herrle and Gleeson and any others who may not be acquainted with this method, I will give a very brief explanation of the process. A zeolite (as exemplified by Refinite, Permutit and Decalso) is a hydrated silicate of aluminum containing a large amount of sodium in a loosely bound condition. By what is known as the law of mass action, this sodium is exchanged for the calcium and magnesium in water percolated through a bed of the zeolite, and the water leaves the filter bed carrying only a trace of calcium and magnesium salts. Just as an aside, this is the only method of water purification known—aside from distillation itself—which *can* give water that will approximate the theoretical 0.0 deg. hardness.

Some may object to the classification of boiler compounds as a method of purifying water, and with justice. The writer, however, knows of at least one company which, by fitting the compound to the water in a scientific manner, really justifies the terminology of water purification. Since any scientifically prepared boiler compound achieves its object by the precipitation of scale-forming substances inside the boiler, it might properly come under their third classification, but it would strain the limits of this classification, as given by the authors.

The primary object of this letter, however, is to point out some erroneous conclusions and the effects to be anticipated should they be allowed to effect the principles under which the water-softening plant is operated.

Their summarization of results from experiments with soda ash alone reads as follows:

"Sufficient soda ash should be added so that a slight excess of this reagent remains after the chemical action between it and the water has been completed. The excess will have no effect upon the hardness and but little effect on the alkalinity, so that the engineer need have no fear of its presence. This excess will prove of great value in case the raw water varies in initial hardness, as such small fluctuations can be readily cared for by this reagent."

This conclusion is diametrically opposed to the best water-softening practice. The standard practice calls for slightly less soda ash than is sufficient to carry the reactions to completion, and tests on a properly treated water will conform to the following proportions:

The hardness shall be slightly less than the total alkalinity. The caustic alkalinity shall be slightly more than half, but never more than two-thirds of the total alkalinity. Hardness to be determined by titration against a soap solution standardized to read in grains per gallon calcium carbonate equivalent. Total alkalinity to be determined by titration with methyl orange as an indicator. Caustic alkalinity to be determined by titration using phenolphthalein as an indicator. Both caustic and total alkalinity to be reported in grains per gallon calcium carbonate equivalent.

In the laboratory a slight excess over the theoretical amount of soda ash is necessary to carry the precipitation of the calcium salts to completion, but for best results in a boiler this excess is not only unnecessary, but is positively dangerous.

The purpose of softening water for boiler use is the prevention of scale, and under boiler conditions the precipitation is completed with less soda ash than the amount necessary to complete precipitation in the water softener. When this precipitation is completed within the boiler, scale is not formed, but the precipitate settles to the bottom of the boiler as a sludge or mud and is disposed of in the blowoff.

All sulphates, chlorides and nitrates present in the raw water remain in the treated water in the form of the corresponding sodium salt. Of these, the sulphate and nitrate (the latter is very rarely present) show a marked tendency to cause foaming and priming with relatively small concentration. This tendency is greatly increased by the presence of soda ash; with the addition of greater quantities of soda ash, it increases in a double ratio. Hence, while—as pointed out by Messrs. Herrle and Gleeson—the addition of an excess of soda ash will not cause the hardness to rise, as is the case with lime, it does add enormously to the danger of foaming and priming, and a thin film of scale which might be caused by an insufficient amount of soda ash in the treatment would cause far less trouble than would the carrying over of water with the steam, not to mention the fact that it might endanger the lives of the engine room attendants.

Turning now to the question of minimum hardness obtainable. By no precipitation process is the theoretical minimum of 0.0 deg. possible of achievement. The minimum hardness possible with any cold water lime-soda ash treatment is approximately 1.66 g. per gal.

(It is not possible to precipitate down to an amount smaller than the solubility of the precipitate. Calcium carbonate has a solubility of 0.76 g. per gal., magnesium hydrate a solubility of 0.53 g. per gal., or calculated to the calcium carbonate equivalent, a solubility of 0.90 g. per gal., a total of 1.66 g. per gal. calcium carbonate equivalent.)

The soap solution used by the authors of the article under discussion was evidently standardized to some odd factor, for with the presence by analysis of 1.52 g. calcium carbonate, and 0.39 g. magnesium hydrate (0.67 g. calcium carbonate equivalent)—a total of 2.19 g. per gal. of hardness—they report 0.50 deg. of hardness.

The explanation they give, that "the theoretical hardness of 0.0 deg. is not obtainable, being probably due to the small sample of water originally treated," does not argue a wide experience in the water-softening field, nor does it indicate a deep knowledge of the chemistry of water softening. It is well known to water-softening experts that it is possible to secure better results with laboratory-sized samples and with laboratory methods of chemical measurement than can be obtained in industrial water softeners. It is also well known that the "theoretical hardness of 0.0 deg." is impossible of attainment by any method other than distillation, for this would require the total absence of all calcium, magnesium and iron salts. Zeolite softeners sometimes approximate a zero hardness, but they never in fact quite reach it.

The statement, therefore, that "In the water-softening system in operation at our plant it is nothing unusual to obtain a hardness of 0.0 deg." is so palpably impossible that it throws a strong element of doubt upon any conclusion reached in the entire article.

WILLIAM M. TAYLOR,
Sometime Chemical Engineer, Kennicott Co., and Chief Chemist, Refinite Co.
Chicago, Ill.

Wood Alcohol as a Beverage

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the *Literary Digest* of Feb. 14, I note a review of an article in your publication for Jan. 21, in which is stated that some chemists have asked the Commissioner of Internal Revenue to change the name of wood alcohol to "woodine." I thought it might interest you to know that a short time ago I wrote one of our legislators from this state, the Hon. Carlos P. Bee, suggesting that he endeavor to have a law enacted requiring manufacturers and dealers to label, list and sell wood alcohol as wood naphtha. This will classify the real nature and use, and prevent so many unfortunate mistakes being made by people confusing it with the alcohol of intoxicating liquors.

The whole source of the use of wood alcohol in beverages, medicines, etc., was in the fact that its very name was misleading, and the only way to eradicate the evil and to combat its mistaken use is to inaugurate a campaign of widespread publicity as to its real nature and use, and the most effective means of doing this is to give it a name that classifies its real use. As a pharmacist and chemist I have studied our methods of preventing the uninformed people from misusing wood alcohol and I have come to the conclusion that the only logical course is to have laws passed making it compulsory with dealers and manufacturers to label it "wood naphtha."

O. W. NOLAN.
San Antonio, Tex.

Spring Meeting of the American Electrochemical Society

THE spring meeting of the American Electrochemical Society will be held in Boston April 7 to 10 inclusive. There will be a meeting of the board of directors Wednesday evening, April 7. The following program is announced:

THURSDAY, APRIL 8

The annual business meeting will be held in the morning and the retiring president, Wilder D. Bancroft, will deliver an address on "Contact Catalysis."

Symposium on Colloid Chemistry:

W. D. Bancroft, "Colloid Chemistry and Electrochemistry."

W. A. Deane, "Settling Problems."

T. R. Briggs and W. J. Bartlett, "The Adsorption of Arsenious Oxide by Metastannic Acid and the Purification of Spent Electrolyte."

G. A. Hulett, "Graphitic Acid, a Colloidal Oxide of Carbon."

A. C. Fieldner, "Determination of Graphitic Carbon."

William C. Moore, "Selective Adsorption by Bacillus Pyocyaneus."

Guy Clinton, "A Criticism of Kohlrausch's Law of the Conductivity of Solutions."

H. D. Holler and L. M. Ritchie, "Hydrogen Ion Concentration in Dry Cells."

D. A. MacInnes, "The Reactions of the Lead Accumulator."

William Roy Mott, "Arc Images in Chemical Analysis."

FRIDAY, APRIL 9

Joint meeting with the American Institute of Electrical Engineers, W. D. Bancroft presiding.

Symposium (A.M.) on Electrically Produced Alloys:

H. E. Howe, "Fundamental Problems in Alloys Research."

R. J. Anderson, "Recent Developments in the Ferro-Alloy Industry."

C. B. Gibson, "The Manufacture of Ferro-Alloys in the Electric Furnace."

B. D. Saklatwalla, "Ferrovanadium."

Elwood Haynes, "Stellite."

F. A. Raven, "Properties of Ferrosilicon."

E. S. Bardwell, "Ferromanganese."

R. C. McKenna, "The Manufacture of High-Speed Steel in the Electric Furnace."

Alcan Hirsch, "Ferrocerium."

Theodore Swann, "Ferrozirconium."

B. G. Klugh, "Ferrophosphorus."

R. M. Major, "Nichrome and Other Special Alloys."

T. D. Yensen, "Electric Properties of Nickel-Iron Alloys."

M. A. Hunter, "Electrical Properties of Titanium Alloys."

C. F. Harding, "Nitrogen Fixation by the Silent Discharge."

Symposium (8:30 P.M.) on Power for Electrochemical Industries, President C. Townley of the A.I.E.E. presiding:

John L. Harper, "Power for Electrochemical Plants."

John A. Seede, "Automatic Control of Arc Furnace Electrodes."

H. A. Winne, "Reactors for Electric Furnace Circuits."

C. A. Winder, "Economies of the Power Situation."

E. A. Wilcox, "Electric Furnace Power From the Standpoint of the Central Station."

H. L. Hess, "The Electric Furnace and the Central Station."

C. T. Maynard, "Location of a New England Electrochemical Plant."

F. F. Fowler, "Water Powers of the Pacific Coast."

J. W. Beckman, "Power Development in Scandinavia."

W. G. Berlin, "Power Problems From the Standpoint of the Furnace Operator."

SATURDAY MORNING AT HARVARD UNIVERSITY

J. W. Richards, "The Soderberg Self-Baking Continuous Electrode."

C. A. Jeller, "Synthetic Electric Furnace Pig Iron."

Philip B. Short, "Step Induction Regulators for Electric Furnaces."

Clarence J. West, "The Electric Furnace as Applied to Metallurgy."

H. M. St. John, "The Electric Brass Furnace; Its Evolution."

L. B. Lindemuth, "The Electric Furnace in Iron and Steel Metallurgy."

Edward F. Kern, "Reduction of Manganiferous Silicate Slags."

INDUSTRIAL EXCURSIONS

Trips will be made to the Lynn Works of the General Electric Co., on Friday at 1:30 P.M., and to the Huff Electrostatic Separator Co., on Saturday afternoon.

An informal subscription dinner will be held Friday evening at the Copley-Plaza.

Spring Meeting of American Chemical Society

The following tentative general program has been prepared for the St. Louis meeting of the American Chemical Society, April 12 to 16.

MONDAY, APRIL 12

4 p.m., Council meeting.
7.30 p.m., Council dinner at the University Club.

TUESDAY, APRIL 13

10 a.m., General meeting, Hotel Statler.
Address of welcome, Mayor Henry W. Kiel.
Response, Dr. W. A. Noyes, president, A. C. S.
Address, the Hon. E. P. Costigan, Tariff Commissioner, "Chemical Industry and Legislation."
Address, Dr. Charles H. Herty, editor, "Victory and Its Responsibilities."
2 p.m., Hotel Statler, general meeting.
J. H. Hildebrand, "The Prediction of Solubility."
Victor Lenher, "Selenium Oxychloride a Neglected Inorganic Solvent."
E. T. Wherry, "Studying Plant Distribution With Hydrogen Ion Indicators."
Three additional general papers to be announced.
8 p.m., Liederkrantz Club. Smoker for men.
8 p.m., Theater party for ladies.

WEDNESDAY, APRIL 14

9 a.m., Hotel Statler, divisional meetings.
2 p.m., Hotel Statler, divisional meetings.
8 p.m., Central High School. Public address. Speaker and subject will appear in final program.

THURSDAY, APRIL 15

9 a.m., Hotel Statler, divisional meetings.
2 p.m., Excursions to Laclede Gas Works, Monsanto Chemical Works, East St. Louis plant, and Laclede-Christy Clay Products plant. Automobile tour for ladies to parks, Art Museum, Washington University, Missouri Botanical Garden, and tea at Bevo Mill.
8 p.m., Hotel Statler, subscription banquet.

FRIDAY, APRIL 16

9 a.m., Excursion to Standard Oil Refinery, Wood River, Ill., and Illinois Glass Co., Alton, Ill.

DIVISIONAL MEETINGS

The usual meetings will be held by all of the divisions except the Fertilizer Division. The Division of Industrial and Engineering Chemistry will hold a symposium on Cellulose Chemistry. The Sections of Leather Chemistry and Sugar Chemistry will meet for the first time. The Division of Physical and Inorganic Chemistry will devote a half day to a "Colloid Symposium." Programs for the divisional meetings are in process of preparation and details will be announced later.

EDWARD MALLINCKRODT, SR.
Honorary Chairman, Executive Committee

Meeting of Electric Furnace Association

Coincident with the meetings of the American Institute of Electrical Engineers and the American Electrochemical Society, there will be a meeting of the Electric Furnace Association, in Boston, April 8 to 10. The annual election and business meeting will be held on April 8. On one other day there will be a session on the proper training of operators of electric furnaces. The Association will meet with the two other societies mentioned above during their discussions on Electrically Produced Alloys and Power for Electrochemical Purposes. The combined program will be of particular interest to electric-furnace operators, inasmuch as subjects of such vital importance to the industry will be discussed. Indications are that there will be a good attendance of electric-furnace men at these sessions and that very excellent papers will be presented. During the meeting the headquarters of the Electric Furnace Association will be at the Copley-Plaza Hotel.

The Dye Industry of Great Britain

During the last year there has been considerable criticism by users of the range of dyes available either from British dye-manufacturing works or from the supplies which have been imported from Germany in fulfillment of the terms of the treaty of peace. These criticisms appear to arise from a fear that the British textile trade may be placed at a disadvantage in the markets of the world.

It is claimed that 80 per cent of the dyes now being used in Great Britain are of home production, but the total quantity available, even of the common grades, does not appear to be sufficient for the needs of the textile manufacturers, to say nothing of the high-class dyes. Prior to the war the highly organized German dye combine maintained in Great Britain large stocks of dyes from which immediate deliveries could be made. At the present time the British dye industry is making strenuous efforts to meet the demand, but is not able to keep a stock on hand for immediate delivery, as the dyes are sold even in advance of production and shipped direct from the plant.

For several months past there has been a great deal of anxiety on the part of dye manufacturers as to the future of the British dye industry, owing to the fact that certain high-class dyes which are very much needed in the textile and other trades are not produced in Great Britain. The fear of the possibility of the removal of the restrictions on the importation of German dyestuffs, or the necessity of the government taking some action to secure for the trade these high-class dyes, seems well founded, from the fact that it is now announced that a committee, representing all the industries using dyestuffs, is now in Germany for the purpose of purchasing such dyes as are required by the British consumers and is authorized to buy up to £2,000,000 worth of fine dyes.

The British Government is reported as taking no part in the financial arrangements, but has granted the necessary facilities for this committee to make these purchases. Any dyes that the committee may secure will be in addition to the 1,500 tons to which the British users are entitled under the reparation clause of the Peace Treaty.

Government Kelp Plant to Continue Operations

The House of Representatives has approved an appropriation of $192,000 "for the completion, operation, and maintenance of the Government kelp plant at Summerland, Cal." The following conclusions of the Department of Agriculture specialists have apparantly had much to do in influencing the House to grant the appropriation in face of persistent efforts to eliminate or reduce the appropriation:

(1) Results to date show definitely that the successful outcome of experiments is assured that byproducts will be developed which will more than carry the production cost of potash. This will enable kelp potash, then, to come into the market where freight rates are not prohibitive, in competition with potash from any other source.

(2) With a successful outcome assured, it would be unwise to discontinue the work and lose the credit which is bound to accrue to the Government through the successful prosecution of a problem undertaken in the face of so much criticism and one advertised so widely by its opponents as illogical and uneconomical.

(3) Its continuation from now on will be at a very slight and decreasing expense to the public, the proceeds from this year's production probably being about enough to equal expenditures and those from next year's operation probably more than equaling expenditures. That the enterprise will be self-sustaining within a short period seems assured.

(4) It should be borne in mind that at the completion of the work, with the results anticipated, the plant will be on a profitable basis and could be put on the market as a going concern earning a profit, and would yield a price accordingly. If it is sold before all the facts are demonstrated it would have to be sold as junk, and as such would yield only about a third of what it would yield otherwise. If sold as a going concern, however, it would yield not less than $100,000.

It is easy to see, therefore, that if we keep going until the work is completed, the net profit to the Government will be greater than if the work were discontinued at the end of the present year.

(5) Since it has been demonstrated that not less than 500,000 tons per annum of raw kelp are available in the vicinity of Summerland, it is to be assumed that when it is demonstrated what profits are obtainable from the treatment of kelp by the process developed here plants will be established sufficient in capacity to utilize the raw material available. We may with confidence, therefore, look forward to the establishment ultimately of an industry in this part of the State of California which will yield the products obtainable from this quantity of kelp and of an annual value of over $7,000,000. This estimate does not take into consideration the equally large industry which may be founded additionally on the kelps of Puget Sound and Alaska. The profit to the public, therefore, from the successful outcome of these experiments seems to be beyond question, and certainly would seem to justify a continuation of the slight net expense to the public now being incurred in this work.

Bureau of Chemistry Appropriation

As reported to the Senate, the agricultural appropriation bill carries $1,393,591 for the Bureau of Chemistry. This is $72,000 more than the total of the appropriations allowed in the bill passed by the House.

The bulk of the increase was allowed on items providing funds for conducting the investigations relating to the application of chemistry to agriculture; for the work connected with the food and drug act and for the investigation of chemical problems relating to insecticides and fungicides. An increase also was allowed to the Bureau of Soils for that portion of its work having to do with chemical properties of soils. The appropriation for that purpose as recommended by the Senate committee is $25,610.

A fund of $36,840 is provided for exploration and investigation within the United States to determine possible sources of potash, nitrates and other natural fertilizers.

Forest Products Laboratory Appropriation

In the agricultural appropriation bill which has been reported out by the Senate committee, the appropriation to be used at the Madison (Wis.) Laboratory of the Forest Service is increased from $173,260, allowed by the House, to $223,260. This money is to be expended for investigations of methods for wood distillation and for the preservative treatment of timber; for timber testing and for testing of such woods as may require test to ascertain if they be suitable for making paper; for investigations and tests of foreign woods of commercial importance to industries in the United States and for other investigations and experiments; to promote economy in the use of forest products and for commercial demonstration of improved methods or processes in co-operation with individuals and companies.

Meeting of American Section, S. C. I.

On Friday, March 19, there was an unusually large attendance at the monthly meeting of the American Section of the Society of Chemical Industry at the Chemists' Club. Chairman Charles E. Sholes submitted the following nominations for officers, which were approved and ordered forwarded to London for final approval: Sumner R. Church, chairman; F. C. R. Hemingway, treasurer; Allen Rogers, secretary; committee: Charles E. Sholes, Ralph H. McKee, Wallace P. Cohoe, D. D. Jackson, H. G. Carrell.

The opening paper by Bruce Silver consisted mainly of slides gathered by the author in a recent tour through the American petroleum fields. Moving picture reels furnished by the Standard Oil Co. were used in conclusion, giving the audience an excellent mental picture of the industry.

Speaking on the subject of "The Manufacture of Rare Chemicals," Dr. C. E. Kenneth Mees reviewed the progress in this country in the manufacture of organic reagents required for industrial and university research laboratories. Chemicals of this class were imported almost exclusively before the war and the shutting off of imports, coupled with the sudden development of the synthetic organic industries, created a situation which rapidly became acute. To meet the increasing demand, Dr. Derrick and later Dr. Roger Adams at the University of Illinois set some of the graduate students in organic chemistry to work on the problem during the summer vacation. The venture was so successful and the development so rapid that it soon became necessary for an industrial firm to take over the production of these small-scale products and also to engage in the purification for research work of certain of the technical organic chemicals which were beginning to appear on the market. This phase of the work was taken up by the Eastman Kodak Co., which now acts as distributing agent for these research chemicals. This requires the keeping of small stocks of a large number of chemicals, which means a large financial investment in proportion to the turnover. Thus, a $50,000 stock would be required for a turnover of about $20,000 a year. Over six hundred chemicals are now available and the list is being rapidly extended.

Much of the work is being done in an improvised laboratory which, judging from the view shown, has reached its productive limit. A larger laboratory will be established in the near future.

Senate Hearings on Fixed Nitrogen Corporation Bill

Senate hearings on the bill to establish the United States Fixed Nitrogen Corporation for the purpose of purchasing and operating the nitrate plants at Muscle Shoals were scheduled to begin before the Committee on Agriculture on March 22. The bill proposes the organization of a corporation, all the capital stock of which shall be owned by the Government. Evidence probably will be introduced to show that the plants should be operated and that such operation should be conducted by the Government through a special corporation rather than by private interests. Among those who may appear before the committee are Secretary Baker, George J. Roberts, Alfred H. White, Arthur B. Lamb, Colonel Burns, Colonel Joyes and Major Gaillard.

Investigation of Fuel-Oil Fire Hazards

Owing to widely divergent views as to the fairness of the tentative fuel oil regulations recently issued by the National Fire Protection Association, E. A. Barrier, chairman of the committee on inflammable liquids of that association, has deemed it advisable to institute immediately a thorough investigation throughout the fuel oil-consuming centers of the country and to gather first-hand information relative to the existing conditions prevalent with regard to fire protection and fire hazards.

Mr. Barrier has asked for the co-operation of the American Petroleum Institute in connection with this important subject. Therefore, it has been decided to engage the services of C. F. Reuter, who was formerly associated with the Tidewater Oil Co's engineering department, to represent the American Petroleum Institute and to accompany F. O. Aspinwall, who was appointed by the National Fire Protection Association to represent the interests of the insurance companies in this investigation.

Considerable significance is attached to the results of this investigation, which will probably cover a period of six weeks. Upon ascertaining the true condition as to fire hazards in the storage and use of fuel oil, it is hoped that the present regulations will be modified so as to possess nothing of a discriminatory character, yet at the same time to conform to established good practice in providing proper safeguards against the danger of fire and accident.

A Grant for Research

The American Pharmaceutical Association has available a sum amounting to about $450 which will be expended after Oct. 1, 1920, for the encouragement of research. This amount, either in full or fractions, will be awarded in such manner as will in the judgment of the association's research committee produce the greatest good to American pharmaceutical research. Investigators desiring financial aid in their work will communicate before May 1 with H. V. Arny, chairman A. Ph. A. research committee, 115 West 68th St., New York, giving their past record and outlining the particular line of work for which the grant is desired. The committee will give each application its careful attention and will make recommendations to the association at its meeting in Washington, May 3 to 8, 1920, when the award or awards will be made.

Revised Text of Federal Reserve Act Issued

A book containing the Federal Reserve act, revised to include all amendments to Dec. 24, 1919, has been issued by the National Bank of Commerce in New York. The volume is prepared for reference purposes, being fully indexed and provided with marginal annotations. Several of the amendments are particularly significant in connection with recent international developments affecting American banking, such as the Edge act and sections relating to the investment by national banks in foreign banking and financing corporations organized under Federal or state laws.

Platinum at Goodsprings, Nevada

The Boss mine at Goodsprings, Nev., which so far as known is the only lode mine on the continent in which platinum is found, shipped $22,365 worth of platinum-bearing ore during 1919.

Electrolytic Zinc Plant of the Judge Mining & Smelting Co.

A Description of the Treatment of Table and Jig Concentrates at Park City, Utah—Leaching—Purification of the Solution—Electrolytic Plant Installation and Operation—Power Consumed—Daily Production Capacity

By L. W. CHAPMAN

THE electrolytic zinc plant of the Judge Mining & Smelting Co., at Park City, Utah, is designed to treat concentrates obtained from a sulphide ore containing zinc, lead and silver. In their concentrator a lead concentrate and a zinc concentrate are obtained. The lead concentrate is shipped and smelted. The zinc concentrate is treated in the plant for the recovery of zinc and the zinc-plant residue is shipped and smelted for the recovery of the silver and lead. This briefly is an outline of the treatment of the ore. The removal in the mill of a large portion of the zinc from the ores produces a concentrate which can be economically smelted for the recovery of the lead and the silver. Previous to the construction of the electrolytic zinc plant a zinc concentrate had been obtained, which was sold to smelters.

Treatment of the Concentrate

The concentrate treated in the zinc plant contains about 38 per cent Zn, 3 to 5 per cent Pb, and 9 to 10 oz. Ag per ton, with small amounts of copper, cadmium, antimony, manganese and arsenic. Concentrates will average about 30 per cent sulphur and 8 per cent iron. Two grades of concentrates are delivered to the zinc plant—a table product and a jig product. These are kept separate, as the jig concentrate is too coarse to give satisfactory recovery of zinc without grinding. The jig product is dried in a cylindrical drier and ground in a Hardinge ball-mill to pass 60 mesh, this size being obtained without screening the product with the return of oversize to the mill. The table concentrate is somewhat coarser than the Hardinge mill product, about 20 per cent being retained on a 60-mesh screen.

Concentrates are roasted in a 25-ft. seven-hearth Wedge roaster which is fired on the sixth hearth by two coal-fired combustion chambers located at opposite ends of a diameter of the roaster. The seventh hearth is used to cool the calcine somewhat before being delivered to a Baker cooler. The roasting operation produces a calcine containing a relatively small amount of insoluble zinc ferrate, most of the insoluble zinc being present as sulphide. Details of the roasting operation, together with data obtained from experiments with this roaster have been published by C. A. Hansen.[1]

Method of Feeding

The product from the Hardinge mill is elevated by a bucket elevator and fed directly onto the top or drying hearth of the Wedge roaster by means of a belt conveyor. The table concentrates are also elevated by a bucket elevator, but are transferred to a feed hopper by a belt conveyor. Below the discharge spout of the feed hopper, at a distance of approximately 6 in., is a horizontal iron plate which prevents the flow of material from the hopper. Adjustable scrapers are bolted to each of the four rake arms of the drying hearth, and these scrape a definite amount of concentrates from the plate onto the hearth. This method of feeding is simple in detail and, although the amount of feed varies somewhat with the moisture content of the concentrate for a given set of scrapers, has operated satisfactorily.

Leaching Operation

Hot calcine flows by gravity from the roaster to a 5 x 12-ft. Baker cooler and from the cooler is transferred by a belt conveyor to a 400-ton storage bin. From this storage bin the calcine is elevated by a hoist to feed bins located above Pachuca tanks. There are two of these tanks, 14 ft. in diameter and 30 ft. in height, made of 3-in. redwood, each holding about 100 tons of solution. In conducting the leaching operation, the Pachucas are filled by gravity with acid electrolyte from storage tanks, together with sufficient sulphuric acid to make up for the loss sustained in neutralization and subsequent operations. The quantity of acid in the tank is determined from the analysis of the solution and an amount of calcine added which is calculated to reduce the acidity of the solution to about 3 g. H_2SO_4 per liter. In addition to zinc, small amounts of copper, cadmium and antimony are dissolved, and these must be removed before the solution is electrolized. As the first step in the purification process iron sulphate is added in the Pachucas sufficient to bring the iron contents to about 0.3 g. per liter. Pulverized lime rock is then added, with further agitation, and the remaining acid completely neutralized. This effects a complete precipitation of the iron and a practically complete precipitation of the antimony and arsenic. The leaching cycle requires from 8 to 10 hr.

Separation of the Sand and Slime

A centrifugal sand pump delivers the neutral pulp from the Pachucas to a No. 7 drag classifier. The sand from the classifier is delivered to a storage bin, the overflow to a 30-ft. Dorr thickener. The overflow of the Dorr is clear solution and is pumped to the purifying Pachucas, the spigot product from the Dorr is filtered and washed on an 11½ x 6-ft. Oliver filter. Oliver cake is delivered to a storage bin and the filtrate pumped to the purifying Pachuca containing the overflow from the Dorr.

The sand from the classifier and the filter cake contain the silver and lead from the concentrate together with the insoluble zinc and the soluble zinc which has not been removed by washing. This residue is shipped to smelters for the recovery of the silver and lead, as previously mentioned. The sand and slimes together are about half the bulk of the original concentrates. The slimes will carry 10 to 12 per cent zinc and the sand 15 to 20 per cent zinc, and together will assay about 12 per cent lead and 20 oz. silver per ton. It is not possible to

[1] "Electrolytic Zinc," by C. A. Hansen, *Trans.*, A. I. M. E., 1919, pp. 1,247-1,281.

wash the Oliver cake or the sands free from zinc sulphate, and a loss of both zinc and sulphuric acid results. This makes it necessary to add about 70 lb. of 50 deg. acid to the Pachucas for each ton of zinc produced.

Purification of the Solution

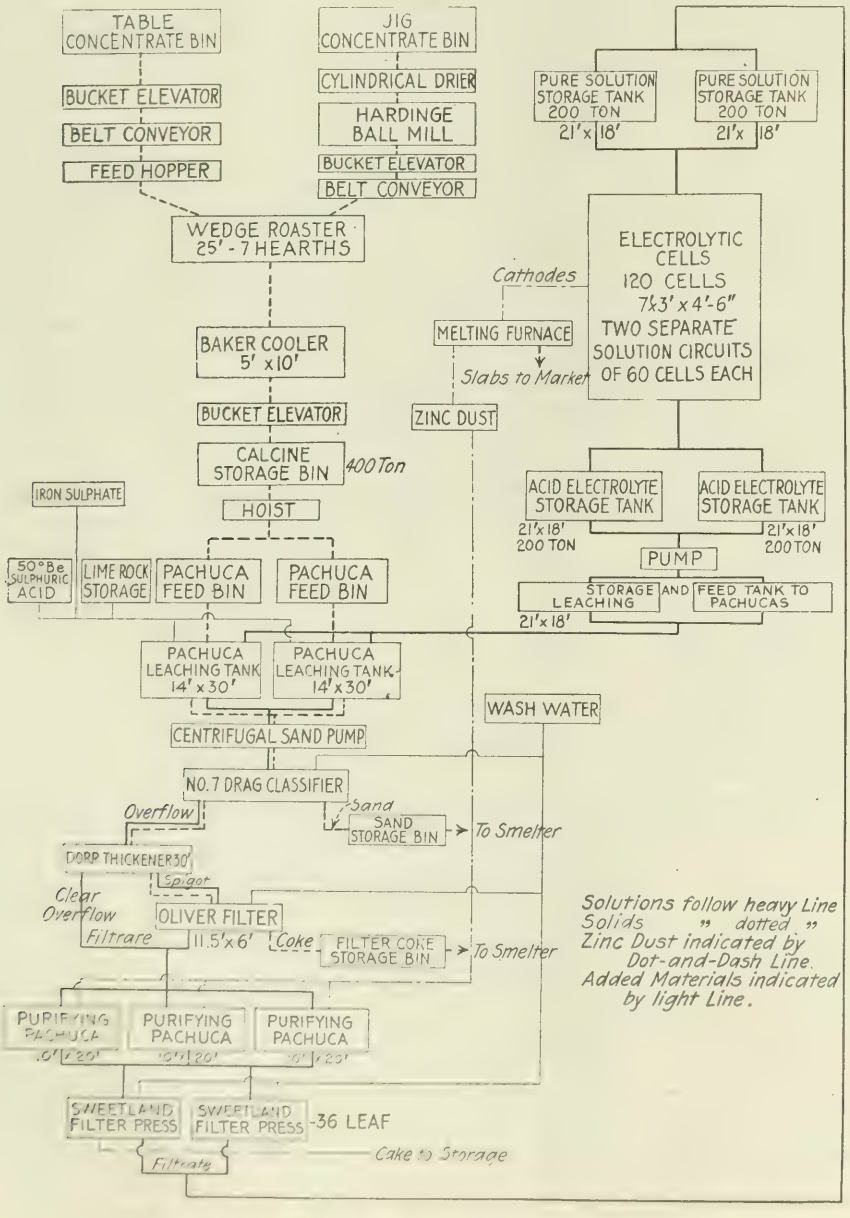
Purification of the solution is carried out in Pachucas by agitation with zinc dust. There are three of these tanks, 10 ft. in diameter x 20 ft. in height, made of 2-in. redwood, each having a capacity of about fifteen tons of solution. The Pachucas are filled with solution and the zinc dust is added in small batches. The quantity of zinc dust needed, the rate of addition and the time required for this operation are determined by the amount of impurities present in solution, but the operation is usually complete in from 20 to 30 min. In this operation all but minute traces of copper and cadmium and also any traces of antimony and arsenic that may have escaped precipitation simultaneously with the iron in the agitation tanks are removed.

Purified solution is filtered in either one of two Sweetland presses and the zinc-copper-cadmium sludge removed. These presses have 36 leaves, each 3½ ft. in diameter. Sweetland filter cake is stored, but a method for the recovery of the metals from the cake which contains 40 to 50 per cent Zn, 4 to 7 per cent Cu and 3 to 6 per cent Cd has recently been developed. The filtrate from the Sweetland presses is pumped to either of two 200-ton solution-storage tanks, from which it is run directly to the electrolytic cells as required. The average analysis of the purified solution is as follows, in grams per liter: Zn, 60; Cd, 0.004; Cu, 0.003; Mn, 0.4; Sb, 0.001; As, trace.

Electrolytic Cell Room

The electrolytic cell room contains 120 tanks. The tanks are arranged in cascade. Five tanks, which constitute a cascade, are placed end to end, the difference in elevation between tanks being 3 in. Two cascades of tanks are placed side by side, forming a bank of ten tanks. There are six of these banks across the cell room with aisles between and between the outside banks and the walls of the cell room. There are two of these sections of sixty tanks down the cell room with a wide aisle between the two sections and below the lower section providing ample room for stripping of cathodes.

Solution from the storage tanks is run into the head tank of each cascade, the flow being parallel throughout a section, each of which is provided with separate solution supply lines. Each section of sixty tanks also forms one electric circuit, the individual tanks of the section being connected in series.

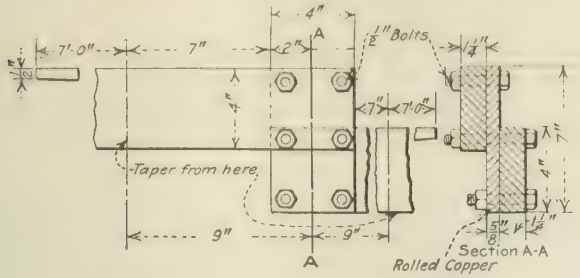


FLOW-SHEET, JUDGE ELECTROLYTIC ZINC PLANT

Design of the Tanks

The tanks are of standard design and are made from 2-in. redwood, and are 7 ft. long, 3 ft. wide and 4½ ft. deep. The overflow chute is made of chemical sheet-lead and is supported on a wooden bracket. The solution level in the tank is 2 in. below the top of the side walls. The chute clears the top of the next tank in the cascade by 1 in. and delivers the solution about 2 in. beyond the inner edge of this tank. Each tank is provided with a cooling coil installed in an upright position at the inlet end. The coil is made from 45 ft. of 1-in. chemical lead pipe, there being five 4-ft. loops to a coil. The solution is delivered to the head tank of the cascade from the storage tanks through iron pipes and the amount of flow controlled by gate valves. Provision is also made to run fresh solution to each tank if desired. The acid electrolyte from the lowest tank in the cascade flows into a lead pipe and thence by gravity to either of two 200-ton storage tanks located outside the building. From these tanks the solution is pumped by a centrifugal pump, with a closed bronze runner, to the supply tanks located above the agitating Pachucas and runs from these supply tanks to the Pachucas by gravity, thus completing the cycle.

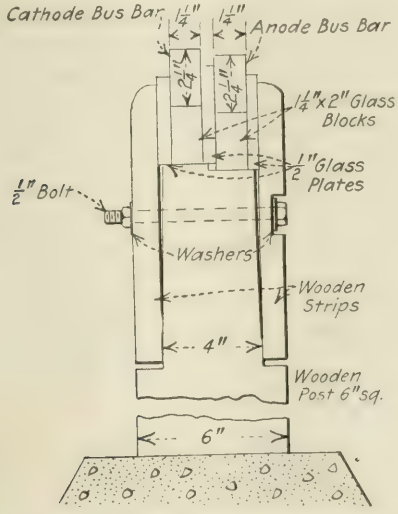
Anode and cathode busbars are both put on the side of the tank next to the aisle and are supported free from the tank by three 6 x 6-in. wooden posts carried down to separate concrete piers. Advantage is taken of the fact that the amount of current carried by the busbars decreases with each anode contact and increases with each cathode contact to effect a considerable saving of copper; the busbars are therefore tapered from ½ in. at the free end to 4 in. at the other, where connections are



DETAILS OF BUSBAR CONNECTION

made to the bus of the next tank. The maximum cross-section of the busbars is 1¼ in. x 4 in. They are made from rolled copper and supported with the long dimension of the cross-section vertical, the anode bus being on the inside next to the tank and ¼ in. lower than the cathode bus. The busbars are insulated from each other and from the guides of the wooden support by means of glass insulators ½ in. in thickness. The weight of the bus is carried upon glass blocks 1¼ in. in thickness.

The connection between busbars is made by means of a plate of rolled copper ⅝ x 4 in. in cross-section. This plate is bolted to the inside of the cathode bus and to the

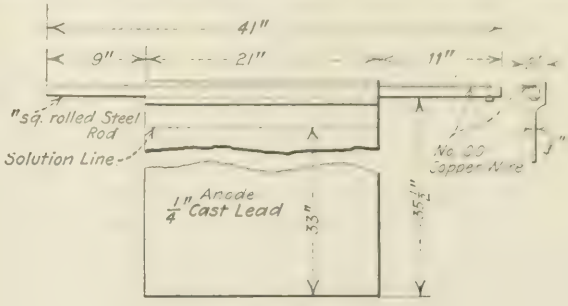


DETAILS OF BUSBAR SUPPORT

outside of the anode bus. The difference in elevation of the tanks of 3 in. makes it possible to have the top bolt holes of the lower or anode bus register with the bottom bolt holes of the top or cathode bus, the two bars and the connecting strip being bolted together with two ½ in. bolts. Two bolts secure the connecting strip to the cathode bus at the top of this strip and two bolts secure the connecting strip to the anode bus at the bottom.

THE ANODES

Anodes are made of chemical sheet lead ¼ in. thick, the area immersed being 21 in. wide x 33 in. deep. The anodes hang vertically in the tank, and are supported by 1-in. square rolled steel rods and weigh about 100 lb., complete. The supporting rod is 41 in. long and extends 9 in. beyond the edge of the anode on one side, being supported by a wood strip resting on the top of the inner wall of the tank and 11 in. on the other in order to clear the top of the outer wall of the tank and rest on the anode bus. The anode was originally supported by being cast around the rod. Electrical contact was provided by sweating the lead to the rod. This method has not proved satisfactory in operation due to the fact that zinc sulphate will creep in between the lead and the rod, causing a poor contact. This resulted in a very decided increase in electrical resistance which caused heating

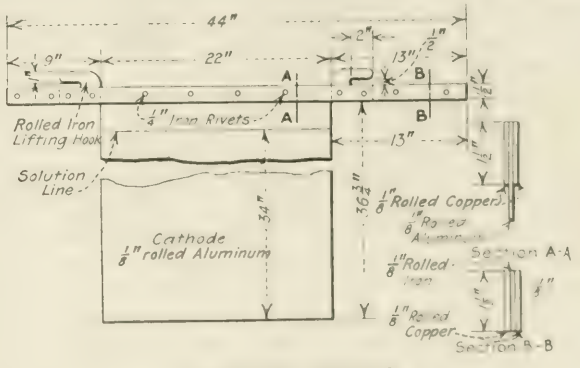


ANODE DETAILS

and further disintegration. The defect has been overcome by burning into the lead above the steel rod a length of tinned No. 00 copper wire. A hole is drilled through the iron bar where contact is made with the anode bus and the copper wire passed through this hole and riveted on the under side. This provides a copper circuit from the anode bus to the lead plate.

THE CATHODES

Cathodes are made of best rolled sheet aluminum, ⅛ in. in thickness. The immersed area is 22 in. wide x 34 in. deep. The cathode rod is made from two strips of rolled copper, ⅛ in. thick x 1½ in. wide x 44 in. long. These are riveted together with the aluminum sheet between. The rod extends 9 in. beyond the aluminum sheet on one side, being supported on the same wood strip on which the anode rod rests, and 13 in. on the other so as to clear



CATHODE DETAILS

the top of the outer wall of the tank and the anode bus and rest on the cathode bus. An iron lug is riveted between the copper strips at each edge of the aluminum sheet, forming a hook by which the cathodes are removed from the tank for stripping. The remaining space between the copper strips at each end is filled with an iron strip and the three strips are riveted together.

In each tank are nineteen anodes and eighteen cathodes which are spaced 2 in. center to center. The im-

mersed cathode area is 203.5 sq.ft. and the effective immersed anode area is 173.25 sq.ft. per tank. With a current of 5,000 amp. the density per sq.ft. of cathode area is therefore 24.5 amp. This current density was chosen as the most economical under operating conditions. The higher the current density the greater the cathode production per kw.-hr., since the resistance of the solution is practically constant for all densities. Too high a current density will, however, produce a poor cathode deposit with a resulting decrease in the current efficiency due to re-solution of the deposited zinc by the acid in the electrolyte. The amount of zinc re-dissolved is increased by rough and non-coherent deposits. The rate of flow of solution through the tanks is such that the acidity of the electrolyte leaving the last tank in the cascade is about 60 g. per liter. This acidity was also chosen as the most economical under operating conditions. The higher the acidity of the solution the greater the amount of deposited zinc dissolved, with the result that there is a decrease in the current efficiency. There are other factors, of course, to be taken into consideration in determining the most economical current density to use in relation to the amount of free acid and zinc sulphate in the effluent solution; such as the cost of cooling the solutions, the cost of power, the market price of zinc, the problem being complicated because these factors are interdependent. The voltage drop per cell will vary from about 3.7 volts in the head cell to 3.3 volts in the last cell in the cascade, the average being about 3.5 volts.

The effect of the electrolysis upon the solution is shown in Table I. It is to be noted that about 20 g. per liter of Zn remains in solution, this amount being carried through the cycle.

TABLE I. EFFECT OF ELECTROLYSIS

	Grams per Liter					
	Zn	H_2SO_4	Cd	Cu	Sb	Mn
Feed to head cell.....	59.5	0.2	0.003	0.0006	0.0010	0.415
Overflow from tail cell...	21.7	58.1	Trace	0.0003	0.0007	0.035

Manganese is deposited at the anodes as dioxide. The deposit is, however, non-coherent and all but a thin film which adheres to the anode settles to the bottom of the tanks. The tanks are cleaned of this mud about once a month; at present no use is made of this product. The solution flows directly through the tanks. It is not necessary to admit the solution near the bottom at one end of the tank with the overflow from the top at the other, or vice versa, since evolution of gas from the anode suffices to prevent stratification of the solution.

The cathodes are removed from the tanks and stripped of the deposited zinc every 48 hr., the average weight deposited per tank being about 515 lb. The smooth crystalline deposit on the cathode sheets is about $\frac{1}{8}$ in. in thickness. The cathodes are lifted from the tanks by means of a lifting frame attached to a 1-ton chain fall which runs on an overhead trolley. The lifting frame has two side-pieces made from 1½-in. angle iron and cross-braced, the toes of the angle-iron being horizontal and directed inward. V-shaped notches are cut in the toe, spaced 4 in. center to center; when the frame is lowered these notches permit the toe of the angle-iron to be slipped endwise under the lugs on the cathodes. The lifting frame removes six cathodes at one time. The cathodes are conveyed by the trolley to the aisle at the end of the section and deposited in a portable stripping frame, where the wooden side strips are removed and the deposited zinc is stripped from the aluminum sheet. The cathodes are thoroughly cleaned, dry wooden side-strips are put on each edge and are then replaced in the tank. These side-strips are made from a $\frac{3}{4}$-in. square strip of wood, 36 in. long, with an $\frac{1}{8}$-in. slot $\frac{1}{4}$-in. deep cut along one side. The wooden strips extend the full length of the cathode sheet and slip tightly over the aluminum sheet and are thus held in place. Side-strips are necessary for the convenient removal of the deposit, and also prevent the formation of irregular deposits at the edge of the sheets.

Cathodes are then melted in a coal-fired reverberatory melting furnace and cast into standard sized slabs for the market. The average analysis of the refined zinc is Zn, 99.930; Fe, 0.005; Pb, 0.038, and Cd, 0.027 per cent.

Power

The power for operating the plant is purchased from the Utah Light & Power Co. and is delivered to an outdoor transformer station at 40,000 volts, there being three independent sources of supply. The voltage is transformed to 2,300 volts for the synchronous motors and to 440 volts for miscellaneous power uses about the plant, such as operating the air compressors which supply air to the Pachucas, operating the sand and solution pumps and calcine elevators.

Direct current is generated for the tank room by two motor generator sets driven by synchronous motors, the generators being rated at 5,000 amp. at 215 volts. The switchboard installation is arranged so that either generator can be used to supply current to either section of sixty tanks. Provision is made for forced ventilation of the motor generator room by washed air.

Production

The plant was one of the first electrolytic zinc plants to be put into operation and was designed to produce fifteen tons of zinc per day, but under operating conditions that have developed the plant will require enlargement in some departments to attain this tonnage. The Wedge roaster will supply sufficient calcine for not more than nine tons of zinc and additional agitating Pachucas will also be needed in order to obtain the rated capacity. It is interesting to note that the original cells in this plant were designed to use the rotating cathodes that were developed at Bully Hill, but that with the development of the process, particularly in the purification of the solution for electrolysis, it was found to be advantageous to install new tanks and to use stationary cathodes.

Acknowledgments

Thanks are due to G. W. Lambourne, of the Judge Mining & Smelting Co., for permission to publish these notes, and to John T. Ellsmith for courteously assisting in the collection of the material at Park City.

Marking of Imported Goods

A Federal proclamation has been issued in Australia prohibiting the importation, except with the consent of the Minister of Trade and Customs, of all articles to which or to the coverings of which there is applied any marking in a language other than the language ordinarily used by the people of the country of origin, unless there is also applied to such articles or to their coverings a definite qualifying statement in the English language indicating the country in which the articles were made or produced.

The History of Mustard Gas

By Clarence J. West

THE discovery and commercial perfection of the reaction between ethylene and sulphur chloride is being aired in the controversy (*J. Soc. Chem. Ind.*, vol. 38, pp. 344R, 363R, 432R, 451R, 469R) which has grown out of an attempt on the part of Dr. H. Levinstein (*J. Soc. Chem. Ind.*, vol. 38, p. 248T) to defend the German Chemical Service against the criticism of Sir William Pope (*J. Chem. Soc.*, vol. 115, p. 397; 1919) that the service was inefficient because of the method employed for the early manufacture of mustard gas. There is no attempt to question the loyalty of Dr. Levinstein or of the men associated with him, for their services in the great war place that beyond doubt. The questions at issue appear to be to whom credit should be given for the discovery of the reaction and how much credit is due to each party for its commercial development. There also seems to be a fear on the part of our British allies that America claims the reaction as her own, from a statement in Dorsey's article (*J. Ind. Eng. Chem.*, vol. 11, p. 281; 1919). It has been clearly recognized all through the war that we were indebted to the British for the information, not only regarding this but many other processes and developments. If full credit has not been given it is not because of any desire on our part to claim things not our own. A further question, which must be settled in the laboratory, involves the chemistry of mustard gas, and in particular its reaction with sulphur chloride.

Chlorhydrin Process

The early method of preparation of mustard gas, used both by the Allies and by the Germans, was based upon the reaction as published by Victor Meyer in 1886 (*Ber.*, vol. 19, p. 3,260) and further studied by Clarke (*J. Chem. Soc.*, vol. 101, p. 1,583; 1912). This consisted in the formation of dihydroxyethyl sulphide by the interaction of sodium sulphide and ethylene chlorhydrin:

$$2ClCH_2CH_2OH + Na_2S = (HOCH_2CH_2)_2S + 2NaCl,$$

and the subsequent reaction with HCl or thionyl chloride:

$$(HOCH_2CH_2)_2S + 2HCl = (ClCH_2CH_2)_2S + 2H_2O.$$

This method was adopted because analyses of German duds showed fairly conclusively that Germany was manufacturing its mustard gas in this way. English and American chemists, therefore, spent several months in improving and adapting Meyer's method to commercial operation. (See, for example, Gomberg, *J. Am. Chem. Soc.*, vol. 41, p. 1,414; 1919.) First of all, a method had to be developed for the large-scale production of ethylene. This was successfully solved by the British through the use of alcohol vapor and heated phosphoric acid (Newth, *J. Chem. Soc.*, vol. 79, p. 915; 1901; Pope, *J. Soc. Chem. Ind.*, vol. 38, p. 345R; 1919). The Americans found that passing a mixture of alcohol and water vapors over kaolin heated to 500-600 deg. C. gave a satisfactory yield of a very pure product (Dorsey, (*J. Ind. Eng. Chem.*, vol. 11, p. 288; 1919). The second step, the production of ethylene chlorhydrin by the reaction of ethylene, chlorine and water, was less successful. Confidential information from British sources show that Irvine developed a catalyzer for the reaction that was fairly satisfactory. Gomberg was able to work out a satisfactory laboratory method and condition for purification which offered commercial possibilities, but at that time the need no longer existed. The other steps offered little difficulty, but everyone is convinced that, as Dorsey states, "the process used by Meyer, namely, the chlorhydrin procedure, proved to be unsatisfactory for huge-scale production." Fortunately, through the efforts of Pope and Levinstein, the method was not needed.

Ethylene-Sulphur Chloride Reaction

The early history of the reaction between the sulphur chlorides and ethylene (the reaction which is the subject of the controversy) is very unsatisfactory. It appears that Despretz (*Ann. chem. phys.*, vol. 22, p. 428) observed the formation of a disagreeably smelling fluid by the reaction of ethylene upon sulphur chloride. Niemann (*Ann.*, vol. 113, p. 288; 1860) obtained a product which he believed to be the disulphide, $(C_2H_4)_2S_2Cl_2$, by the action of ethylene upon a mixture of the two sulphur chlorides ("brown" sulphur chloride), of which he says:

"The characteristic property of this oil is also a very dangerous one. It consists in the fact that the minutest trace which may accidentally come in contact with any portion of the skin, though at first causing no pain, produces in the course of a few hours a reddening and on the following day a severe blister which suppurates for a long time and is very difficult to heal."

The same year Guthrie (*Quart. J. Chem. Soc.*, vol. 12, p. 117; 1860) studied the reaction of ethylene upon sulphur dichloride, and the following year the reaction with sulphur monochloride. Since he allowed the ethylene to remain in contact with the chloride for 20 hr. at 100 deg., it is very unlikely that he had any mustard gas. This is supported by the fact that the product was non-toxic and produced only a slight soreness when placed beneath the tongue. From the experiments carried out by the Chemical Welfare Service, it is very doubtful whether Green is correct in his statement that "mustard gas can be produced of satisfactory purity and in good yield by reacting ethylene with sulphur monochloride at a temperature which is never below 100 deg. throughout the whole reaction." This is the experience of Pope, who reports that at a temperature above 65 deg. practically no mustard gas is formed. On the other hand, Green is undoubtedly right in his contention that pure mustard gas is not materially attacked by sulphur chloride. These facts are probably explained by the formation of an intermediate compound of ethylene and sulphur chloride as observed by Conant (See *J. Am. Chem. Soc.*, vol. 42, p. 585; 1920).

This reaction was next studied by Spring (*Bull.*, vol. 48, p. 629), who ascribed to the product the formula

$$ClCH_2CH_2S\text{-}SCH_2CH_2Cl.$$

Failure of the Sulphur Dichloride Process

The possibility of preparing mustard gas by the reaction of ethylene and sulphur dichloride was suggested in America in 1917. Several laboratories (unpublished reports, Bureau of Mines) tried the reaction, but obtained a compound containing three chlorine atoms. This is perfectly clear in view of the studies of the behavior of pure mustard gas or its solutions with sulphur dichloride; a chlorinated mustard gas results, which has about the same boiling point as pure mustard gas, but which is practically lacking in vesicant properties. The reaction was therefore dropped for the time and all energies were concentrated on the chlorhydrin method.

In January, 1918, a cablegram was received by the

American Gas Service to the effect that Pope had succeeded in preparing mustard gas from ethylene and sulphur dichloride. In spite of very careful trials the method could not be duplicated by the American University. It was natural that attention should be turned to the monochloride, and the day previous to the receipt of a cable from England to the effect that Pope had successfully carried out the reaction, the experiment was started by Conant. There is thus no question as to Pope's claim to the reaction. Green has made much of the fact that the reaction is not entirely novel, as Pope claims, and in this he is probably justified. The reaction is recorded in the literature and in Beilstein. Credit is due him, however, not only for calling attention to this reaction but in showing that, on a laboratory scale, the reaction was very simple and gave a mustard gas in good yield and of sufficient purity so that it appeared perfectly feasible to proceed with a commercial development. All the world now realizes how much this meant to gas warfare.

Laboratory Method Modified in Factory

Every one who has attempted to place a laboratory reaction into commercial production will sympathize with the attitude that Green takes [*J. Soc. Chem. Ind.*, vol. 38, p. 363R] regarding the amount of research necessary. It should be a well-recognized fact that no laboratory method is directly applicable to factory conditions, and further, that in a large number of cases the conditions of operation may entirely change as the result of experience gained in the factory. It is not surprising, therefore, that Levinstein, Ltd., having the fundamental idea as developed by Pope, should be able so to modify the reaction conditions that a superior working method and product should result. Had Pope followed the method into factory production, which he did not do, he probably would have made the same observations.

The reaction was also studied on a small and large scale by the American Chemical Warfare Service, and while it was able to work out a satisfactory process, it was very glad to adopt the Levinstein "reactor" as soon as it was demonstrated; and in all reports, the American chemist was very careful to refer to it as Levinstein's process.

Williams [*J. Soc. Chem. Ind.*, vol. 38, p. 451R] calls attention to the fact that the H. M. Factory, Avonmouth, was also concerned in the development of Pope's reaction on a commercial scale, but it apparently did not accomplish the elimination of sulphur deposition, though it was recognized as an evil to be overcome.

According to Pope, England seems to have suffered from a lack of co-ordination of "scientific advisers" and technical men. Apparently all the scientific men were not consulted in the matter of the best method to be employed, although we believe that such men as Irvine were intimately connected with the early history of mustard gas. It must not be supposed, however, that their scientific advisers did not make use of their opportunities. Mention of mustard gas, of the new synthesis of diphenylchlorarsine and the discovery of D.M. is sufficient to show how very valuable their services were to gas warfare in general.

America was fortunate in that all of her chemists worked together and that finally a very complete organization was built up in the Chemical Warfare Service through the efforts of Major General Sibert. The success of this organization is evidenced by the gas program planned for the year 1918-1919.

May we not then give Sir William Pope the credit for having called attention to the one satisfactory method of preparing mustard gas, and for the laboratory demonstration of this reaction, and to the technical chemists of England and America, and especially to Levinstein, Ltd., for having surmounted the many factory difficulties in putting the reaction into the plant, and finally to the men of the Chemical Warfare Service of all countries for their faithfulness under conditions not always agreeable in its actual manufacture?

Current Activities of the Bureau of Mines Stations

THE investigations conducted at the various stations of the Bureau of Mines are of interest in that they reflect the problems that are confronting the mineral industries and the trend of metallurgical developments in this country.

Berkeley (Cal.) Station

The Berkeley Station is investigating the reaction between silver chloride and water vapor and between metallic silver and hydrochloric acid. This is in connection with the volatilization of the chlorides of silver, copper, lead and zinc as a means of recovering these metals from ores that are not amenable to usual metallurgical methods. This latter problem is being studied in detail by the metallurgists at the Salt Lake City Station. The Berkeley Station is also working in co-operation with the Northwest Magnesite Co. on the problem of producing caustic magnesite from deposits which occur in the Western States. It has first been necessary to standardize and improve technical methods of analysis and to perfect an exact method for the determination of calcium. Work is also being done to determine the effect of the time-temperature-size-of-particle factors in the calcination of magnesite and in determining the tensile strength of magnesian mortars.

Bartlesville (Okla.) Station

The work at the Bartlesville Station is primarily in connection with the problems related to the production and refining of petroleum and natural gas. The losses due to evaporation in the storage of oils are being studied in the Oklahoma, Texas and California fields. The reduction of the loss is of importance in view of the increasing demand for gasoline. The losses which occur in the fire distilling of mineral seal oils are also being investigated. The heating value of gases that have been treated for the recovery of gasoline is being compared with that of untreated gas. Field work covers investigation in various oil and gas fields.

Columbus (Ohio) Station

Ceramic investigations are being conducted at the Columbus Station. The comparative qualities of bond clays in the production of graphite crucibles used in the melting of brass and steel have been determined. Further investigations are to be undertaken to determine the comparative value of American and imported graphite. Tests are conducted to determine the value of clays for different uses such as for pottery, building and fire brick.

Fairbanks (Alaska) Station

The Fairbanks Station deals with the minerals and ores from the Alaska district. Black sands in different localities are being tested for gold and platinum; where these metals are found in paying quantities, concentration methods are worked out. Black sands from Fairbanks Creek and from Goldstream are now being investigated. Methods for the separation of copper from pyrrhotite in ores from the Kennecott Copper Corp. at Latouche are being investigated. Custom assaying is also carried on at this station.

Golden (Col.) Station

At the Golden Station radium research is conducted. The spectra of krypton and xenon have been the subject of investigations by Dr. Moore and Dr. Lind of the station in co-operation with Prof. Nysander of Denver University. Dr. Marden of the University of Missouri has completed a monograph on the analytical methods of zirconium. Key West copper-nickel-platinum ore from Pioche, Nev., has been examined, and preliminary investigations indicate that a separation of the copper and nickel can be made by differential flotation and that 85 per cent of the platinum can be recovered. A co-operative agreement among the Primos Chemical Co., the Bureau of Mines and the Colorado School of Mines has been entered upon to conduct research work on molybdenum steels. The factors which influence the phosphorescence of zinc sulphide are being investigated by C. W. Davis. The production of a luminous paint from this material will help conserve the limited supply of radium. J. E. Conley is experimenting with a descloizite from Goodsprings, Nev. The removal of the vanadium from this low-grade ore carrying a highly calcareous gangue is being attempted by passing dry chlorine over the reduced ore at low temperature. About 85 per cent of the vanadium was volatilized without the calcite being appreciably attacked. Mr. Conley is also preparing a chapter on the analytical methods of vanadium.

Minneapolis (Minn.) Station

The Minneapolis Station is erecting an experimental iron blast furnace, the blowing in of which has been delayed by the unusually early and severe winter weather. The Fuel Division has been working on the economical use of fuels common to the Northwest in house-heating units. The work has demonstrated that economy may be effected by proper burning of these fuels and the public has evidenced an appreciation of this work. C. E. Plummer is investigating the standardized methods of determining phosphorus in iron ores and the separation of manganese and magnesium in iron blast furnace slags.

Pittsburgh (Pa.) Station

The work of the Pittsburgh Station in the physical testing of explosives and in the examination of explosives to be put on the permissible list is being carried on as usual. Messrs. Howell, Munroe, Rice and Hall have been appointed on a committee to consider the rules and regulations governing the testing and placing of explosives on the permissible list. An investigation is being conducted in co-operation with the New York and New Jersey State Bridge and Tunnel Commission to determine the amount and composition of exhaust gases in motor vehicles to obtain data for the ventilation of the proposed tunnels under the Hudson River. A new furnace and apparatus has been built for the study of the forms of coal sulphur carbonized at temperature of 500 deg. C. and over. Additional data are being gathered in regard to scrap loss in aluminum foundry practice and the available statistics are being correlated. Metallographic and chemical work in connection with typical defects in aluminum castings is being conducted. Methods for the analysis of aluminum and its alloys are being investigated. The Fuel Section is conducting boiler tests for the United States Emergency Fleet Corp. in determining the efficiency of oil-burning equipment.

Salt Lake City (Utah) Station

The work on chloride volatilization is being continued at the Salt Lake City Station. Recent test runs on ore from Yellow Pine Mining Co. from the Goodsprings district in Nevada showed an extraction of 83 per cent of the lead and 88 per cent of the silver. In these runs salt was used as a chloridizing agent and powdered calcium chloride was introduced into the discharge end as a volatilizing reagent. Silver-lead residue from zinc retorts and oxidized copper ores are also being investigated to determine the adaptability of this method for recovery of the metals. Ore of the Tintic Standard mine was treated for the extraction of silver and lead in concentrated acid brine solution.

Seattle (Wash.) Station

At the Seattle Station attention is being given the problem of the utilization of Washington coal. Fuel oil shortage has necessitated the use of the available coals from the district. Investigations cover the field of mining, washing, briquetting and the utilization of powdered coal. The co-operation work with the Idaho School of Mines at Moscow covers differential flotation experiments on lead-zinc ores and cyanidation tests of gold-silver ores from Idaho.

Tucson (Ariz.) Station

At the Tucson Station co-operative work is being carried on with the Miami Copper Co. Equipment is being installed to investigate the leaching of low-grade copper ores by sulphur dioxide. Equipment at the Miami plant has been recently overhauled, a counter-current decantation system has been added for the clarification of copper sulphate solutions, also a Cone settlement apparatus for the recovery of precipitated copper. The production of sponge iron for the precipitation of the copper from solutions is being investigated. Dr. C. M. Bouton, of the Berkeley Station, has been detailed on special chemical investigations connected with SO_2 leaching problems.

Urbana (Ill.) Station

The Urbana Station is investigating the coals of the Midwest field. W. W. Odell has submitted plans to the Chicago gas companies whereby improvement in operating efficiencies may be obtained.

San Francisco (Cal.) Station

The San Francisco Field Office is studying the problem of reducing the viscosity of heavy asphalt-base crude oil. The work is being conducted by C. P. Bowie and M. J. Gavin. Mr. Gavin is also investigating the problem of oil-shale development. A. R. Elliott is investigating the evaporation losses and changes in temperature of oil in storage.

A Test on Sulphur Content of Clean, Cold Producer Gas

By Carl F. Kaufmann

THE field of uses for clean, cold producer gas has broadened to such an extent that this gas is now bidding for the place long held by hot, raw gas in the making of steel by the open-hearth process. In this connection the presence of sulphur in the gas must be considered, as naturally a high sulphur content will have a deleterious effect upon the steel. The sulphur exists in the raw producer gas in three forms: hydrogen sulphide, carbon bisulphide and sulphur dioxide, but principally in the forms of hydrogen sulphide and carbon bisulphide in the proportion of about one of the former to two of the latter. The ratio varies with the character of the coal used.

The writer directed an extensive series of analyses conducted to ascertain the quantity of sulphur contained in the coal, the amount going down with the ash, the quantity carried over by the raw gas, the quantity absorbed by water in both the primary and secondary condensers, the quantity carried off in the tar, and the quantity that is finally present in the clean, cold producer gas.

At the start of the test the bunkers were stocked with a 24-hr. supply of coal, and during the test, approximate analyses were made from samples taken from the chutes to the producer, at intervals of two hours so as to insure a fair average representation.

The approximate analysis of the coal is given as follows:

	Per Cent		Per Cent
Moisture	1.37	Ash	9.59
Volatile and organic	36.23	Sulphur	1.81
Fixed carbon	51.00		
B.t.u. per lb., (calorimeter)			13,709

The quantity of coal burned in the producer was 58,900 lb. As the sulphur content of the coal was 1.81 per cent, the total sulphur present was therefore 1,066.09 lb. There was produced from burning the above quantity of coal 5,706.5 lb. of ash containing 92.5 per cent mineral and 7.5 per cent combustible matter. The sulphur present in the ash analyzed 0.16 per cent by weight, equaling 9.13 lb. Deducting this quantity from that contained in the coal leaves a total of 1,056.96 lb. carried off from the producer in 3,540,000 cu.ft. of raw gas to the primary condenser.

The volume of water supplied to the primary condenser in 24 hr. as indicated by a Bailey flow meter was 314,000 gal., to the secondary condenser 156,000 gal.

Analysis of the condenser water before using is given as follows:

	Parts per 100,000		Parts per 100,000
Silica	2.64	Calcium sulphate	32.78
Iron dioxide	0.14	Calcium chloride	38.03
Aluminum oxide	0.11	Magnesium chloride	23.30
Calcium carbonate	26.50	Sodium chloride	162.84

Analysis of the primary condenser water, determination made every 2 hr., averaged 14.4857 grains per gal., or for the total volume of water, 649.79 lb. The secondary condenser water showed an absorption of 14.3689 grains per gal.; for the total volume of water, 320.22 lb.

The quantity of tar distilled and separated by the extractors was 366.75 gal. delivered to the tar decanter. Taking the weight of tar as 8.336 lb. per gal., it will follow that the total weight of the tar equals 3,058.228 lb. The sulphur present in the tar analyzed 0.253 per cent by weight, or a total quantity of 8.737 lb.

The ultimate analysis of the gas showed a sulphur content of 0.1451 grain per cu.ft., or a total of 73.78 lb. contained in the 3,540,000 cu.ft. of gas produced.

Ultimate analysis of gas is given as:

	Per Cent		Per Cent
Carbon dioxide	5.00	Hydrogen sulphide	0.02
Carbon monoxide	23.20	Hydrogen	11.80
Oxygen	0.60	Nitrogen	54.18
Methane	5.20		

RECAPITULATION

Duration of test, hr.	24
Coal consumed, lb.	58,900
Ash produced, lb.	5,706.5
Tar distilled, lb.	3,058.2
Gas produced, cu.ft.	3,540,000
Water consumed, primary condenser, gal.	314,000
Water consumed, secondary condenser, gal.	156,000
Temperature water entering primary condenser, deg. F.	58
Temperature water leaving condenser, deg. F.	125
Temperature gas entering condenser, deg. F.	1,000
Temperature gas leaving condenser, deg. F.	120
Temperature water entering secondary condenser, deg. F.	58
Temperature water leaving secondary condenser, deg. F.	72
Temperature gas entering condenser, deg. F.	124
Temperature gas leaving condenser, deg. F.	68
Sulphur content in ash, lb.	9.13
Sulphur content in water primary condenser, lb.	649.79
Sulphur content in water secondary, lb.	320.22
Sulphur content in tar, lb.	8.74
Sulphur content in gas (ultimate analysis), lb.	73.78
Sulphur content unaccounted for, lb.	4.43
Sulphur content in coal, lb.	1,066.09
Sulphur content in gas, grains per 100 cu.ft.	14.31

Crucible Steel Co. of America.

Aluminum in Norway

ACCORDING to a report by R. B. Ladoo of the Bureau of Mines (Monthly Reports of Investigations, December, 1919), Norway has not previously been a producer of aluminum, having been wholly dependent upon imports, but during the war the Hoyangfaldene Co. was formed to undertake domestic production. Jetland Falls, from which the Hoyanger plant obtains its power, furnishes an available 80,000 hp., of which 30,000 hp. has been utilized at a cost of 6,708,207 kroner ($1,811,215.90 at the normal exchange rate). It is estimated that the total development cost for the whole plant installed will be 300 to 350 kroner ($80 to $95) per hp. The whole enterprise includes works which will produce 7,000 tons of metallic aluminum, 5,000 tons of electrodes and 12,000 tons of carbide.

No sources of bauxite are known in Norway, but the company is affiliated with the Société des Alumines & Bauxite de Provence, of France, which owns adequate sources of bauxite.

In the meantime the Hoyangfaldene Co. has been manufacturing electrodes, carbide and iron and has been experimenting on a large scale with domestic raw materials to discover a local source of aluminum ore, and it is reported that results are encouraging.

Alumina From Labradorite

In this connection it is of interest to note that the development of a process of extracting alumina from labradorite has recently been reported from Norway. The process involves the solution of labradorite in dilute nitric acid made locally, leaving the impurities as a residue; evaporation and heating to a point at which the aluminum nitrate alone is decomposed, and dissolving the calcium and sodium nitrates in water, leaving pure aluminum oxide. Labradorite, as ordinarily found in this country, is not sufficiently soluble in nitric acid to make this process seem feasible on a commercial basis; but it is possible that the Norwegian material is not a true labradorite and is much more soluble. Pure labradorite contains about 30 per cent alumina or 16 per cent aluminum.

Aluminum Rolling-Mill Practice—II Melting Furnaces—Ingot Pouring

Continuous Versus Intermittent Melting, Prior to Casting Rolling-Mill Ingots, Is Discussed by the Authors in Their Second Installment—Correct Melting and Pouring Practice for a Minimum of Drossing Is Also Indicated*

BY ROBERT J. ANDERSON AND MARSHALL B. ANDERSON

FOR casting into rolling ingots, aluminum is melted in gas- or oil-fired (and occasionally coal-fired) furnaces of the open-flame reverberatory type, and in electric furnaces. Ordinarily, open-flame gas-fired furnaces are preferred; the firing is accomplished by the combustion of the fuel ejected from burners and with the aid of air. A typical gas-fired furnace is one of 5,000-lb. capacity (2,300-kg.), and such a furnace will consume about 1,000 cu.ft. of natural gas per hr. (28 cu.m.) under the conditions of fast melting practice. Gas- and oil-fired furnaces for melting aluminum for casting into rolling ingots are represented by a number of common types, for example the Rockwell, and no lengthy description will be given now. The usual furnace is built with a refractory hearth or bottom of firebrick and with inside walls and roof of the same material. The outside walls are made of common brick; the whole furnace is bound firmly together with channels or I-beams and stay rods. There may be two or more burners to a furnace; one type has two burners, one at the front situated so that the flame is about 12 in. (30 cm.) above the bath, and the other at the rear but about 30 in. (75 cm.) above the bath. Melting furnaces using gas or oil for fuel may be built in pairs, i.e., the side of one furnace abuts the side of another. Charging and cleaning are accomplished through a door at one side, and the metal is tapped through a tap hole at the front.

Coal-fired furnaces have been used for melting aluminum, but there are certain definite disadvantages which arise with the use of these furnaces. They are built with a firebox at one end; the flame sweeps over a bridge wall and across the metal, and finally out through a stack. One difficulty in the use of coal lies in the lack of anything like accurate control of temperature. From the rolling mill standpoint, another disadvantage lies in the fact that metal melted in coal-fired furnaces is usually more dirty and discolored than metal which has been melted in gas-fired or oil-fired furnaces. This statement is based upon inspection of ingots, slabs and sheets.

Use of Electric Furnaces

Electric furnaces have lately received some attention in the United States for aluminum melting. In particular, the Baily resistor furnace[6] has been used for this purpose. Offhand, electric furnaces might appear to be entirely unsuited to aluminum melting because of the fact that high temperatures are usually associated with these furnaces. Arc furnaces do not appear to be desirable appliances for aluminum melting, but resistor-type furnaces apparently have some advantages. Even though aluminum melts at a rather low temperature, it may be considerably superheated in a neutral atmosphere without ill effects or large volatilization losses because the boiling point[7] is quite high: viz., 1,800 deg. C.

It is assumed by some that reducing atmospheres follow from the use of electric-arc furnaces or electric-resistor furnaces using a carbon-base resistor. A reducing atmosphere will not be obtained in these furnaces unless the furnace is tightly luted so as to prevent ingress of air, and the average furnace will not be operated in this way. With resistor-type furnaces, better control of temperature is possible than with either gas-, oil- or coal-fired furnaces. A neutral or reducing atmosphere is rather difficult to maintain in gas- or oil-fired furnaces under the conditions of melting.

With regard to furnace atmospheres, there is this to be said: Under the usual conditions involved in charging continuous heats the doors are open for such a considerable portion of the time that no particular atmosphere could be maintained very long.

Melting for Minimum Dross

A usual method for melting aluminum prior to ingot casting, in reverberating furnaces, calls for charging into a hot furnace, say, 5,000 lb. (2,300 kg.) of cold metal, i.e., pigs alone or plus scrap. When the charge is melted, ingots are poured until the furnace is empty. This is a rather uneconomical procedure in the case of 24-hr. practice. Aluminum is readily oxidized in the presence of air and rapidly with increasing temperatures. Under the above conditions, a large surface area of metal is exposed to both air and a free flame; this normally results in high dross losses. If reducing conditions could be positively and completely under control at all times, then the case would be altered.

Dross, in aluminum melting practice, is understood to consist of aluminum oxide (Al_2O_3 or some other oxide) plus metallic aluminum mechanically entangled. Dross losses resulting from poor melting methods have, at times, amounted to as much as 3 per cent of the total metal charged, but this, as shown later, is an excessively high figure for good practice.

In order to melt aluminum for ingot casting, a method more to be preferred than the one above is as follows: To a hot furnace, charge about 500 lb. (230 kg.) of pig metal, and when this has been melted continue adding more pigs from time to time until the whole charge has been put in. After each addition the cold pigs should be put down below the surface of the

*For Part I see CHEM. & MET. ENG., vol. 22, No. 11, p. 489, March 17, 1920.

[6]Dwight W. Miller, "The Remelting of Aluminum Pig in the Electric Furnace," CHEM. & MET. ENG., vol. 19, 1918, pp. 251-254.

[7]Smithsonian Physical Tables, 1918, p. 218.

bath, and sufficient time should be allowed for them to melt before adding more cold metal. There will be no difficulty in keeping the cold metal under the surface, because the density of liquid aluminum is less than that of solid aluminum. In this way the smallest possible surface is exposed to the action of the flames, and oxidation is kept lower than otherwise.

If the endeavor is made to keep the temperature of the bath low in order to avoid gas absorption, excessive oxidation, and the formation of aluminum nitride, then too much cold metal should not be added at one time, or the whole bath may freeze. Normally, however, there is not an accurate control of the bath temperature, and usually the bath will be sufficiently hot so that several hundred pounds of cold pigs can be charged at intervals of one hour.

Aluminum melting may be either intermittent or continuous; in the former a furnace is charged, and the metal is melted in the manner just described; the entire melt is then poured into molds, the furnace is recharged, and the whole operation is repeated. In continuous melting, a furnace is started as in intermittent melting, and additional metal is added from time to time (usually every hour or so) in order to keep pace with the rate of ingot pouring. In this method, a furnace is always practically full of metal, but it presupposes 24-hr. operation unless it is desired to hold a bath of hot metal over night. This latter is hardly advisable, since furnace breakouts might occur.

Continuous Melting

A continuous heat may run for about one week, being started on Monday and continuing until the end of the week, when the furnace is emptied and cleaned. For an example, it may be assumed that a 5,000-lb. heat is in the furnace in the liquid condition and that pouring of ingots has commenced. It is the duty of the furnace fireman to keep the furnace full of metal and at a sufficiently high temperature at all times so that ingot pouring will not be delayed. In order to do this, he should keep account of the number of ingots poured during a given time, say 1 hr.; at the end of that time sufficient pig or scrap, or both, should be added to replace the metal already tapped from the furnace. Thus, if there had been poured ten ingots of the 4 x 12 x 17-in. size (10 x 30 x 43-cm.), weighing approximately 76 lb. (35 kg.) each, the fireman should add twenty-three pigs of the 33-lb. (15-kg.) size, or an equivalent weight of pig plus scrap. If the additions are not made at regular intervals, too much cold metal may be charged at one time and the bath will be unduly chilled.

For practical purposes, in the case of a 5,000-lb. (2,300-kg.) furnace, the danger limit is 3,500 lb. (1,600 kg.) of metal in the furnace. If the bath is allowed to fall below this amount, the fireman will not be able to keep the furnace at a high enough temperature so that ingots may be poured continuously. This trouble soon culminates and stops production. When less than about 3,500 lb. of hot metal at the correct temperature is in the furnace, not more than twenty-five cold pigs of the 33-lb. (15-kg.) size can be charged at one time, since otherwise the bath will be unduly chilled; it will require at least 60 min. for 800 lb. (350 kg.) of cold pigs to go into solution, and in that time about 800 lb. of aluminum will have been poured into ingots. It will again not be feasible to charge more cold metal for another hour, and in the meantime more ingots will have been poured. Hence the difficulty becomes cumulative, and if the cold metal is not charged at regular intervals to keep pace with the rate of pouring, production on the furnace must be stopped in order to allow time for the bath to regain the correct pouring temperature. In short, the rate of charging cold metal, in continuous melting, should correspond closely with the rate of pouring, with the object of maintaining the temperature of the bath reasonably constant.

The relative merits of continuous and intermittent melting may be summed up as follows:

(*a*) In small plants or where the production is irregular, or elsewhere if the melting capacity is greater than the rolling capacity, intermittent melts will be employed.

(*b*) Intermittent melts give more uniform ingots, as to composition, when mixed pig and scrap, or all scrap charges, are run.

(*c*) Intermittent melts may possibly have some advantages in that they allow better separation of dross. The evidence is not entirely clear on this point, but more uniformity in the subsequent sheets is usually found.

(*d*) On the other hand, continuous melts are cheaper from the standpoint of fuel consumed and labor employed.

(*e*) Continuous melts give greater production for a given melting capacity.

Intermittent Melting

The above remarks refer to either reverberatory-type or electric-furnace melting. In order to avoid the less efficient night work, a small plant will cast ingots only by day. For large plants where the production is irregular, it will not be advisable to run the melting department at capacity when the rolling and fabricating departments are not at capacity also. Again, if the melting capacity is out of proportion to the rolling capacity, e.g., larger, then it is advisable to melt intermittently, because in this way the melting can be so carried out as to keep pace with or be a little ahead of the rolling.

Greater uniformity of ingot composition can be obtained by intermittent melting, for the reason that it is possible to obtain separate lots of metal of practically the same composition. It is difficult to keep scrap assorted according to lot, and the pig composition itself may be somewhat variable. Lots of scrap from slab shearing can readily be kept separated, but it is more difficult to segregate shearings on finished sheet and pack trimming, and practically impossible to keep any accurate account of small fabricating scrap by lots.

With intermittent melts, more men must be employed at short intervals for charging; with continuous melts, one man could charge two furnaces and be kept busy most of the time. Melting furnaces are charged by hand, and the labor is not severe.

Time required for melting a cold charge of aluminum varies with type of furnace, character of the charge, and with available working temperature of the furnace. Electric furnaces will melt aluminum more rapidly than will open-flame furnaces, for the self-evident reason that higher temperatures can be obtained. Medium scrap in the loose or baled condition will melt more rapidly than massive pig metal.

In order to give a specific idea of the time required to melt aluminum charges under mill conditions, there may be considered a gas-fired furnace of 5,000-lb. (2,300-kg.) capacity. Starting with a cold furnace, it

requires 6 to 10 hr. to heat the interior to 900 deg. C.: if pig metal be then charged as fast as it will melt, it will require about 4 or 5 hr. more to melt 5,000 lb. of aluminum and superheat it sufficiently for casting.

It also takes time to remove as much of the already formed dross as possible before starting to pour ingots. Consider the case of an open-flame reverberatory furnace of 5,000 lb. capacity, it being also assumed for purposes of illustration that the furnace is run continuously during the day, that no ingots are poured at night, and that a capacity heat is put in the furnace over night. In the morning, the day fireman should clean the bath before any pouring is started. Cleaning may be accomplished by the use of about 5 lb. of zinc chloride, $ZnCl_2$, to a 5,000-lb. heat. This reagent should be placed in a long-handled ladle and run back and forth through the bath from one side of the furnace to the other, below the surface. The bath should then be stirred vigorously with a long-handled pointed prong in order to insure thorough mixing of the zinc chloride. After allowing the melt to stand for about 10 min., the accumulated dross on the surface may be removed by a skimmer. While the value of zinc chloride is still a matter of contention among aluminum melters, it appears to be of some advantage for cleaning aluminum heats before ingot pouring.

Removing Molten Metal

One feature of aluminum-melting furnace design which is of interest lies in the provision for removing the metal from the furnace to the pouring crucible. In general, there are two ways in which this may be accomplished; first, by tapping the metal through a tap hole and runner, and, second, by ladling the metal out through a door. Of the two methods, the former is to be preferred. In tapping, the tap hole has been previously plugged with a 50:50 dough-asbestos ball on the end of an iron-handled cone; to tap, the cone is pulled out of the hole, and the metal flows down the runner. The hole is then replugged with a new ball. Difficulties occasionally arise by the metal freezing up around the tap hole; this is more often due to poor design of the tap hole than to the method itself.

Ladling is very bad practice, in the opinion of the writers. The ladle is usually hung on a swing at one of the furnace doors, and the metal is ladled out until sufficient has been placed in the pouring crucible. In this way there is more opportunity for the metal to cool than when tapping; further, it is much slower. In addition, there is more opportunity for dross to become entangled with the pour because several ladlesful are necessary to fill the pot; each ladle of metal will be more or less covered with dross. It is possible that there may be some advantages in using large tilting crucible furnaces for aluminum melting; such furnaces would empty more easily than either tapping or ladling, and there would be less opportunity for overheated melts.

Temperature Control

Pyrometric control of aluminum-melting furnaces has apparently not been applied to any considerable extent, but definite advantages would follow from the control of melting temperatures. There have been certain difficulties in the way of pyrometric control of aluminum melting, but these are not insuperable. In open-flame furnaces, iron-protection tubes break down rather rapidly under the flame action, while alundum and silica tubes are too fragile for heavy duty. Irrespective of what kind of thermocouples are used for taking temperatures, there is the liability that they will be damaged during charging if they are kept in the furnace at all times. Thermocouples have been permanently installed, on some furnaces, in the roof or side walls, or both; the recorded readings do not furnish the temperature of the bath of course, but may be more or less useful. These readings may be supplemented by taking the actual bath temperature at regular intervals by means of a portable pyrometer. At the present time, it appears that the most reliable and simplest method of pyrometric control of aluminum melts is to take temperature readings every 30 min. or so with a portable pyrometer. Aluminum is cast into rolling ingots at 700 to 760 deg. C., the temperature depending upon the size of the ingots.

Dross

As has already been noted, one of the principal sources of metal loss in aluminum melting is that resulting from oxidation according to

$$2Al + 3O = Al_2O_3$$

or possibly

$$3Al + 4O = Al_3O_4$$

Prevention of oxidation is one of the main difficulties with which aluminum melters have to deal. Whether the oxidation is due to an oxidizing flame, or to air entering the furnace when the doors are opened or through cracks, does not alter the final result. The specific gravity of aluminum oxide, Al_2O_3, is 3.73 to 3.99, that of the amorphous oxide being 3.85; it melts at 2,020 deg. C. Since aluminum oxide has a greater density than liquid aluminum, the tendency for the oxide formed would be to sink to the bottom of a bath and collect there; the viscosity of the metal may prevent such a separation in part, and surface tension can help in maintaining an oxide scum on the bath surface. Moreover, the possibility of aluminum oxide being soluble in aluminum should not be overlooked. Consideration of these factors, however, is liable to lead to speculation, and the fact is that the necessary information is lacking as to what actually takes place during dross formation in melting practice.

For the purpose of the present article, it is sufficient to know that the most serious losses in aluminum melting result from oxidation, and that care should be taken to guard against excessive dross losses. That excessive dross losses may be prevented by fairly simple precautions will be shown. In practice, it is found that whenever a furnace is emptied a considerable amount of dross has collected on the bottom; cleaning the furnace practically amounts to scraping out this accumulation of dross. During melting, aluminum oxide is probably being formed continuously, and it appears that part of this oxide finds its way to the bottom of the bath, given sufficient time. In some instances, the dross collected at the bottom of the bath has been removed by scraping it out through the bath in order to prevent it from being carried into the pouring crucible on tapping; much aluminum is also removed in this way, and it is doubtless better to remove dross by cleaning the bath with zinc chloride before pouring and then clean out the furnace after all the aluminum has been tapped and the furnace drained of metal. During the pouring of ingots, the bath also should be scraped off every 2 hr. or so with a skimmer to remove the surface dross. The use of zinc chloride for cleaning

melts has already been described. On a 5,000-lb. (2,300-kg.) intermittent heat, about 50 to 100 lb. (23 to 46 kg.) of dross will be removed from the emptied furnace, equivalent to 1 to 2 per cent by weight, in addition to the amount which is removed from the surface of the bath during pouring and that taken off the ladles.

This dross is not entirely aluminum oxide, but contains perhaps from 30 to 60 per cent metallic aluminum mechanically entangled with the oxide; the amount of metallics in dross depends upon the care with which the bath is skimmed. Dross also contains iron, silica, and other impurities. On continuous heats, the dross removed at the end of a week's run will be much larger in quantity, usually from 300 to 500 lb. (135 to 230 kg.), and the daily skimmings will amount to about 50 lb. (23 kg.) per day, or 300 lb. (135 kg.) in the week. Furnace dross has a salable value as such, and its price will depend upon its content of elemental aluminum and the condition of the secondary metal market.

Grading Melts

In what has gone before it has been shown how aluminum melting is either intermittent or continuous, and consideration is now given to various grades of furnace heats and the use of scrap aluminum in charges.

TABLE III. PERCENTAGES OF SCRAP AND PIG IN ROLLING INGOTS

Ingot Designation	Percentage of Pig	Percentage of Scrap
A	100 to 80	0 to 20
B	80 to 60	20 to 40
C	60 to 40	40 to 60
D	40 to 20	60 to 80
E	20 to 0	80 to 100

Aluminum-melting charges for ingot production are made up according to the quality of ingots desired, and they may vary more or less, depending upon local conditions, the amount and character of the scrap made in the plant, as well as upon the conditions existing in the aluminum pig and scrap markets. Rolling ingots may be designated by any suitable symbols, according to the percentages of contained scrap and pig metal. Thus, ingots may be designated as A, B, C, D and E, depending upon the relative proportions of scrap and pig in the furnace charges. Table III shows how the percentages of pig and scrap may vary, but the figures and the symbols are arbitrary; as a matter of fact, the relative percentages of scrap and pig may be anything from 0 to 100 per cent of each.

Strictly speaking, first-grade rolling ingots are understood to be ingots cast from an all-pig melting charge, or they may include ingots cast from a charge consisting of pig plus scrap originating in the manufacturer's own plant and of a composition not differing markedly from the composition of the pig. All-scrap ingots are made from an all-scrap charge. Usually varying amounts of scrap are charged together with pig metal.

All-pig ingots will have practically the same chemical composition as the original pig metal, but there is usually a higher silicon content due to reduction of SiO_2 from the furnace lining by the aluminum. With increasing percentages of scrap in the charge, the aluminum content of the ingots becomes lower and lower, and all-scrap ingots seldom, if ever, contain 99 per cent Al.

Copper, brass, iron, steel, etc., may become mixed with aluminum scraps, particularly the lighter ones; hence, on melting, zinc may be introduced, copper and iron will be increased, and other impurities may find their way into the resultant ingots, depending upon the nature of the contaminating materials. The common aluminum-mangenese alloy, containing about 1.50 per cent Mn, and employed for so-called "hard sheets," may also become mixed with aluminum scrap, with a consequent introduction of appreciable amounts of manganese on remelting. In a word, it is practically impossible to guard against the contamination of scrap under existing plant conditions. On the basis of a 99 per cent aluminum content for virgin pig, remelted scrap will rarely contain that much aluminum, and it usually contains about 98 per cent.

Influence of Impurities

The presence of certain impurities, in subordinate amounts, appears to cause no particular harm, at least so far as rolling is concerned. However, it is a fact that ingots cast from high scrap content charges, such as D and E in Table III, usually contain more occluded dross than A ingots; and sheets rolled from the former never appear to have so good a surface appearance as those rolled from A ingots. D and E ingots are rarely used for sheet rolling, and if used at all should be worked into strip rolled metal. The lower grade ingots will split more readily than the higher grade ones on rolling, but strip metal is drawn out rather than spread, so that D and E ingots may be utilized for this.

In commercial mill practice, furnace charges will be made up according to the grade and quality of the sheets demanded, whether strip is made or not, and whether specifications are called for or not. Specifications for sheet aluminum will be included later.

Pouring Practice

Generally speaking, the size of ingot to be poured will depend upon the size of sheets to be rolled, and this matter, knowing the scrap allowances for shearing, is one of simple mathematical calculation. Ingots are poured as a rule in the sizes tabulated in Table IV, but any size can be cast according to the requirements. In any plant, the ingot production is governed not only by the melting capacity but also by the number of available ingot molds, since a mold can be used only once every 30 min. on the average, unless provided with a water

TABLE IV. DIMENSIONS AND WEIGHTS OF ALUMINUM ROLLING INGOTS

Ingot dimensions, in.	Calculated weight[1] lb.	Actual average weight,[2] lb.
4 x 12 x 17	79.5	75.5
3.5 x 12 x 20	81.4	79.0
3.5 x 12 x 21	85.9	86.5
3.5 x 12 x 22	90.0	89.0
4 x 12 x 20	93.0	90.0
4 x 12 x 21	98.0	94.5
3.5 x 12 x 24	98.0	95.0
4 x 12 x 24	112.2	107.0
4.75 x 11.75 x 22	119.6	114.5
4 x 12 x 27	126.3	121.0
4.75 x 11.75 x 24	130.5	123.5
4 x 12 x 30	140.3	135.0
7 x 16 x 24	261.9	259.0
7 x 16 x 26	305.5	300.0
7 x 16 x 30	327.4	315.0
7 x 16 x 36	392.8	366.0

1 in. = 2.54 cm.; 1 lb. = 0.454 kg.

[1] Calculated for ingots of the dimensions indicated and based on specific gravity = 2.70

[2] The actual average weights given are based on figures obtained by weighing a number of ingots from a given set of molds. The actual weights are less than those calculated, because the molds did not have the exact dimensions given. Furthermore, when speaking of a 4 x 12 x 17-in. ingot, for example, reference is had to the inside dimensions of the mold into which the ingot was poured. Shrinkage on freezing, blowholes, occluded gas, variation in filling the molds, and the fact that the molds were not exactly the same size as the dimensions indicated for the ingots account for the apparent discrepancies.

circulating cooler, when it can be used every 9 or 10 min. Aluminum ingots are cast in cast-iron chill-molds of proper dimensions.

In ingot-casting practice, as carried out at present, the melting furnace, if stationary, is tapped by withdrawing a plug filling the tapping hole at the front of the furnace. The metal then flows down an iron runner into the pouring crucible. When the crucible (a No. 125 to No. 200 in size) is about three-quarters full, or contains sufficient metal to pour one ingot of the desired size, the tap hole is plugged, and the stream of metal is shut off. This plug consists simply of a conical iron tool with an iron handle, and a 50:50 dough-asbestos ball is stuck on the point of the cone. Pouring crucibles are also filled by ladling out the aluminum from the furnace through one of the doors, the ladle being supported on a swing. With the ladle ordinarily used, it requires three or four ladlesful to fill a crucible. This method of filling crucibles is to be regarded as bad practice, because there is more opportunity for dross to become tangled in the metal.

Whether the metal is tapped or ladled, the surface of the aluminum in the pouring crucible should be skimmed before pouring. The pouring crucible when filled is conveyed by hand, or on an overhead monorail with hoist, to an adjacent battery of ingot molds drawn up into position by a chain hoist. The molds are tilted at an angle of 70 to 90 deg. with the horizontal. Pouring is accomplished by allowing the aluminum to run into the tilted mold, and at the same time lowering the mold slowly back and down to its original vertical position, so that as the mold finally assumes this position pouring is complete, and the mold is full of metal. An even stream of metal should be maintained from the crucible to the mouth of the mold; as the mold is lowered, the crucible is raised, and in this way the required condition is maintained until the mold is full. This procedure is followed so as to avoid splashing, for the metal can thus be made to flow down one side and thus fill the mold evenly.

Correct Feeding of Iron Molds

Aluminum has a relatively high coefficient of contraction, and in order to avoid piping, the mold must be continually fed at the head until the entire ingot is frozen. Feeding is accomplished with a hand ladle by adding hot metal from the liquid aluminum remaining in the crucible. Aluminum freezes very rapidly in chill molds, so that feeding at the head must be fairly rapid in order to keep pace with the contraction. When the metal has frozen, the molds are knocked open, and the ingots are removed.

Ingots are sometimes rolled directly from the molds, but more often are allowed to cool and then preheated before rolling. That the latter is a more rational procedure will be shown later.

Iron molds, as already mentioned, can be used, on the average, about twice in an hour, unless they are water cooled by circulating water. If not cooled in this manner, cooling may be hastened, apparently without any ill effects upon the molds, by "swabbing" them inside and out with cold water. It is more advisable to have the molds provided with a circulating water-cooling attachment. Molds should always be swabbed out on the inside with water after pouring each ingot so as to prevent accumulation of "fuzz" and insure that the surfaces of the ingots will be smooth. A swab can be made by tieing a ball of rags on a stick.

Some idea of the output of an average ingot-casting plant may be derived from the following figures: With an equipment consisting of 24 molds of the 4 x 12 x 17 in. (13 x 30 x 43 cm.) size and two 5,000-lb. (2,300-kg.) melting furnaces, five men can cast about 200 ingots in a day of 10 hr. It may be assumed that there are two men working on the furnaces, one melter and one helper. The melter will be charged with keeping the heats in good condition; the helper may spend most of his time with the ingot-casting crew. With twenty-four molds set up in two batteries of twelve each, there will be one man on each battery of molds. These men will remove the ingots after pouring, swab out the molds, and prepare the molds for the next pouring. Two men will be used for casting the metal, and the furnace helper will tap the furnaces. Daily production will vary, of course, with local conditions. For example, if ingots are rolled directly from the molds, the casting should be so arranged as to keep pace with the rolling. As has already been intimated, rolling directly from the molds is a rather dubious practice, and, as will be shown later, is not to be recommended.

1.5 Per Cent Manganese-Aluminum Ingots

Before dealing with the mechanical treatment of aluminum, a little space will be given to a consideration of the production of 1.5 per cent manganese-aluminum alloy ingots. As has been mentioned above, an alloy of this composition is rolled for the purpose of making so-called "hard sheets." These sheets are rolled for particular purposes where more strength is required than substantially pure aluminum can provide.

This alloy is rather troublesome to make, mainly because of the wide difference in melting points of aluminum and manganese, the usual procedure being to employ a 25:75 Mn-Al alloy for the purpose of introducing the manganese. Such an alloy can be purchased in the market or made up in the plant; it is economical to make the alloy as needed if much 1.5 per cent manganese-aluminum sheet is to be rolled.

On the assumption that a 25:75 Mn-Al alloy is used for introducing the manganese, the procedure to be followed in the production of ingots is substantially this: On the basis of a 5,000-lb. (2,300-kg.) heat, part of the aluminum (pigs and scrap) should be first melted and superheated. Then an addition of the 25:75 Mn-Al alloy should be made; either all or part of the rich alloy may be charged at this stage. The bath should be thoroughly stirred and churned to insure alloying and to prevent segregation. Then more aluminum and more of the rich alloy (provided it has not all been put in) should be charged from time to time until the whole charge is liquid. It is advisable, in making a large heat of the 1.5 per cent manganese-aluminum alloy, to charge into the melting furnace approximately enough of the rich alloy to produce a final alloy of the composition desired, as may be found by simple calculation. On the supposition that a 5,000-lb. heat is melted, then 300 lb. (135 kg.) of the 25:75 Mn-Al alloy would be charged. Samples of the melt should be taken before casting and sent to the chemical laboratory, where the manganese content can be determined in 15 to 20 min. In general, it is better practice to aim for a slightly higher manganese content than that actually desired, and then reduce it by later additions of Al, rather than to have the Mn too low, because of the difficulty in incorporating manganese.

TABLE V. MELTING RECORD[1]

Month	Consumption of Metal in Pounds: Pig	Rolling-mill scrap	Utensil scrap	Baled scrap	Furnace scrap	Outside scrap	Total metal charged	Production in Pounds: Rolling ingots	Furnace scrap[2]	Dross[3]	Per cent loss[4]
January	57,871	64,182	5,375	2,701	368	995	131,492	128,925	356	1740	1.68
February	54,550	89,377	3,727	2,508	300	.....	150,462	147,540	305	1729	1.74
March	43,549	68,175	3,879	2,241	401	3,791	122,036	120,360	530	1622	0.94
April	72,782	63,506	5,781	2,052	1,238	3,004	148,363	145,101	1,291	1997	1.33
May	115,475	67,423	5,368	4,160	2,165	9,980	204,571	199,205	2,154	3262	1.57
June	77,330	72,115	6,850	3,225	1,802	14,990	176,312	170,810	2,276	3820	1.83
July	56,268	61,309	4,055	3,790	1,250	1,023	127,695	124,739	1,255	1952	1.33
August	104,105	76,995	3,037	2,889	1,851	764	189,641	183,861	1,807	3011	2.10
September	97,591	69,300	2,671	2,390	1,635	2,044	175,631	172,264	1,872	2785	0.85
October	124,269	74,741	2,574	1,454	1,765	512	205,315	199,870	1,735	2811	1.81
November	99,680	83,774	.....	.....	568	3,432	187,454	183,746	1,770	2907	1.57
December	11,368	121,214	8,750	4,661	270	1,252	147,515	144,505	279	3312	1.85
Totals	914,838	912,111	52,067	32,071	13,613	41,787	1,966,487	1,920,926	14,630	30,948	1.57

[1] Based on the performance of one 5,000-lb. gas-fired, open-flame furnace (1 lb. = 0.454 kg.)
[2] Furnace scrap includes drippings, splashings, sweepings, etc., in the melting room
[3] Dross was weighed as such; metallics vary from 30 to 60 per cent.
[4] The figures for per cent loss are based on calculations derived from the formula

$$\frac{\textit{Weight of total metal charged} - (\textit{weight of rolling ingots} + \textit{weight of furnace scrap})}{\textit{Weight of Total Metal Charged}}$$

The necessity of keeping accurate records for the melting room will be readily apparent, and in fact, no systematic cost finding system can be applied to the plant if the melting records are neglected. Since balance sheets are customarily drawn each month, it may be advisable to keep monthly melting records; the results of the day-to-day performance can be readily added and transferred at the end of each month. In devising any record for melting, it is well to be guided by the principle that simplicity will prevent confusion. The essential data will include the amount of metal charged, the amount of ingots poured, the dross weight, and the shrinkage. Metal charged should be classified according to kind, i.e., pig, rolling-mill scrap, fabricating scrap, furnace scrap, scrap purchased outside, etc.

Table V shows a year's record for one 5,000-lb. (2,300-kg.) furnace in the melting room of a plant which operated a rolling mill and a utensil plant, during which time both intermittent and continuous melting were employed. Consumption of metal in pounds refers to the amount of metal charged into the melting furnace; the metal charged is classified as pig, rolling-mill scrap, utensil scrap, baled scrap, furnace scrap and outside scrap. In the present record, pig was mainly in the form of 33-lb. (15-kg.) four-notch bars, but some 3-lb. (1.4-kg.) six-notch ingot was also charged; rolling-mill scrap was made up of sheet and slab shearings from re-squaring operations and of defective sheets; utensil scrap consisted of defective utensils and large scrap from the utensil plant; baled scrap was baled hay, chips and trimmings from the utensil plant; furnace scrap consisted of splashings, floor sweepings and drippings occurring in the melting room on casting ingots; and outside scrap was made up of scrap purchased from outside sources, and was in various forms of light scraps. Production refers to the output of the melting furnace, and is made up of rolling ingots, furnace scrap and dross. A month's collection of furnace scrap was recharged early in the subsequent month. Dross consisted of the scrapings resulting from cleaning out the furnaces and skimmings from the furnace heats. Strictly speaking, there is also some flue scrap, where fine particles of metal admixed with dross are blown into the flues and collect there. In the case in hand, flue cleaning was done only at long intervals, and during the year one cleaning yielded 1,176 lb. (534 kg.) of flue dust.

Since the true metallic content of the dross cannot be accurately estimated, due largely to the difficulty in sampling this material, figures for losses are rather uncertain. Various methods are used for determining the shrinkage on melting, none of which are entirely satisfactory.

Calculation of Losses

In Table V, the loss has been calculated from the formula

$$\frac{\textit{Wt. metal charged} - (\textit{Wt. metal poured} + \textit{scrap})}{\textit{Wt. metal charged}}$$

Other figures have at times been based on the formula

$$\frac{\textit{Wt. metal charged} - (\textit{Wt. metal poured} + \textit{dross} + \textit{scrap})}{\textit{Wt. metal charged}}$$

Figures derived from both formulæ are liable to be exceedingly erroneous, and it appears to be better to assume a definite metallic content for the dross. By so doing, a nearer approximation to the shrinkage can be obtained. Thus, if the dross contains say 40 per cent metallic aluminum, closer figures would result from the use of the formula

$$\frac{\textit{Wt. metal charged} - (\textit{Wt. metal poured} + \textit{scrap} + 0.40\ \textit{dross})}{\textit{Wt. metal charged}}$$

than would be obtained from the first two formulæ.

(Part III, dealing with ingot heating and mill calculation, will be published in our next issue.)

Four Billion Dollar Balance of Trade

The excess of American exports over imports in 1919 amounted to $4,017,000,000, a new record, according to a statement issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce. Exports for 1919 totaled $7,922,000,000, as compared with $6,149,000,000, while imports were valued at $3,904,000,000, against $3,031,000,000 in 1918.

December exports amounted to $681,000,000, a falling off from the $741,000,000 recorded for November. Imports also fell off for December, the total being $381,000,000, as compared with $425,000,000 for November. Both exports and imports were higher than in December a year ago.

The imports of gold in 1919 amounted to $77,000,000, compared with $62,000,000 in 1918 and $552,000,000 in 1917. Exports of gold in 1919 jumped to $368,000,000 from $41,000,000 in 1918. In 1917 they amounted to $372,000,000.

No marked change was noted in the imports or exports of silver, receipts amounting to $89,000,000 and shipments to $239,000,000 in 1919.

Double Pipe Heat Interchangers*

A Study Establishing the Importance of the Factor of Film Velocity in the Helical and Straight Length Double Pipe Heat Interchangers—Effect of Varying Pump Pressure, Pipe and Overall Dimensions

BY GEORGE A. RICHTER

THE chemical engineer is vitally interested in experimental data giving information on the flow of heat from one fluid to another through metal surfaces. Although many papers have been written on this subject, there is still room for a vast amount of experimental work to confirm established heat laws and to pry further into unknown regions.

George A. Orrok gives an excellent review of published information on conductivity experiments in the 1910 volume of the *Transactions* of the American Society of Mechanical Engineers. Most of the work so summarized refers to the surface condensation of steam, and although some of the deductions listed may be applied directly to a liquid-to-liquid heat interchange, the conclusions reached must be studied with due reservation. A host of formulas have been presented by experimenters for surface condensation. It is very probable that discrepancies in their results do not point necessarily to inaccuracy in work, but may give evidence that there are other factors involved which have not been recognized.

Although the experimental work upon which this present paper is based concerns only double pipe heat interchangers, using hot and cold liquids, a brief résumé of heat transference in general may not be out of place.

Definition of Conductivity

Heat transference is conventionally expressed in terms of heat units transferred per unit of surface per unit of time per unit difference in temperature. In this country English units are employed. A given system has a certain conductivity (K) representing the number of British thermal units transferred per sq.ft. of surface per hr. per deg. difference in temperature between the hot and cold fluid. Mathematically this temperature difference is the logarithmic mean of the incoming and outgoing hot and cold liquid:

$$T = \frac{D_1 - D_2}{\log_e \frac{D_1}{D_2}},$$

where D_1 represents the difference in temperature at the beginning of the system and D_2 the difference at the end.

It is at best exceedingly difficult and probably impossible to cover all cases of such heat transference by means of a few well-selected formulas. A new condenser, or a surface heater of radically different design, always requires experimental investigation in order to learn more concerning the application of heat laws already in existence. Such investigation sometimes involves the fixing of new constants in equations already worked out for other types. Often it means the establishment of entirely new relationships.

*Read at the Savannah meeting of the American Institute of Chemical Engineers, Dec. 3-6, 1919.

Plant Considerations

The conductivity, or K, of a system is a function of the rate of heat transfer in that system. Often the value of K is all-important in the design of new cooling or heating installations. There are cases, however, where other factors are equally important. In general, the design of a new interchanger involves the following plant considerations:

1. Conductivity, or K, of various types of units.
2. Capacity of interchanger in total B.t.u. per volume of space occupied.
3. Amount of fluids to be pumped or moved in other ways.
4. Power required.
5. Limiting temperatures of incoming and outgoing fluids.
6. Construction and determining cost of material, practicability, resistance to corrosion, etc.
7. Intelligence required in operation.
8. Physical and chemical characteristics of fluid to be heated and cooled.

Each problem is apt to present other phases for consideration, depending upon requirements. Sometimes one factor of those enumerated above is of paramount importance. Factors 2 to 8 as listed demand the application of engineering sense and judgment. The conductivity factor cannot be calculated from theoretical principles, and consequently most of the experimental work on cooling and heating systems is concerned with that end of the problem.

Effect of Velocity of Liquor

If the total cost of introducing or abstracting a given number of B.t.u. in a system is to be minimized, compensatory advantages and disadvantages must be carefully weighed. For instance, the engineer must decide whether it will pay him to raise the conductivity by increasing the velocity of the liquid. In order to make such a decision he must have experimental data showing the effect of liquor velocity on power consumption of pump as well as on conductivity realized. He knows in general that raising the velocity either of the hot or of the cold liquor will increase the conductivity. He also knows this increase in conductivity is not a straight line function of the power consumption involved. The above example is merely one of several which confront the engineer on any new cooling or heating installation. The more data available the less guesswork and worry result.

Several investigators have established equations showing the effect of velocity of liquor on conductivity. Their equations vary quite considerably. In general, they express conductivity as a function of the nth root of the velocity of liquor. This value n is usually different for different types of condensers, and conse-

quently an equation cannot be taken without a thorough study of conditions under which this equation was established. Factors of which we have little knowledge may cause very great changes in conductivity with but slight changes in design.

Importance of Film Velocity

For example, we may state with some assurance that the so-called film velocity of water has marked effect on conductivity realized. But what determines film velocity?

Tabulated experimental results indicate rather forcibly that a very slight change in design of heat interchanger may cause an almost unbelievable change in conductivity, and there appears to be no better explanation than that there has resulted a greater film velocity although the average velocity has not been altered. Marked differences in formulas established in the past and in our own work emphasize the necessity of more intense study and further experimental investigation.

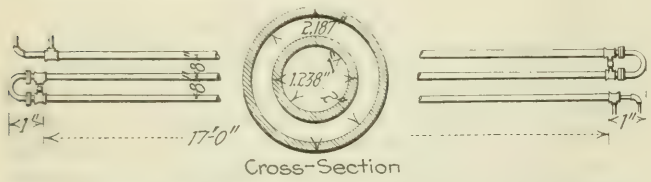


FIG. 1. VIEW AND CROSS-SECTION OF FLAT COIL COOLER

Scope of Investigation

As stated before, the work discussed in this paper concerns mainly the efficiency of so-called double pipe heat interchangers. We were interested in a system represented by a liquid-to-metal-to-liquid heat transfer. Inasmuch as the problem involved cooling acid liquors, a lead inner pipe was enclosed in a wrought iron jacket pipe. The procurement of maximum thermal conductivity was necessary in order to conserve lead pipe and to use a minimum amount of cooling water.

Although several designs of coolers were constructed for experimental data, this paper confines itself to a comparison of two types, the helical and the straight length. Sufficient data were accumulated to establish direct relationships, which may to a limited extent be used in considering other designs. It is to be noted, however, that although the factors which influence conductivity in these tests may be used qualitatively for other types of coolers, no quantitative relationship should be assumed.

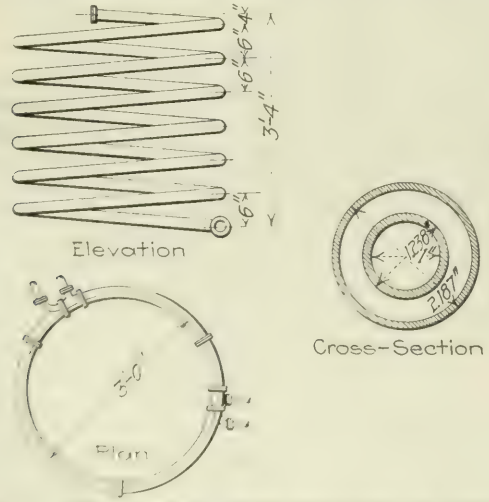


FIG. 2. VIEWS AND CROSS-SECTION OF SPIRAL COIL COOLER NO. 2

Final Objects

Tests were carried out with three objects in view: first, to determine whether a double pipe coil put into the form of a helix would give higher conductivity than one with the same pipe dimensions put into 20-ft. lengths; second, to learn more regarding the effect of varying the diameters of the inner pipe of a helical cooler; third, to study the effect of changing the overall dimensions of a helical cooler.

Apparatus Used

The units were set up as follows:

1. A 60-ft. 1-in. lead pipe within a 2-in. wrought iron pipe arranged in three 20-ft. lengths. The general assembly and a cross-section of the double pipe is shown in Fig. 1.

2. A 60-ft. 1-in. lead pipe within a 2-in. wrought iron pipe wound in the form of a helix and connected by flanges as illustrated in Fig. 2.

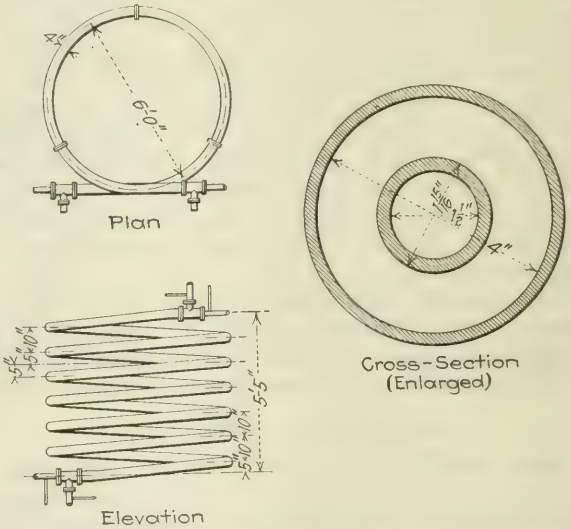


FIG. 3. VIEWS AND CROSS-SECTION OF SPIRAL COIL COOLER NO. 3

3. A 120-ft. 1½-in. lead pipe within a 4-in. wrought iron pipe flanged and wound in the form of a helix as shown in Fig. 3.

4. A 120-ft. 2-in. lead pipe within a 4-in. wrought iron pipe wound in the form of a helix in exactly the same way as represented by Fig. 3.

Each of these four coolers was set in place in very much the same way. The method for determining volume of liquor, temperatures, and velocities is shown diagrammatically by Fig. 4. Before each test, the hot liquor to be cooled was heated in a tank to the desired temperature by means of live steam. The volume delivered during the test was measured directly by drop of the level of the liquor in this tank. Cold water was pumped through the jacket and delivered over a weir for measurement. Pump pressures were regulated by means of a rheostat and thermometers installed at parts needed.

Usually a series of runs was made with different initial temperatures, in order to determine whether the temperature difference of hot and cold liquor materially influences the conductivity. During the test, readings were taken of the volumes and temperatures

of ingoing and outgoing liquor every 30 sec. The first readings were recorded after the system had been operating one full minute, in order to allow time for equilibrium to be established. Knowing the cross-section of lead pipe and wrought iron pipe, the velocities could be calculated.

Variables Studied

The following factors influencing the conductivity in each case were studied:

1. Velocity of cold jacket water.
2. Velocity of hot water within lead pipe.
3. Change in conductivity due to a change in temperature.

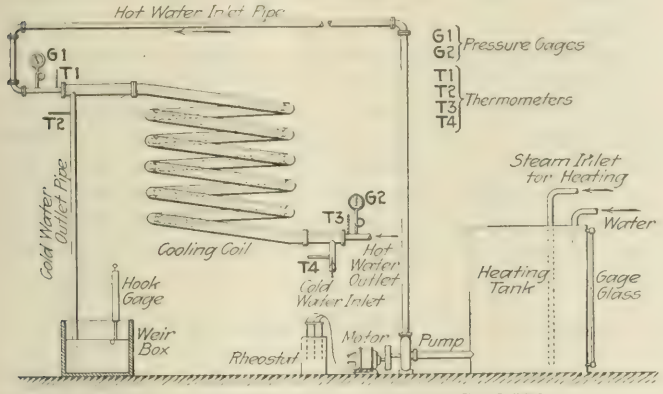


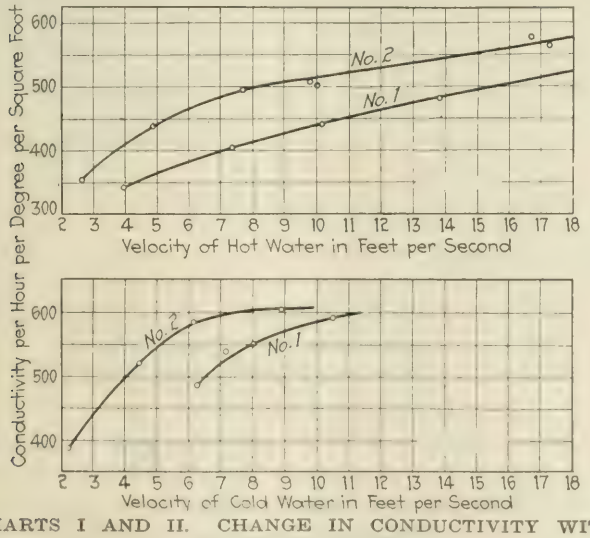
FIG. 4. DIAGRAM OF COOLING UNIT

4. Pressure of hot and cold water entering the system.
5. Change in conductivity due to change in design of cooler.

The tabulated results and data obtained in this way are shown by Charts I to VIII.

Helical vs. Straight Length Cooler

Chart I illustrates the change in conductivity of No. 1 and No. 2 coolers with change of velocity of hot water, the cold water velocity being held practically


Conductivity per Hour per Degree per Square Foot
600
500
400
300
No. 2
No. 1
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Velocity of Hot Water in Feet per Second
Conductivity per Hour per Degree per Square Foot
600
500
400
No. 2
No. 1
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Velocity of Cold Water in Feet per Second

CHARTS I AND II. CHANGE IN CONDUCTIVITY WITH WATER VELOCITY

constant. Chart II pictures the change in conductivity taking place with different cold water velocities, keeping the hot water velocities practically constant. Inasmuch as there is no change in pipe dimensions, the differences in K represent the effect of curvature in the pipe.

Both charts show a substantial increase in K as the velocities of liquids are increased. This was to be expected. At corresponding velocities, the helical cooler gave in each case a higher K, indicating that the pipe curvature does increase the effectiveness of heat transfer. Chart II represents runs made with a rather high (17 ft. per sec.) velocity of hot water, and consequently the entire curve lies in a region higher than the curves shown in Chart I, which represents runs with a constant cold water velocity of only 6.1 ft. per sec. Moreover, the curves in Chart II are steeper, showing a greater mathematical change in K with change in cold water velocity.

Molier calculated from Joule's researches (*Z. Ver. deut. Ing.*, 1897, No. 6) that the conductivity of heat from liquid through copper to liquid could be represented by a formula (English units)

$$K = \frac{61.5}{\frac{1}{1 + 3.3V_h^{0.5}} + \frac{1}{1 + 3.3V_c^{0.5}}}$$

where V_h and V_c represent velocity of hot and cold liquids respectively. Such an equation means that either hot or cold water velocity increments have equal effects in changing conductivity obtained. This is probably true for some forms of coolers, but is dependent upon the design.

Equations were deduced from the experimental data

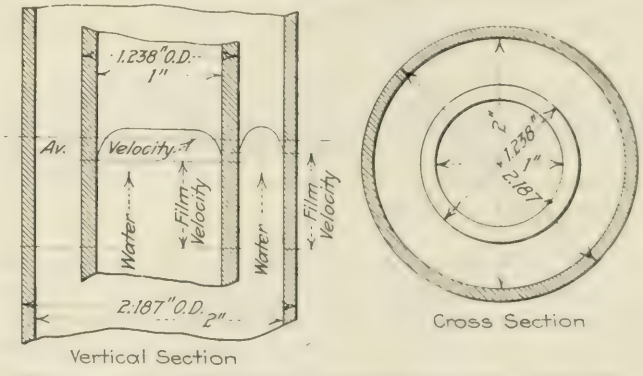


FIG. 5. FILM VELOCITY IN DOUBLE PIPE COOLER

on coolers 1 and 2 and are put into similar form as taken by Molier's equation.[1]

Cooler 1 (straight pipe).

$$K = \frac{62.7}{\frac{1}{1 + 5V_h^{0.57}} + \frac{1}{1 + 5V_c^{0.57}}} \qquad (1)$$

Cooler 2 (small helix).

$$K = \frac{76.2}{\frac{1}{1 + 5V_h^{0.6}} + \frac{1}{1 + 10V_c^{0.5}}} \qquad (2)$$

It is to be noted from these formulas that with each cooler an increase in cold water or jacket velocity can have a greater effect in increasing K than a corresponding increase in hot or inside water velocity. This may be due to a greater actual increase in film velocity of water in the jacket than that obtained by the same increase of average velocity of liquid within the inner coil, and this greater increment may be caused by the obstruction formed due to the position of the inner pipe. In order to get a clear mental picture of this explanation offered, it will be well to consider a sketch (Fig. 5) drawn to represent and distinguish average velocity and film velocity in the same pipe or tube.

[1] See Appendix for explanation.

The diagram shows a cross-section of a double pipe cooler, water flowing in the direction of the arrows. The average velocity in both jacket and in the coil is equal and represented by a.v. We have reason to believe that it is not this a.v. which determines the *K* of the system, but rather the film velocity, and this f.v. is evidently dependent upon the cross-section of channel as well as the a.v. of total liquid flowing through. Thus, we would state that the smaller the cross-section of the pipe or other channel, the higher will be the actual film velocity for a given a.v. As inferred above, quadrupling the a.v. may increase the film velocity of the inner coil by 2, whereas the same increase of average velocity in the jacket may raise the film velocity of

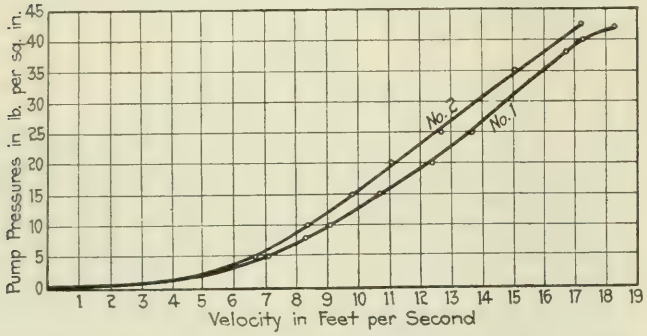


CHART III. VELOCITY IN INNER COILS WITH DIFFERENT PUMP PRESSURES

the jacket water by 2.5. We do not know whether *K* is *directly* proportional to film velocity. If it is, then by reversing the computations used, one could actually calculate the effect of increased a.v. on increased f.v., or solve the equation:

$$\text{f.v.} = f\ (\text{a.v.})$$

In imagining the flow of water through a helical and through a straight cooler, it is not difficult to picture a higher f.v. for a given a.v. in the case of the helical cooler. The a.v. is calculated from actual gallons delivered and does not take into account the path of each particle of water as it travels through the cooler. The helical form would naturally add rotary as well as linear motion and result in greater total velocity of water film next to the surface. The data plotted confirm such a prediction. The conductivities obtained with the helical form of cooler averaged from 10 to 20 per cent higher than those obtained with the straight cooler.

The question of power arises. The rotary motion evidently causes more friction, and would necessitate a greater pump pressure to deliver a given capacity of water. Chart III shows the pump pressure plotted against average velocity with both coolers.

In the operating region of the chart the straight cooler shows a greater a.v. at a given pressure of about 1 ft. per sec. Referring back to Charts I and II, it will be noted that it would require a 4 to 5 ft. difference to compensate for difference in *K* found.

There are other analogies and differences which may be pointed out in reviewing the data from which these curves were drawn, only one of which will be considered here. For many years experimenters have made attempts to find relationships of *K* and temperature difference in a given system. The curves as plotted in Charts I and II were based on data which include at least four runs at each point, the initial water temperature ranging from 110 to 180 deg. F. A careful survey of the data[2] indicates that in general the *K* goes up very slightly with the initial temperature of hot H_2O. Inasmuch as the initial cold water temperature was held practically constant during any given series, an increase in initial hot water results in a greater average hot water and cold water temperature of both liquids passing through the apparatus. The only explanation we have to offer for a slight increase in *K* with higher average temperatures in the system depends on the fact that the viscosity of water decreases as the temperature is raised. It is probable that the film velocity for a given a.v. increases as the fluidity of the liquid increases, thus allowing greater conductivity. Graphically, we may represent in an exaggerated way the film velocity of water at three different temperatures. (Fig. 6.)

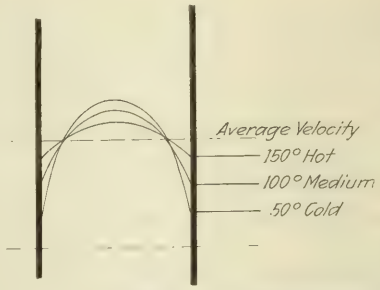
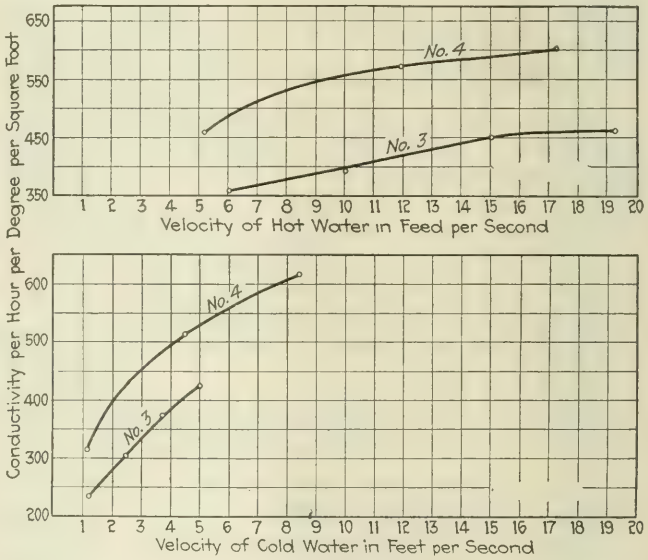


FIG. 6. TEMPERATURE EFFECT ON FILM VELOCITY

Large vs. Small Inner Pipes in Helical Cooler

As outlined above, work carried out in the investigation allowed us to learn more concerning the effect on *K* of changing the diameter of the inner pipe and incidentally to speculate further on factors which influence film velocity. The units employed for the work were larger in size. Cooler 3 consisted of 120 ft. 1½-in.



CHARTS IV AND V. RELATIONSHIPS OF WATER VELOCITIES AND CONDUCTIVITIES

lead pipe inside a 4-in. wrought iron pipe in the form of a helix 6 ft. in diameter. Cooler 4 substituted a 2-in. lead coil for the 1½-in. coil. Otherwise there was no difference. Similar series of runs were conducted as in the case of the smaller coolers. Charts IV and V show relationships of water velocities and conductivities.

These charts picture consistently the greater *K* obtained with the No. 4 cooler at average liquid velocities equal in each case. The magnitude of the differences rules out all chance of accident or inaccuracy. Our first hope was to explain this increase by some applica-

[2]Data were given in Appendix but are not included here.

tion of the film theory, and although subsequent work may confirm or reject our explanation, we will offer it for what it is worth.

It is reasonable to suppose that an increase in internal pipe diameter will, by contracting the jacket space, increase the ratio of $\frac{\text{f.v.}}{\text{a.v.}}$ in the jacket. Granting this, the greater will be the K, as far as determined by jacket velocity, as we increase the internal pipe diameter. Conversely, as the inner pipe diameter is increased, we should expect a lowering in ratio $\frac{\text{f.v.}}{\text{a.v.}}$ within the inner coil, which in turn would counteract

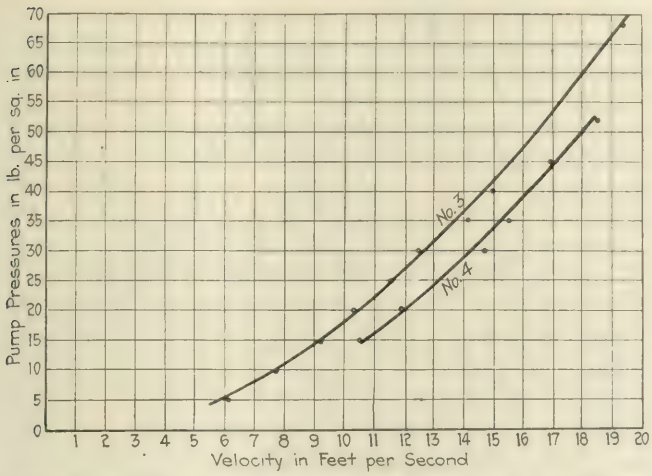


CHART VI. VELOCITY IN INNER COILS AS AFFECTED BY PRESSURE

to a certain extent the jacket water ratio. Experimental results apparently prove that this compensating effect is only partial, which means that for a given increase in cross-sectional area of the inner coil, the f.v. increases much more in the jacket than the f.v. decreases in the inner coil.

Chart VI illustrates the changes in average velocity of hot water with change in pump pressure for both No. 3 and No. 4 units. Although no data are available to cover the point, it is reasonable to suppose that similar curves for jacket water velocities would be reversed.

The curves plotted on Charts IV and V may be represented by equations.

$$K \text{ (No. 3 cooler}^3\text{)} = \frac{57.5}{\frac{1}{1 + 5V_h^{0.57}} + \frac{2.60}{1 + 10V_c^{0.57}}} \quad (3)$$

$$K \text{ (No. 4 cooler)} = \frac{80.0}{\frac{1}{1 + 5V_h^{0.60}} + \frac{2.60}{1 + 10V_c^{0.50}}} \quad (4)$$

At zero velocity of hot and cold water, No. 3 cooler (by computation) has a conductivity of 15.95, whereas No. 4 cooler would show K equal to 22.2. It is of interest to note that Molier's equation for zero velocities gives a value $K = 30.75$.

Small vs. Large Helical Heat Interchangers

In the above we have attempted to draw comparison between a straight pipe and helical cooler; also between helical coolers of different inner pipe diameters. It may be instructive to compare results obtained with the small No. 2 helical and large No. 3 and No. 4 helical units.

Charts VII and VIII show the characteristics of these three coolers grouped for comparison.

It is noted that No. 4 cooler gives highest K values, with No. 2 cooler ranking a close second. No. 3 unit is appreciably lower in K. The difference in pipe diameters as well as diameter of entire helix makes it difficult to theorize on similarities and differences.

We will, however, tabulate certain relationships which may throw some light on the subject. If $x =$ the distance from the inside surface of the jacket pipe to the center of the annular channel and $y =$ the inside radius of the inner coil, then for each of these coolers:

$$\text{No. 2} \ldots\ldots \frac{x}{y} = 0.48$$

$$\text{No. 3} \ldots\ldots \frac{x}{y} = 0.687$$

$$\text{No. 4} \ldots\ldots \frac{x}{y} = 0.406$$

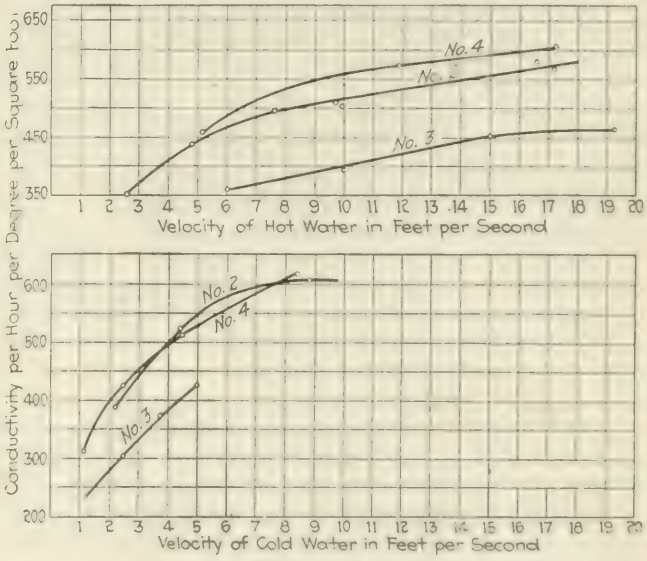
Referring to Charts VII and VIII, we note that the conductivities increase inversely as the ratio listed. This appears to be in accordance with a theory advanced earlier in the paper; viz., that a narrowing in jacket area has greater effect in increasing film velocity than a corresponding enlargement of inner tube cross-section would have in decreasing the film velocity.

Equation 2 and equation 4 show the same close relationship as pictured by the curves covering No. 2 and No. 4 coolers.

Summary

1. A double pipe heat interchanger in the form of a helix gives a marked increase in K over the same tubular parts put into the form of straight pipe lengths.

2. The film theory may account for this difference in K obtained.


Velocity of Hot Water in Feet per Second
No. 4
No. 3
Conductivity per Hour per Degree per Square foot
Velocity of Cold Water in Feet per Second
No. 2
No. 4
No. 3

CHARTS VII AND VIII. CHARACTERISTICS OF THREE TYPES OF COOLERS

3. The increase in pump pressure required with the helical unit is small in comparison with the added increase in thermal efficiency.

4. Conductivity in all cases apparently increases slightly with increase in average temperatures in the system. This may be due to an increase in ratio of $\frac{\text{f.v.}}{\text{a.v.}}$ as is explained in the contents above.

5. A helical cooler consisting of a 2-in. pipe within a 4-in. pipe gives higher conductivity than a correspond-

ing cooler equipped with a 1½-in. inner coil. A reason is offered for discussion.

6. Conductivities in helical coolers appear to vary inversely as the ratio of distance from inside surface of jacket pipe to center of jacket channel, to the radius of inner coil.

The writer acknowledges with thanks the valuable assistance of Frank M. Jones, who carried on the actual experimental work.

Appendix

Method

Water was heated to the desired temperature in a large iron tank by means of live steam. A centrifugal pump, motor driven, circulated the hot water; the velocity being regulated by means of a rheostat. The amount of water pumped out of the tank was measured by means of the drop in a gage glass.

Cold water was obtained from the river and its velocity regulated by a valve. Its flow was measured by means of a weir and hook gage.

Temperature changes were observed through four thermometers directly immersed in the flowing liquids. Melted sulphur was used to seal these in the various apertures. The thermometers were placed as near the inlets and exits of the cooler as possible. Runs were made at temperatures approximating 110, 130, 150, 170 deg. Fahrenheit scale.

Data on Apparatus Used

Tank—Height 5 ft. 6 in., diameter 4 ft. 7 in., capacity 677 gal. Water heated by live steam. Graduated water gage on side to measure outflow.

Pump—Lawrence, vortex 1½ in. discharge, single side suction, gage 5 in. from discharge to measure pressure.

Motor—Westinghouse 5 hp. constant speed, 60 cycle, two phase, 440 volts.

Weir Box—Length 12 ft., width 1 ft. 4 in., depth 1 ft. 3½ in.; contracted type, crest length 4.87 in., sharp crested. Channel of approach lined with tin, two vertical baffle plates serving to lessen surging.

Hook Gage—Of brass, reading to $\frac{1}{100}$ in.

Remarks—No. 1 straight cooler consisted of three 20-ft. lengths of 2-in. iron pipe containing 1-in. lead pipe. A surface of 36 in. of lead pipe (at the two ends) was exposed to the air and not affected by the cooling water. The under surface of the lead pipe was beaded at intervals to center it.

No. 2 helical cooler consisted of several sections of iron pipe bent to form a helical form. Three sections constituted one turn and were united by flanges. The overall dimensions were 36-in. diameter and 40 in. high. The lead coil was likewise beaded (or provided with lugs) at intervals to center it.

No. 3 helical cooler was similar to No. 2 except that 4-in. iron pipe was used for a jacket; three flanged sections to a turn; nineteen sections in all (or 6⅓ turns). The inner lead pipe was not beaded (or "lugged") but merely laid loosely inside the jacket.

No. 4 helical cooler had the same jacket as No. 3 but contained a 2-in. instead of 1½-in. lead pipe.

Calculations

Mean Temperature Difference.—The logarithmic mean was taken according to the formula (for counter-current).

$$T = \frac{(t_1 - t_4) - (t_2 - t_3)}{\log_e \frac{(t_1 - t_4)}{(t_2 - t_3)}}$$

where T = mean T. diff.
t_1 = initial hot water temperature.
t_2 = final hot water temperature.
t_3 = initial cold water temperature.
t_4 = final cold water temperature.

Conductivity

K, the conductivity constant, or B.t.u. extracted per hr. per deg. F. per sq.ft. of surface, is determined by:

$$K = \frac{A \times B}{T \times D}$$

Where A = lb. of hot water flowing per hr.
B = drop in temperature of hot water $(t_1 - t_2)$.
T = mean temp. difference.
D = sq.ft. of cooling surface.

Velocity

$$V = \frac{\text{cu.ft. per sec. flowing}}{\text{cross-section of pipe (in sq.ft.)}}$$

Weir

The weir flow was calculated from the well known Francis formula:

$$Q = 3.33(l - 0.2h)h^{1.5}$$

where Q = discharge in cu.ft. per sec.
l = width of notch, in ft.
h = height of water above notch level, in ft.

Empirical Equation of Velocity—K Curve

Since the velocities of both hot and cold water are independently variable, the desired equation connecting K with water velocity will contain three variables. In the cases in which one velocity was held constant while the other was varied, and then *vice versa*, the relation of hot and cold water velocities to K can be studied separately. The simplest way to do this is to plot on logarithmic paper values of K against those of the variable velocity, which tests for a relation of the form $K = AV^b$, where A and b are constants, or indirectly also for the similar form $K = AV^b + C$, where C is also a constant. In the former case the graph approximates a straight line, in the latter a curve which is concave upward if C is positive, downward if C is negative. The experimental data give a graph which is a curve concave downward; this is an absurd result physically, since it means that at zero velocity K is negative. Another form of equation should be sought.

The form which is suggested by Hausbrand ("Evap. Cond., & Cooling App." Revised Ed., p. 305), namely,

$$K = \frac{1}{1 + 3.3V_h^{0.50}} + \frac{1}{1 + 3.3V_c^{0.50}} \text{ (English units)}$$

has been found to satisfy the experimental data quite accurately, given slight changes in some of the numerical constants. An equation as this cannot be directly fitted to data, and a method of "cut and try" until the errors are below the experimental limit of accuracy is the only available method; on this account the constants are mainly round numbers, and the fit is not as close as might result from some method of direct solution.

Research Dept.,
Brown Co.,
Berlin, N. H.

Political and Commercial Control of the Nitrogen Resources of the World—III

A Review of the Economic Nitrogen Industry Outlook: Chilean Nitrate, Nitrogen Fixation, Byproduct and Organic Nitrogen and Byproduct Ammonia—Bibliography of Recent Literature on the Nitrogen Industry*

By CHESTER G. GILBERT†

THERE is no import duty on nitrogen, nor is there likely to be any, for nitrogen is an important cog in the mechanism of food supply, and the peace-time emphasis, reversing the war-time order, is primarily on cheapness and only secondarily on the point of origin. Accordingly, looking ahead, the American market conditions, once world trade is fully restored, are due to reflect the world conditions. As indicated in Fig. 4,[1] the sudden ending of the war with its calling off of the military requirements which had been building up steadily since even before the outbreak of hostilities in 1914, left the world with a producing capacity 30 to 40 per cent above normal. To what extent this apparent overproduction, amounting to about half a million tons of nitrogen, will prove real is impossible to foretell; not all of it certainly, for under the stimulus of a food shortage the curve of normal consumption will doubtless bend upward. On the other hand, however, there is the producing capacity of the plants not yet in operation to be taken into consideration. Whatever may be the capacity of agriculture to absorb from the surplus, it cannot be expected to take up the full amount immediately or without special inducement. The inference follows that price and production will come down to stimulate and co-ordinate with the increase in demand. Where the meeting point will be between the upcurve of demand and the downcurve of production it is impossible to predict. It is of interest, however, to figure in review on how the three types of industrial source, the natural, the byproduct and the fixation types, are equipped for the evident strife of competition implied in the situation.

Chilean Nitrate as Competitor of the Nitrogen Fixation Industry

With the development of fixation, there have been a lot of unfounded statements to the effect that the day of Chilean nitrate is passing. Whenever a synthetic development comes to the fore, a peculiar fallacy of reasoning is indulged in which ignores the fact of inherent natural worth, disregards the inescapable cost of its duplication, and regards the synthetic achievement as giving open sesame to the natural treasure. By way of substantiation in the case of nitrogen, the cost of producing Chilean nitrate is high, amounting to around $30 per ton. This, however, is largely contributed to by the unsystematized crudity of the operations, by the high export tax, and by over-capitalization. But these, it will be observed, are variable factors, susceptible of indefinite modification in keeping with the need. Chilean nitrate has never made any pretence of competing against byproduct nitrogen with its advantages in the way of low incidental producing costs and proximity to the market. The discrepancy between the byproduct supply and the total demand for nitrogen has all along comprised the field of opportunity opening to Chilean nitrate. In this its only noteworthy competitor is the fixation industry.

Variable Factors Affecting the Cost of Nitrogen Fixation

The fixation sources are impossible of analysis on a definite basis of cost. Too many variable factors and uncertainties are involved. Repeated attempts have been made, but all they have served to bring out is that under certain conditions, as for instance cheapness of power supply, and for certain purposes, one form of project has an apparent margin of advantage over another, and vice versa for other conditions, but that at best the cost of production, if not actually prohibitive, is dangerously close to the normal pre-war price of fixed nitrogen. Back of it all is the fact that fixation has to deal with the problem of overcoming the native chemical inertia of nitrogen, and the problem has not yet been solved at all convincingly. Always the solution advanced has called for some special measure of relief from industrial competition, whether natural as in the case of the Scandinavian power supply, or political as in the case of the American and German projects.

Prospects for an Economical Nitrogen Fixation Industry

Fixation has been widely heralded of recent years as due not only to emancipate the world from its dependence upon the Chilean source, but to reduce materially the cost of nitrogenous fertilizer, hence the cost of food production, to the marked betterment of living conditions as well. In its promise of political and economic betterment in one, it has claimed the attention of all. However, the claim of special economic advantage coming from an industry barely, if at all, able to meet conditions even as they are has been overdrawn. This does not aim to imply that there is nothing but failure ahead for fixation in the test of competition. It has its possibilities of development into something commercially and economically as well as politically worth while, but the existing hothouse order of upgrowth is unquestionably due for a lot of training down, and much that is worthless is as certainly due to go. The American developments have a particularly inauspicious economic setting in the prevailing scale of costs. The only saving alternative for them

---

The basis of this article by Mr. Gilbert was issued in mimeographed form for Government use only as one of the Political and Commercial Geology Series prepared under the direction of J. E. Spurr, to whom book rights are reserved.

*For Parts I and II see CHEM. & MET. ENG., vol. 22, Nos. 10 and 11, March 10 and 17, 1920, pp. 443 and 501.

†Curator of Mineral Technology, U. S. National Museum.

[1]See CHEM. & MET. ENG., vol. 22, No. 10, p. 447.

would seem to be in one form or another of Federal provision for their continued support on some such basis as that on which they were projected, and this is unlikely, for there is no apparent reason. True, lowered nitrogen costs tend to make for a lowering in the cost of foodstuffs, but so, for that matter, would a lowering in the cost of agricultural implements, and any arguments that apply in the case of nitrogen apply as equally for potash, for phosphate, for agricultural implements, for coal; in fact, for industry in general.

Outlook for the Byproduct Nitrogen Development

With reference to byproduct nitrogen the situation is very different. In general, the byproduct sources are of an order such that they were not materially affected one way or the other by the war, and consequently are not due to be materially affected in the process of readjustment, except in the case of coke-oven ammonia, where the temporary slump in the steel industry will result in a temporary slump of probably 15 to 20 per cent from the 1918 output. Of special significance in connection with what lies on beyond for the byproduction of nitrogen is its relationship to the progress of industrial co-ordination. The whole current trend of industrialism as represented, integration, volume production, and the like, is actuated in the interests of co-ordination and the overcoming of lost motion; and nitrogen comes in for an important share in these developments.

Outlook for Organic Nitrogen Development

With reference to the organic group of compounds, the outlook for the future is as uncertain as the actual conditions of today. The centralized development of meat-packing, of animal-rendering establishments, and of cotton ginning gave rise in their time to highly important recoveries of nitrogenous waste; but with the forward progress of developments this usage in turn is giving way to a more advanced order. Cottonseed as a fertilizer is giving place to a cottonseed products industry; tankage as a fertilizer is giving place to the artificial compounding of animal food; horses, an important contributor of agricultural nitrogen in times past, are yielding much of their place in the sun to the automotive engine. Meanwhile, with the factor of dilution to be overcome, our sewage disposal is employed to pollute streams and destroy the fish supply instead of being put to useful ends. So it goes. Developments are on foot that lead in both directions, and there is no telling how the balance is due to shift. Probably the best guess is that relatively at least it will be downward rather than upward.

Outlook for Byproduct Ammonia

The outlook for byproduct ammonia is more definite. Ammonia is the end point of material refinement, so here the nitrogen developments hold all they get rather than going on to lose out again in a further refinement of usage, as in the case of the organic group. The output has increased consistently and rapidly, owing to the transition from beehive to byproduct coking operations, to the progress of centralization and co-ordination—in other words, with reference to coke manufacture. Even now, less than half of the coal coked is treated in the retort oven; but the beehive oven is out of the line of progress and is due to be entirely displaced. Also, the industry is still expanding as the process of transition with its separate potentiality for doubling the present output of coal-product ammonia goes forward.

So far, the recovery of byproducts in connection with the use of coal has been confined in the one direction of coke making, along with the analogous procedure of gas manufacture. But the development which has thus started in the coke industry will not stop there. The loss of motion resulting from lack of co-ordination in the use of coal is just as great in other directions as in that of coke making, and the advantages of integral usage may confidently be expected to assert themselves. Already projects of the kind are coming under serious contemplation in proposals such as those for furnishing gas to cities, for employing byproduct operations located at the mine in support of the waning natural gas supply, and for integrated heat, light, and power projects operating on coal with byproduct recovery. Meanwhile, the motor-fuel situation is suggestive of interesting developments ahead. There is every reason to believe that the petroleum resources cannot continue to meet the growing demand, in fact, that the occasion for support is already at hand. Whatever the nature of these supporting developments, whether they take the form of a shale oil industry or what, it seems certain they will usher in an important source of byproduct nitrogen.

Summary

Fig. 3 summarizes the American situation with reference to chemical nitrogen, as does Fig. 4 in less detail that for the world. Organic nitrogen is omitted, partly because of the lack of information, partly because the issues more directly involved in the situation as it stands are those of chemical nitrogen.

Bibliography

General

Mineral Resources of the United States. Issued annually by the United States Geological Survey.

The American Fertilizer Handbook. Published annually by Ware Brothers Co. of Philadelphia.

Statistical publications. The International Institute of Agriculture, Bureau of Statistics, Rome.

Roeber, *Mineral Industry*, vol. 19, pp. 58-67, 1910.

The Fertilizer Industry, U. S. Federal Trade Commission Report, 1916.

Gilbert, C. G. "Sources of Nitrogen Compounds in the United States." Publication 2421, Smithsonian Institution, 1916, 12 pp.

Martin and Barbour. "Industrial Nitrogen Compounds and Explosives." D. Appleton & Co., New York, 1916.

Brown, F. W. "Sources of Our Nitrogenous Fertilizers." United States Department of Agriculture Yearbook, 1917, pp. 139-146.

Hosmer, Helen R. "Literature of the Nitrogen Industries, 1912-1916." *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 424-438, 1917.

Nauchkoff, S. "How Do the Warring Nations Obtain Their Nitrogen Supply?" Metallurgical & Chemical Engineering, vol. 17, pp. 525-536, 1917.

"Work of the British Nitrogen Products Committee." Metallurgical & Chemical Engineering, vol. 18, pp. 77-81, 1918.

Mineral Nitrates

Metodo de Esplotacion del Salitre Chileno por Medio de Palas a Vapor. *Bol.*, Soc. Nac. de Mineria, March-April, 1913.

Junghann, H. Die Saltpeterindustrie Chiles unter besonderer Berucksichtigung ihrer Wirtschaftslage. *Glückauf*, March 7, 1914.

Lamb, M. R. "Chilean Nitrate Industry." *Engineering and Mining Journal*, vol. 99, pp. 811-815, 1915.

Singewald, J. T., Jr., and Miller, B. L. "Genesis of the Chilean Nitrate Deposits." *Economic Geology*, vol. 11, pp. 103-114, 1916.

"Chilean Nitrate." *Pan American Magazine*, vol. 25, pp. 273-298, 1917.

Hobsbawn, I. Berkwood. "Nitrate Industry in Chile." METALLURGICAL & CHEMICAL ENGINEERING, vol. 16, pp. 253-259, 1917.

Rogers, A. H., and Van Wagenen, H. R. "Chilean Nitrate Industry." *Bulletin* of the American Institute of Mining Engineers, No. 134, pp. 505-522, 1918.

Irvin, D. F. "Chilean Nitrate Industry During 1918." *Engineering and Mining Journal*, vol. 107, pp. 265-267, 1919.

BYPRODUCT NITROGEN (ORGANIC)

Vageler, P. "Die Bindung des atmosphärischen Stickstoffs in Natur und Technik." Braunschweig, Vieweg, 1908, 132 pp.

Jodidi, S. L. "Chemistry of the Soil Nitrogen." *Journal* of the Franklin Institute, vol. 175, pp. 483-495, 1913.

Headden, W. P. "Excessive Quantities of Nitrates in Certain Colorado Soils." *Journal of Industrial and Engineering Chemistry*, vol. 6, pp. 587-590, 1914

Sullivan, M. X. "Nitrates in Colorado Soils." *Journal of Industrial and Engineering Chemistry*," vol. 6, pp. 532-533, 1914.

Sackett, W. G., and Isham, R. M. "Origin of the Niter Spots in Certain Western Soils." *Science* (new series), vol. 42, pp. 452-453, 1915.

Stadler, W. "Niter Spots." *Science* (new series), vol. 43, pp. 712-713, 1916.

Copeland, W. R. "Is the Recovery of the Nitrogen in Sewage Sludge Practicable?" *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 374-376, 1917.

O'Brien, W. J., and Lindemuth, John R. "The Fertilizer Value of City Waste. I. The Composition of Garbage." *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 49-54, 1917.

Schroeder, P. J. "The Fertilizer Value of City Waste. II. Garbage Tankage. Its Composition; the Availability of Its Nitrogen, and Its Use as a Fertilizer." *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 513-518, 1917.

Fred, E. B., and Davenport, A. "Influence of Reaction on Nitrogen-Assimilating Bacteria." *Journal of Agricultural Research*, Article 14, pp. 317-334, 1918. (Published by the United States Department of Agriculture.)

Genoud, Ernest G. "The Use of Micro-Organisms in Chemical Industry." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 616-617, 1918.

Hendrick, Ellwood. "Micro-Organisms in Plant Chemistry and Nitrogen Fixation." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 574-576, 1918.

BYPRODUCT NITROGEN (CHEMICAL)

Atwater, C. G. "Nitrogen and Nitrates From Bituminous Coal." *Gas Age*, vol. 38, pp. 403-405, 1916.

Childs, William H. American Iron and Steel Institute, May, 1916.

Koppers, H. Co., Pittsburgh, Pa. "Byproducts of the Coking of Coal in America." 1916.

Porter, H. C. "Coal and Coke Byproducts as a Source of Fixed Nitrogen." METALLURGICAL & CHEMICAL ENGINEERING, vol. 15, pp. 470-475, 1916.

Riley, L. A. "Byproduct Coal Ammonia as a Domestic Nitrate Source." METALLURGICAL & CHEMICAL ENGINEERING, vol. 15, pp. 112-113, 1916.

Atwater, C. G. "Sulphate of Ammonia: Its Source, Production, and Use." Issued by The Barrett Co., New York, 1917.

Woodward, Clarence R. "Recovering Ammonia at Tar-Distilling Plants." METALLURGICAL & CHEMICAL ENGINEERING, vol. 18, pp. 299-301, 1918.

FIXATION NITROGEN

Norton, Thomas H. "Utilization of Atmospheric Nitrogen." Department of Commerce and Labor, Bureau of Manufactures, Special Agents Series No. 52, pp. 1-178, 1912.

Tucker, S. A., and Read, H. L. "Fixation of Nitrogen by Alumina and Carbon." *Transactions* of the American Electrochemical Society, vol. 22, pp. 57-66, 1912.

Perlick, "Die Luftstickstoff Industrie in ihrer volkswirtschaftlichen Bedeutung." Leipzig, 1913.

Scott, E. K. "Manufacture of Nitrates From the Atmosphere." Annual Report of the Smithsonian Institution, 1913, pp. 359-384.

Baekeland, L. H. "Some Aspects of Industrial Chemistry." METALLURGICAL & CHEMICAL ENGINEERING, vol. 12, pp. 557-560, 1914.

Haber, Tamaru, Oeholm. *Z. Elektrochem.*, vol. 21, pp. 191-245, 1915.

Haber, Tamaru, Ponnaz. *Z. Elektrochem.*, vol. 21, pp. 89-106, 1915.

Landis, W. S. "Fixation of Atmospheric Nitrogen." *Journal of Industrial and Engineering Chemistry*, vol. 7, pp. 433-438, 1915.

Summers, Leland L. "Fixation of Atmospheric Nitrogen." *Transactions* of the American Electrochemical Society, vol. 27, pp. 339-383, 1915.

Washburn, Frank S. "The Cyanamide Process." *Transactions* of the American Electrochemical Society, vol. 27, pp. 385-407, 1915.

Addicks, L. "Conditions Affecting the Establishment of the Nitrate Industry in the United States." *Journal of Industrial and Engineering Chemistry*, vol. 8, pp. 1048-1050, 1916.

Nitrate Supply Committee Recommendations on Synthetic Nitric Acid for the Government, With Reports on Various Methods. *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 829-841, 1917.

Boyce, John C. Bibliography of the Production of Synthetic Nitric Acid and Synthetic Ammonia. Part I, Literature; Part II, British, German, American, and French Patents. METALLURGICAL & CHEMICAL ENGINEERING, vol. 17, pp. 328-337, 1917.

Bucher, John E. "The Fixation of Nitrogen." *Journal of Industrial and Engineering Chemistry*, vol. 9, pp. 233-253, 1917.

Maxted, Edward B. "The Synthesis of Ammonia and the Oxidation of Ammonia to Nitric Acid." METALLURGICAL & CHEMICAL ENGINEERING, vol. 17, pp. 345-349, 1917.

Landis, W. S. "The War and the Nitrogen Industry." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 828-830, 1918.

Scott, E. Kilburn. "Direct and Indirect Methods of Nitrogen Fixation." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 411-414, 1918.

Scott, E. Kilburn. "Nitrogen Fixation Furnaces—I." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 710-715, 1918.

Scott, E. Kilburn. "Nitrogen Fixation Furnaces—II." CHEMICAL & METALLURGICAL ENGINEERING, vol. 19, pp. 757-761, 1918.

Fairlie, Andrew M. "Muscle Shoals Nitrate Plant." CHEMICAL & METALLURGICAL ENGINEERING, vol. 20, pp. 8-17, 1919.

Hollister, H. E. and C. E. "Erection of Huge Sulphuric, Nitric, Mixed Acid, and Denitrating Plant Under War Pressure." CHEMICAL & METALLURGICAL ENGINEERING, vol. 20, pp. 406-412, 1919.

Landis, W. S. "The Oxidation of Ammonia." CHEMICAL & METALLURGICAL ENGINEERING, vol. 20, pp. 470-477, 1919.

Parsons, Charles L. "The Oxidation of Ammonia." CHEMICAL & METALLURGICAL ENGINEERING, vol. 20, pp. 502-503, 1919.

White, Alfred H. "The Present Status of Nitrogen Fixation." *Journal of Industrial and Engineering Chemistry*, vol. 11, pp. 231-237, 1919.

Polish Salt Resources and Production

Rock salt is one of the most important natural resources of the new State of Poland. The production of salt in Polish territories just prior to the war was approximately as follows: Former Austrian Poland (Galicia), 141,215 metric tons; former German Poland (Poznania), 81,269 tons; former Russian Poland, 3,007 tons; total, 225,491 tons.

There is no doubt that these Polish salt deposits are capable of much more intense exploitation and, under proper organization, they could probably become the base for several branches of the chemical industry. This is one of the Polish industries wherein American capital would probably be welcomed at the present time.

Galicia also possesses at Kalusz the only potassium salt mines, besides those at Stassfurt, Germany, and a company has recently been formed to exploit this deposit. These Kalusz salts are composed chiefly of kainite and sylvite. The production of kainite, which amounted in 1893 to 4,000 tons, had risen in 1913 to about 17,500 tons, valued at $47,000. This deposit also was worked before the war by the Austrian Government, and it is hoped that now, under private initiative, it will become a considerably greater source of revenue.

American Beet Sugar Industry

IN ADDRESSING the Detroit Engineering Society on Jan. 23, Martin J. Kermer, chief engineer of the Cannon-Swenson Co., Chicago, spoke at length on processes employed in refining and economic features surrounding the sugar industry at present.

The total world production of sugar for 1919, expressed in terms of refined, is approximately 16,500,000 tons of 2,000 lb. each. Of this, the United States produced 915,000 tons, of which 795,000 tons were beet and 120,000 tons were made from cane. In other words, the United States produced approximately 5½ per cent of the world's supply. In regard to our consumption, we used last year approximately 4,000,000 tons, or 22,200,000 lb. per day, or 76 lb. per capita per annum. We are, therefore, consuming one-fourth of the world's production. We are producing approximately 23 per cent of what we consume. Another 24 per cent comes from Hawaii, Porto Rico and the Virgin Islands; while the remainder, over 53 per cent, comes from the Philippine Islands, Cuba, and foreign countries.

Consumption per Capita

It is interesting to note that from 1865 up to 1914 our consumption of sugar per capita per annum has gradually increased from 18 to 89 lb. Ever since the war started this consumption has been reduced year by year due to the shortage of production, which necessitated our restrictions. Today the world's production is 2,800,000 tons less than it was in 1914. If we consider the annual increase of consumption per capita for this country from 1900 to 1914, it is safe to say that we would have reached 100 lb. per capita per annum if conditions were normal.

In the period 1904-13 the average yearly consumption per person in countries named was as shown in Table I.

TABLE I. PER CAPITA CONSUMPTION OF SUGAR

	Lb.		Lb.
Australia	113	Belgium	26
United Kingdom	85	Russia	14
Germany	30	United States	78
France	28		

Comparative Production

Previous to the war the United States ranked fourth in beet sugar production, today second. This is due to decreased production in Europe, as shown by Tables II and III.

TABLE II. BEET SUGAR PRODUCTION IN THE UNITED STATES

	Tons		Tons
1913-1914	726,000	1917-1918	766,000
1914-1915	724,000	1918-1919	762,000
1915-1916	872,000	1919-1920	795,000
1916-1917	824,000		

TABLE III. COMPARATIVE PRODUCTION OF BEET SUGAR

	1913-14 Tons	1919-20 Tons
Germany	2,920,000	800,000
France	877,000	165,000
Austria	1,870,000	16,000
Czechoslovakia	.....	700,000
Poland	.....	300,000
Russia	1,918,000	None
Belgium	252,000	112,000
United States	726,000	795,000

In 1913-14 Europe produced 9,827,000 tons, and 3,503,000 in 1919-20, a decrease of over 6,300,000 tons.

Before the war, Europe had about 1,250 beet sugar factories in operation, and the European countries have realized for a long time the importance of the beet sugar industry. These governments were justified in encouraging the sugar industry, as it not only meant the development of the industry proper, but also its allied industries.

Production Should Be Increased at Home

The United States has ninety-nine factories in operation, which should be increased to 500 factories to satisfy domestic consumption. Comparing with Europe, the area is about three-quarters the total. If our beet sugar industry were developed in proportion to areas, the United States would have 930 factories in operation, or ten times the present number.

About $420,000,000 is spent abroad for importing sugar to this country each year. The distribution of this sum at home means something when analyzed.

If we say that our sugar consumption is 4,000,000 tons per year, that 23 per cent is produced in the United States proper, 24 per cent from Hawaii and Porto Rico; then the remainder, 53 per cent, or 2,100,000 tons, has to be imported. If we figure this at 10c. per lb., it means that we are sending to foreign countries $420,000,000.

The mere fact that we are sending over $400,000,000 out of the country for a product which we could produce ourselves does not signify so much until we begin to analyze how this money would have been distributed among our own people had we produced this sugar ourselves.

Supposing this sugar was made from beets, containing, say, 15 per cent sugar, at twelve tons of beets per acre, while the factory would have an extraction of 83 per cent. Then for every ton of sugar we require eight tons of beets, or a total of 16,800,000 tons of beets produced on 1,400,000 acres of land. This would mean that the sugar companies would pay the farmers $168,000,000 for beets; the farmer pay his laborers for preparing the soil, planting, cultivating and harvesting his crop, $90,000,000; while the farmer would have about 4,000,000 tons of beet tops left on his land after the crop was removed, which represents valuable cattle feed after it has been properly siloed. This would feed and fatten some 2,000,000 steers for 120 days.

The factories would be paying, during a campaign of approximately 100 days, $20,000,000 for labor in the factory for producing sugar from beets, $13,000,000 for coal, $20,000,000 to the railroad company, and $47,700,000 for miscellaneous items such as coke, lime rock, bags, maintenance and repairs.

If these factories would have pulp drying plants such as all modern factories have, they would produce 840,000 tons of dried pulp, which is also valuable cattle feed and would represent a value of approximately $27,000,000. In order to produce this 840,000 tons of dried pulp, the sugar company would spend in the neighborhood of $3,000,000 worth for labor. Approximately $113,000,000 is paid out for direct labor. If we consider the turnover of this amount alone, we get figures that would astonish us.

It is the money set in circulation by the sugar companies and farmers for labor and materials that pay for harbors, highways, schools and churches, and support our universities, and make it possible to further develop our lands, railroads and allied industries.

La Belle Coke Plant

By G. P. Blackiston

BEING the first Koppers byproduct coke plant in the Pittsburgh district, excluding Youngstown, and the only modern plant of its kind in the Ohio Valley, is the distinction which belongs to the new ninety-four oven Koppers plant of the La Belle Iron Works, located on the south bank of the Ohio River, opposite the company's main plant at Steubenville, Ohio.

The new plant, which has two batteries, each of forty-seven standard Koppers 12½-ton ovens, and is planned to permit duplication, replaces beehive ovens formerly operated by the company at La Belle, Pa.

Location of the Plant

It was the original plan of the owners to build the plant on the Ohio side of the river, adjacent to the Steubenville mill and furnaces, but the West Virginia site was decided upon when it was found impossible to secure enough land contiguous to the present plant to allow room for future expansion. The choice of the West Virginia site added considerably to the cost of the plant. A great amount of extra foundation work was necessitated, and a fill of 15 to 20 ft. over the entire site was required to bring the plant to an elevation above the flood stage of the river. The ovens themselves were carried 8 ft. above the new level

BRIDGE CONNECTING COKE PLANT WITH THE STEUBENVILLE WORKS

in order to bring the stack flues above the flood stage. An excess of 900 yd. of filling material was placed on the site and more than 70,000 yd. of concrete was used in the construction of foundation. Void wall construction was used in the oven foundation, which extends to a depth of 28 ft. below the oven mat, the voids being filled with granulated slag. Piers and curtain walls were used in the foundations of all the buildings and the floors were laid on a granulated slag fill. All underground conduits were laid before the fill was made, being erected on concrete piers.

Connection Between the La Belle, Pa., and Steubenville, Ohio, Plants

To provide traffic communication between the two plants and insure an uninterrupted supply of fuel for the furnaces, it was necessary for the company to erect and maintain its own bridge across the river. This structure, which is of the cantilever type, is 1,520 ft. in over-all length, and consists of four 100-ft. girder spans, two 30-ft. anchor spans, and a main channel span 660 ft. long. It was planned and built by the American

GENERAL VIEW OF BYPRODUCT PLANT, SHOWING LOADED COAL BARGES IN HARBOR, COAL UNLOADING DOCK, COAL HANDLING AND PREPARING PLANT, OVENS AND BYPRODUCT BUILDINGS

Bridge Co., and is the first cantilever bridge ever erected without a traveler or creeper, a crane with 110-ft. boom being used in its erection throughout. The supporting piers are of reinforced concrete 120 ft. high, which were sunk to bedrock, a distance of 43 ft. below pool level, the caisson method being employed.

Coal Supply and Transportation

A unique feature of the new plant is the coal-handling system. The coal used, excepting a small percentage which is mined in the nearby West Virginia fields and brought to the plant by railroad, is transported over the Monongahela and Ohio Rivers from the Pennsylvania coal district. For this purpose barges having a capacity of 350 to 600 tons are used, the barges being towed down the river in fleets of six to ten. Harbor facilities are provided where approximately thirty loaded barges may be tied up awaiting their turn at the unloading dock, while the same number of empties can also be accommodated. A truck hopper handles the coal shipped in by rail and a storage yard of 100,000-ton capacity is provided to insure an adequate supply for use during the winter months when the river may be closed to navigation.

Unloading Coal Barges

Coal is unloaded from the barges by two Heyland & Patterson traveling gantry cranes, with 100-ft. bridge. These cranes are each mounted on four two-wheeled trucks and travel over a 20-ft. gage track,

COKE SIDE OF OVENS AND COAL GALLERIES

PUSHER SIDE OF OVENS, SHOWING COMBINED COKE PUSHER AND LEVELING MACHINE

so that they may also be used to handle coal in the stock yard. They are equipped with 3½-ton buckets, and have a hoisting speed of 500 ft. per min. The buckets are specially designed with a view to clean unloading in minimum time with minimum labor.

When unloading, the crane remains stationary on the dock, the barge being moved along the dock by an electrically operated barge shifter. Under normal conditions the coal is dropped into a small hopper located on the dock. It is then fed through the bottom of this hopper into a 30-in. conveyor belt, which in turn discharges it into the track hopper. If it is desired to stock the coal from the river, empty cars are placed over the track hopper and the coal is discharged from the conveyor into them.

Coal Storage

Loaded cars are moved by means of a cable haul to one of the several unloading pits which are located every 125 ft. along the entire length of the storage yard. From these pits the coal is transferred to the storage pile by one of the gantry cranes. When it is desired to use coal from stock this operation is reversed, the crane loading the cars, which are then transferred to the track hopper and unloaded.

The unloading dock, which is 100 ft. long and has a 100-ft. fender at each end, was built by the National Contracting Co., of Cleveland, Ohio, while the coal-handling system and storage-yard system was designed and built by the Heyland & Patterson Co., of Pittsburgh, Pa.

From the track hopper, coal is carried by a short length pan conveyor to a 36-in. conveyor belt, which,

COKE WHARF AND SCREEN STATION IN BACKGROUND

driven by two 50-hp. G. E. motors, travels on a 20-deg. incline to the top of the breaker building, where it delivers the coal to the Bradford breaker. From the breaker which removes the slate and sulphur, the coal, having been reduced to 1½-in. lumps, is carried by a conveyor belt and discharged into the proper one of three mixing bins. From the mixing bins it is fed by gravity into the regulator by adjustable gates, so that any desired percentage of each grade of coal can be secured. The three mixer belts discharge into the same chute, which leads to the hammer mills, where the coal is pulverized to a fineness of 85 per cent through a ⅛-in. screen. It is then elevated by conveyor belts to the 1,800-ton storage bin located above the charging floor and between the two batteries of ovens. Rovins-Conveyor Belt Systems are employed throughout.

Electric Handling Equipment

The chutes on either side of the hammer mills are equipped with rotary feeders, which insure an even and constant feed and eliminate about 90 per cent of the dust which is so common about coal-handling plants.

BENZOL BUILDING, SHOWING WASH OIL COOLERS, CIRCULATING TANKS AND OVENS IN THE BACKGROUND

All the coal-handling equipment is individually motored and the control is interlocked in such a way that no conveyor belt or crusher can be started or operated until the machine next in progression is in operation; in this way spillage or piling up of the coal, if one machine should stop while the operator or attendant is not present, is eliminated; three-phase, 220-volt, alternating current is used throughout the coal-handling plant, which is equipped with General Electric motors throughout.

All the control boards for the various motors are housed in the control building, which is located at a sufficient distance from the main plant that the delicate electrical control instruments may not be injured or incapacitated by coal dust; a push button located near each motor enables the operator to stop and start the machine at will.

Coke Ovens

The pulverized coal from the storage bin is fed by gravity into one of the two (Morgan) charging machines. The ovens are of the standard Koppers 30-flue type, and the heating system is so arranged that gas is burned in the fifteen flues at one end of the furnace and the heated air and products of combustion pass out through the remaining fifteen flues

INTERIOR OF BENZOL BUILDING, SHOWING CRUDE AND PURE STILLS

to the flue stack, giving off heat as it goes. This arrangement is reversed every 30 min., insuring a continuous even heat at all times. This change is made automatically, the gas valves, stack dampers and draft dampers being controlled from the control house, which is situated between the two batteries of ovens. The entire operating mechanism is governed by an electric clock, no attendant being required. The machines which operate these valves and dampers are electrically driven, but a steam engine is provided for use in an emergency.

In the central building are also located a venturi gas meter for recording the gas consumed, and other devices for indicating the temperature, gas production, etc.

Coke Handling

The discharging, quenching and handling machinery is all standard Koppers equipment. The coke, after quenching and cooling, is dumped into a wide chute, from which it is fed through gates into a conveyor belt, on which it is carried to the grader, where it is graded into various sizes. Some is transported across the river to the furnaces, some sold for commercial consumption and the breeze used in the power plant.

Byproducts Plant

The byproduct gas given off at about 1,000 deg. C. is collected in a 16-in. main, through which it is drawn by two Connersville Stove Blower Co.'s steam-driven gas blowers at 128 cu.ft. displacement, driven by a 250-hp. Harrisburg Foundry & Machine Co. compound engine, and forced through water-tube coolers, where it is cooled to about 28 deg. C. The sudden cooling condenses the tar vapors; the tar is run off into a settling reservoir. Here the gas liquors which are contained in the condenser, being lighter than the tar itself, rise to the top and are drained off. The tar in this state is pumped to the nearby plant of the American Tar Product Co.

The gas, relieved of its tar contents, passes into the reheater, where it is brought to a temperature of 60 deg. C. and forced into the saturator, and the ammonia is removed as ammonium sulphate.

The byproducts plant is equipped with four water-tube coolers, tar extractor, reheater, saturator ammonia stills and draining tables and centrifugal driers for the ammonium sulphate, for which a 2,500-ton storage room is provided, three benzol scrubbers, two continuous condensing stills for benzol vapor, agitators, fractional condensing stills where the light oil is fractionated into crude benzol, crude toluol, crude light solvent naphtha, crude heavy solvent naphtha, agitators and four 8,000-gal. purification stills where the pure products are produced and two final coolers for the gas.

Pumping Equipment

Three Gould 20,000-gal. circulating pumps are employed to keep the water in circulation through the water tube coolers. A tar-loading pump of 10,000-gal. capacity and two 6,000-gal. hot drawing pumps are provided, together with two 6,000-gal. ammonia pumps, driven by 150-hp. Westinghouse motors for circulating the ammonia liquor through the stills. Six Gould wash oil circulating pumps with a capacity of 15,000 gal. per min. against a 180-ft. head are employed in connection with the benzol scrubbers. There are also two 150-hp. Westinghouse motor Gould single-stage circulating pumps with a capacity of 3,000 gal. per min.

The other pumping equipment, in addition to two air compressors which furnish compressed air for general use, includes a 250-hp. Westinghouse motor-driven gas pump which pumps the surplus gas through a 16-in. main over the bridge to the Steubenville furnace, and a 200-hp. Westinghouse motor-driven Ingersoll-Rand type 10 Imperial gas pump.

All pumping machinery is electric motor driven, but has emergency steam drive.

Power Plant

The power plant, which forms a separate unit, consists of four 400-hp. Stirling water tube boilers which are fed by two Epping Carpenter 12 x 7 x 12 boiler feed pumps. The boiler water is heated in a Cochrane feed water heater.

The boilers are equipped to burn either gas or coke breeze, but the coke breeze is generally used, being burned on a Cox chain grate with forced draft.

Electric current is supplied by the West Pennsylvania Power Co. from its Beech Bottom, W. Va., plant, being received at the plant at 22,000 volts, 60 cycle, three phase, but is stepped down to 2,200 and finally to 220 by a series of Westinghouse transformers.

Two G. E. motor generators, Type M. P. C. 6,500-200 Form L 200 amp., are used to furnish the direct current required in the plant.

Other notable features of the plant include a model laboratory, one office building, coal test building, and service building which is equipped with individual chain hangers for the clothes of the employees, showers, toilet accommodation, etc.

BOILER HOUSE, POWER STATION, TIME OFFICE, GENERAL OFFICE AND TAR STORAGE TANKS

Legal Notes

By Wellington Gustin

Mutual Releases in Settlement of Claims No Bar to Recovery of Metals

From the Supreme Court of New York comes a case arising out of cancellation of war contracts. The parties had made a settlement of a claim for damages on account of a breach of contract. The plaintiff claimed that the terms of settlement required the return to it of certain metals, which the defendant refused to deliver on the ground that a general release delivered to him along with plaintiff's check for $8,500 "in full settlement" concluded the entire transaction. (R. A. Union Metallic Cartridge Co. vs. Atkinson, 177 N. Y., 723.)

It appears that plaintiff had taken a contract from the French Government and part of the order was re-contracted for with the defendant. The French Government cancelled its contract with the plaintiff, which in turn cancelled its own contract with the defendant after part of the supplies had been made and delivered to plaintiff. Defendant thereupon presented his bill for damages, in three items: First, prospective profit; second, metals on hand; third, depreciation on other metals used by defendant outside the contract. Controversy arose over the claim for prospective profits. Plaintiff offered to settle this if it be reduced one-half. Reaching no agreement, suit was instituted by the defendant. During progress of this suit terms of settlement were discussed. Finally defendant's counsel offered to throw off $1,000 from the profits item, and the plaintiff's counsel replied, offering to pay $8,500 in full settlement.

The court here said that had the defendant's acceptance of this offer been unqualified, there was no doubt that he would have been obligated to return the metals, for their delivery was unquestionably contemplated in all previous negotiations. But instead of an unqualified acceptance of plaintiff's offer, defendant's counsel added, "if mutual general releases can be exchanged at the same time." This modification was accepted, the $8,500 paid and the general releases exchanged. When a few days later plaintiff asked for the return of the metals, defendant's attorney ruled that the release of the defendant given by plaintiff barred its claim. Then this suit was started by the plaintiff to recover the value of the metals.

That the offer of $8,500 was conditional upon the return of the metals—an item of $3,927.09 in the invoice claiming the damages—is unquestionable, said the court. In the light of the invoice as presented and of the protracted controversy concerning its principal items of prospective profits, throughout all of which the return of the unused metals to the plaintiff was an understood condition, to be performed as soon as the amount of the invoice should be agreed upon and paid, what is the reasonable construction to be placed on the acceptance of the offer of $8,500 in full settlement "if mutual general releases can be exchanged at the same time" became the point to be determined by the court. Did the additional clause have the same force and effect as if it had read, "Your offer is accepted on condition that the metals are not to be returned"? That is impliedly the stand taken by the defendant. But the court thought otherwise. "I think not," said the court, "whether the question is viewed as one either of fact or of law."

"There is no such magic in the condition that releases be exchanged as can obliterate all that had gone before. . . . The obligation to return the metals grew out of that transaction, was a part of it, and the release from the plaintiff to the defendant did not bar it. It was, indeed, a part of the consideration for the release."

Plaintiff, being held entitled to the metals in defendant's hands, was held entitled to their market value on the date of the demand for their delivery, with interest.

Compliance With Statute Requiring License for Sale of Fertilizer

In an action of assumpsit to recover on a note given for the price of fertilizer sold to defendant, he defended on the ground of illegal consideration for the note, in that it was given in payment of fertilizer to parties who, at the time of sale, did not have a state license authorizing them to make a sale as required by law. These parties testified they were a partnership having a contract with the Dothan Chemical Co., otherwise known as the Alabama Chemical Co., both companies being one and the same and under the same management. Under the contract the fertilizer was shipped on consignment to the partnership as trustee for the company, the property remaining in the company until sold and paid for, and when sold all proceeds, including cash, notes, open accounts, mortgages, securities therefor, etc., were to be kept separate and held by the partnership as trustee for the company, and turned over as collateral security and pledge against the notes of the partnership until their indebtedness under the contract of sale was paid in full. (Bowdoin vs. Alabama Chemical Co., 79 So., 4.)

The two questions presented for decision were: First, whether a contract of sale of commercial fertilizer made without the seller's first having taken out a license as required by the statute is void; and second, if it be void, did the sales contract in this case between the partnership and the Dothan Chemical Co. create the relation of principal and agent as regards the sale of the fertilizer in question?

Said the Alabama Supreme Court: The rule in this state is that, if a statute was not designed to prohibit the making of contracts without previous compliance with statutory provisions, but was intended merely to provide revenue, it is not void if no specific prohibition or penalty is provided or imposed. If the conditions of the statute were made for the benefit of the public, and not for the purpose of raising revenue only, an agreement is void that does not comply with the statutory conditions.

In the adoption of the statutes in question the legislative intent and primary purpose was to protect the public against being sold worthless or deleterious compounds represented as commercial fertilizers, and not merely to raise revenue, so held the court.

Referring to the second question, the court held that the contract and testimony of the partner showed the partnership was selling as agent of the chemical company, and therefore the statutes were complied with on proof that the chemical company was issued a fertilizer license by the Commissioner of Agriculture covering the period for which the sales were claimed illegally made. The contract between the partnership and the chemical company being interpreted as one of agency instead of sale, the sale to defendant for which the note was given was held to be valid, having been made under the license held by the chemical company.

A New Aluminous Abrasive

By Otis Hutchins

FOR some time the mechanical industry has needed an abrasive which could be bonded into a wheel having extraordinary sharpness, fast, cool-cutting ability, uniformity and long life—a wheel that would not only have these qualities but at the same time would be what might be termed open and "brittle" so far as its structure was concerned. Such a combination of virtues was extremely necessary in the wheels that are principally used in the grinding of high-speed and case-hardened steel and for surface grinding.

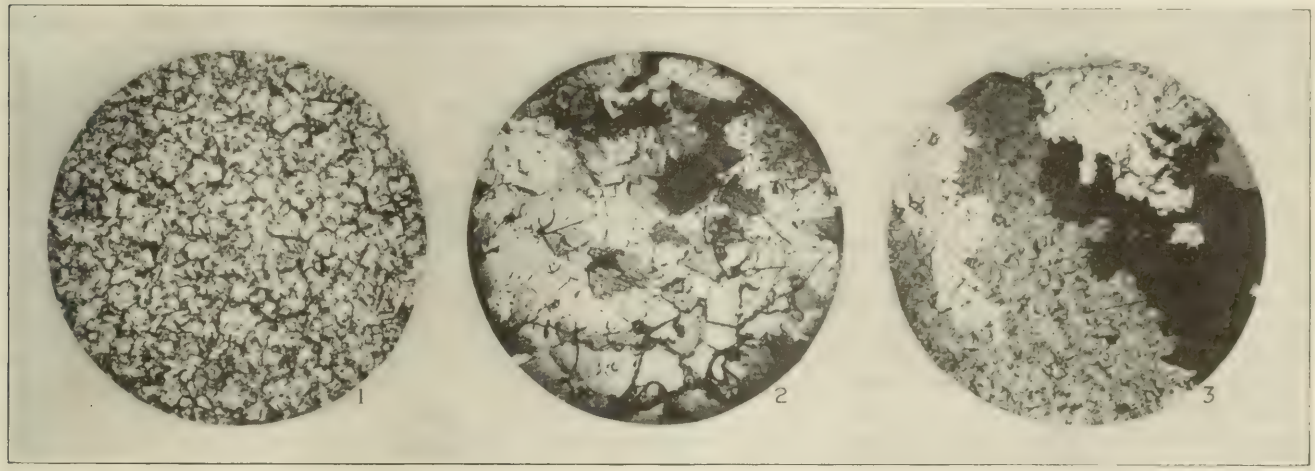
After a period of research the Carborundum Co. has perfected a new abrasive material having such characteristics. This new abrasive material is to be known as Aloxite "AA," and is now being made in quantity.

The bulk of the aluminous abrasive now used in grinding operations contains from 92 to 96 per cent alumina, 2½ to 4 per cent titanium oxide, ½ to 1 per cent each of iron oxide and silica and lesser amounts of lime and magnesia. Most of the alumina is present in the crystallized state, while the other impurities combined with a small portion of the alumina form a glass which functions as a matrix of cement holding together the crystals of alumina. The shape and size of these alumina crystals and the amount of matrix present have an important bearing upon the characteristics of the abrasive, and a microscopic study of the internal structure of the abrasive is of great importance.

Fig. 1 is a microphotograph at 8 diameters of an aluminous abrasive of the ordinary type containing about 94 per cent of alumina. The white areas represent crystals of alumina, while the black patches surrounding the white areas represent the matrix holding together the crystals. Fig. 2 is a microphotograph of an aluminous abrasive of the ordinary type containing about 96 per cent alumina, taken by means of polarized light to better bring out the size and shape of the crystals. The average diameter of the alumina crystals is about 0.7 mm. (0.0027 in.). The types of abrasive represented by Figs. 1 and 2 are admirably suited for general grinding and are used in large quantities.

Fig. 3 is a microphotograph taken with polarized light of a thin section of Aloxite "AA." The areas of the same color in the photograph represent the same allotriomorphic crystal of very large size, in some cases having a length of 12 mm. (0.5 in.) or more. Impurities are present to about 1.5 per cent or very much less than in the ordinary type of aluminous abrasive. This decreased amount of impurity has an important bearing on the characteristics of the abrasive grain and the wheel made from it. Its cutting power is increased due to the greater amount of crystallized alumina present. There is less fluxing between the bond and the grain, this resulting in the brittle wheel so necessary for rapid cutting. It also makes possible, due to the high purity of the grain, to produce wheels of very soft grade. The small amount of impurities allowed to remain in the abrasive is not objectionable, but on the other hand is extremely beneficial. It prevents the formation of skeletal crystals and prevents the more or less open and porous structure which is obtained when molten pure alumina is allowed to solidify. The resulting abrasive consequently exhibits a greater toughness and the wheel has a longer life.

The large size of the alumina crystals in Aloxite "AA" has an important bearing on the cutting power of the abrasive. As the grits commonly used are 20 and finer, almost every individual grit will consist of a fragment broken from a larger crystal of alumina and due to this fact will possess exceptional sharpness. During the process of grinding there is a breaking down of the abrasive grains in a wheel and the character of the new grains formed depends largely upon the size of the alumina crystals in the original abrasive. When the alumina crystals in the abrasive are small, a rupture of the grain may mean a tearing away of a few small crystals without fracture. However, when the crystals are large and a rupture occurs in an abrasive grain, it means that a crystal of alumina has been actually fractured and that new sharp cutting points and edges have been produced.



FIGS. 1 TO 3

Fig. 1—Ordinary aluminous abrasive; 94 per cent Al_2O_3; × 8. Fig. 2—High-grade aluminous abrasive; 96 per cent Al_2O_3; in polarized light; × 8. Fig. 3—Aloxite "AA," by polarized light; 98 per cent Al_2O_3; × 8.

A New Type of Manufactured Fuel

A new type of fuel for which remarkable claims are made has been invented by Richard Bowen, managing director of Laminated Coal (Ltd.) The new fuel is produced from coal slack and dust, lignite, peat, or other material, with a binder of pitch.

Put briefly, the inventor's claim is that out of what has so far been regarded as waste material reconstructed coal, in layers or laminations, just as it occurs in the earth, has been produced.

Dust-Conveying Equipment

In the development of machinery and apparatus for the conveying of dust by suction, the Dust Recovering & Conveying Co. of Cleveland, Ohio, has arrived at the production of systems capable of handling material as coarse as ½-in gravel and ⅜-in. iron rivets from cars to bins and about the plant. There are over thirty installations in successful operation at present.

It is possible to empty a box car of bulk cement, ground limestone, raw rock phosphate or similar material at the rate of 8 to 10 tons per hour by simply guiding an intake nozzle through the material.

At first thought it would seem that this method would cause a heavy abrasive action as the materials are carried through the conduits, but it is found in practice that the bulk of the load travels in the center and away from the walls. This, however, is accounted for by the fact that the air travels swiftest in the center where it is not retarded by friction with sides and the conveyed substances follow the path of this current.

A typical installation is shown in the accompanying figure and is located at the plant of the Aluminum Co. of America, East St. Louis, Ill. The material is drawn from cars either through the lower system to dissolving tanks or by the upper and independent system to an overhead screw conveyor to storage.

Each system consists essentially of a receiving station, filter and hopper over discharge outlet; steel pipe lines from station to vacuum pump, and between station and suction nozzles, valve connections in these lines; vacuum pumps; and intake nozzles with armored hose connection.

The filter removes the material from the air and it arrives at the vacuum pump, cleansed from all dust. This permits the use of a standard motor-driven pump.

Other plants installed are handling coke and butt dust, graphite materials, smelter fume, coal dust, bauxite, phosphates, cement products, etc. The adaptation to unloading of many obnoxious materials in chemical works should be especially welcome.

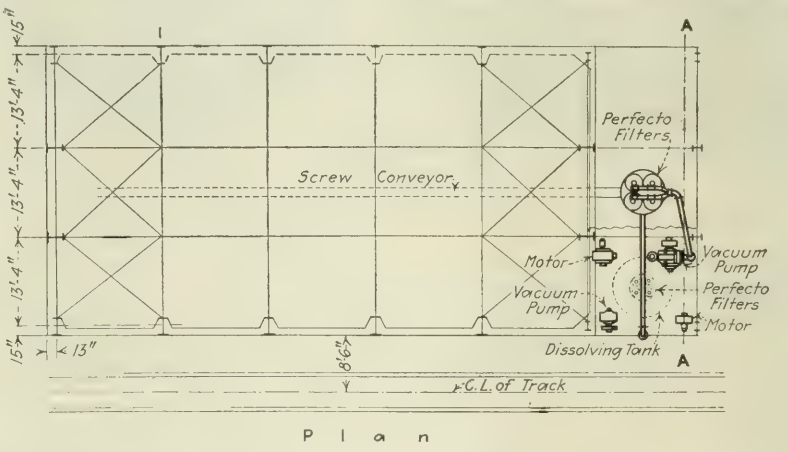
Improved Method of Belt Joining

An unusual problem in the handling of hot cement clinkers with a temperature of 200 deg. and over was recently solved at the plant of the Standard Portland Cement Co., Leeds, Ala., in a cost-reducing manner.

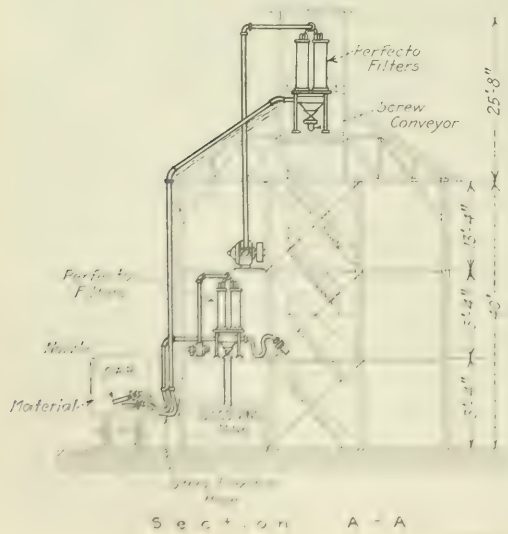
The method decided upon for moving the clinker was a rubber conveyor belt, but the clinker could not be cooled sufficiently in the process previous to conveying to prevent scorching of the belt and its rapid destruction. The answer to this problem was found by running the belt at an incline of 12 deg., so that the lower pulley dipped into a trough of water, thus carrying a film of cold water upon the belt, onto which the hot clinker from the loading hopper was deposited.

At this point a new problem was encountered; namely, how to join the belt so that its full strength would be retained, and in a way which would withstand the extremes of temperature, the wear on the pulleys and the abrasion of the clinker. For this purpose Crescent belt fasteners were adopted, because they brought the belt ends tightly together in a snug joint, making it practically endless on the pulley side, so there was no opportunity for clinker ash to get into the joint and abrade the belt ends, and also because in this method of joining, no metal came in contact with the pulleys to cause wear and a permanent joint was thus assured.

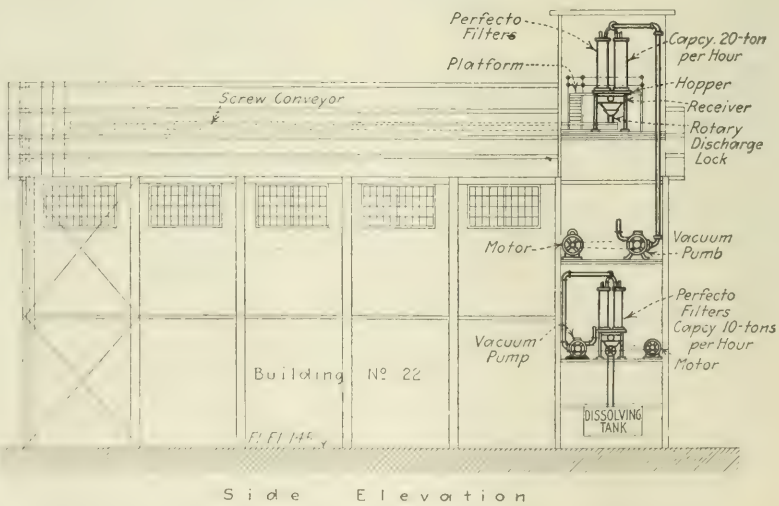
In six months of operation, this conveyor has carried 61,000 tons of clinker, and the Standard Portland Cement Co. credits the saving of $300 in belt cost alone to this conveyor. The belt used was Goodyear Hy-temp, made particularly to withstand temperatures to 200 deg.



Plan



Section A-A



Side Elevation

PNEUMATIC CONVEYING EQUIPMENT

Synopsis of Recent Chemical and Metallurgical Literature

Galvanizing Large Steel Parts by Hot Process.—A recent issue of *Iron Age* contains a description of the galvanizing plant of the Wellman-Seaver-Morgan Co.,[1] at Akron, Ohio, including details of the hot process and of the galvanizing kettle, which is of unusual size. The extreme dimensions of material which can be handled are: length, 19 ft. 6 in.; width, 3 ft. 4 in.; height, 7 ft.

Parts to be galvanized must first be thoroughly cleaned by the use of lye solution (to remove oil, grease, etc.) or a wire brush (for marking paint, heavy rust, etc.), followed by pickling. The pickling solution contains H_2SO_4 and water in the proportion of 1 to 15 by weight. About 75 lb. of 66 deg. H_2SO_4 is used per ton of steel. The solution is maintained at a temperature of about 100 deg. F. by means of steam coils. Considerable experience is required to determine when pickling is complete. In over-pickled articles the fibers of the metal are visible and the part will take a heavier coat when galvanized, which is liable to peel off through vibration.

After pickling, the article is washed with warm water in the rinse tank and then immersed in the muriatic acid tank, which contains acid and water in the proportion of 1 to 15 by weight. This solution is also heated. About 75 lb. of 18 deg. hydrochloric acid is required per ton of steel.

The article is now suspended over the galvanizing kettle, where it is thoroughly dried by the radiated heat. Before immersing in the molten zinc, the surface of the article is sprinkled with powdered ammonium chloride. The surface of the zinc bath is skimmed of zinc oxide and the article entered into the bath at the predetermined rate, which is about 10 ft. per min. for sheets. The zinc becomes greatly agitated at the points of immersion and the piece is not withdrawn for several moments after this agitation has ceased. During withdrawal, which is done at the same speed as immersion, the article is carefully examined for uncoated spots.

The ammonium chloride (or sal ammoniac) melts on the surface of the bath and gradually dissolves zinc oxide until it becomes an impure, sticky mass which is skimmed off and sold as "sal ammoniac skimmings" to chemical manufacturers. In galvanizing large sheets and tanks, an average of 5 lb. is used per ton of steel.

The 50-lb. pigs of zinc or spelter used analyze: Zinc, 99.77; lead, 0.19; iron, 0.04. The amount of zinc per sq.ft. of surface galavanized averages from 1 to 2 oz., depending on the texture of the metal and the time of immersion. The working temperature of the bath is about 800 deg. F. A great improvement can be made in the appearance of galvanized surfaces by adding a very little aluminum to the molten bath.

The acid tanks and the water tank have inside dimensions 19 x 4 x 7 ft. deep. The two acid tanks are of 6-in. double-keyed Oregon fir, with bolts and nuts encased in lead, while the water tank is of 3-in. Oregon fir. All joints are made with white lead. Each tank contains a 50-ft. steam coil of 1-in. lead pipe.

The galvanizing kettle (inside dimensions, 20 ft. x 3 ft. 6 in. x 7 ft. 6 in. deep) has side plates of 1¼-in. fire-box steel and end and bottom plates of 1-in. flange or boiler steel. There are ten fire chambers on each side of the kettle, five being gas fired and five coke fired. Either one of the firing systems is ample for the operation of the kettle, 2,000 lb. of byproduct coke or 40,000 cu.ft. natural gas per 24 hr. being required.

The kettle when full contains 200,000 lb. of zinc and about seven days are required to prepare the bath. In starting, the pigs are carefully piled endwise into the kettle until full and pieces of sheet iron are placed over the top to retain as much heat as possible. Heat is applied gradually, and at the end of four days the kettle is full of molten zinc. There will be quite an accumulation of zinc ashes (oxide) on the surface. These ashes sometimes contain considerable zinc which is melted out by throwing on and igniting several handfuls of resin. The zinc ashes are raked over during the burning of the resin in order to hasten the operation and are then skimmed off. The kettle is now ready for duty. While the kettle is in operation, some of the zinc forms an alloy with the iron of the kettle. Since the kettle is heated at the sides, this alloy settles to the bottom as dross which is removed from time to time and cast into pigs weighing about 125 lb.

In designing the first kettle installed at this plant, no provision was made for reinforcing the sides of the tank to counteract the hydrostatic pressure of the liquid metal. This pressure will be considerable in a long, deep kettle, since molten zinc has a specific gravity of 6.48. As a result, the kettle soon spread a distance of 13 in. in the center at the top. The sides were then reinforced by a pair of special cast iron braces, which were designed as beams with concentrated loads equal distances apart. The calculations involved are given in detail in the original paper.

Cast Iron as a Chemical Engineering Material.—At the January meeting of the Philadelphia Section of the American Chemical Society, HOWARD A. HOFFER, of the United States Cast Iron Pipe & Foundry Co., presented a paper on "The Manufacture of Cast-Iron Equipment Used in Chemical Engineering." An interesting report of this lecture will be found in the February *Catalyst*.

Cast iron is not acted upon by many of the chemicals used in industry and, consequently, it plays an important part in the equipment of a chemical manufacturing plant. In many instances, the major operations take place in cast-iron apparatus, such as nitrators, sulphonators, nitric acid retorts, caustic soda fusion kettles, crystallizers, digesters, autoclaves, etc. In general, the metal composition depends upon the temperature of the reaction taking place in the apparatus, as well as the concentration and chemical nature of the reacting substances.

Cast-iron water pipe is cited as an excellent example of the resistance of cast iron to corrosion. This use of cast iron dates back to 1664, when fifteen miles of pipe was laid by order of Louis XIV to supply the reservoirs in the park at Versailles. This pipe is still in use and in excellent condition after more than 250 years of service.

The most modern and practical method of making cast-iron pipe is in vertical dry sand mold, bell end down, without the use of chaplets, and casting with a shrinkhead so as to avoid the segregation of dross,

[1] "Galvanizing Plant Handles Large Work," A. H. Myers, *Iron Age*, vol. 105, p. 181, Jan. 15, 1920.

occluded gases or foreign material. In making pipe or castings intended for chemical processes chaplets should be eliminated when centering the core in the mold. This is necessary to avoid electrolytic corrosion, as a galvanic current would be generated because of the difference in potential of the metal in the chaplet and in the casting, the chemical solution in the casting acting as the electrolyte.

Cast-iron pipe is being widely used in chemical works for conveying acids, alkalis and other corrosive chemicals. In sulphuric acid work, it is used for carrying acid of 50 to 60 deg. Bé. and also for concentrating from 60 to 66 deg. Bé. At ordinary temperatures, acid down to 1.53 sp. gr. has very little effect upon cast iron, if excess of air is excluded. This material is not recommended for acid between 50 deg. Bé. and 8 per cent H_2SO_4. It is used, however, for weak acid solutions (1 to 3 per cent).

Iron apparatus for acid between 3 and 10 per cent is usually lead-lined, as in the case of ammonia saturators used for the manufacture of ammonium sulphate by the direct process.

In the manufacture of sulphuric acid, hot and cold SO_2 is carried in cast-iron pipes and the hot H_2SO_4 is cooled in cast-iron coils. Other uses for cast-iron pipe are: In mines, for handling acid mine waters; in acid soils; in stoker feed pipes, where the abrasion by the coal and the corrosion by the sulphur content cause rapid deterioration of rolled metal pipe; in byproduct coke plants for conveying the gases from the ovens, the coal tar and oils produced by the condensation of these gases, ammonia, and the solvents used for the extraction of benzol and toluol in the scrubbing towers.

Since many chemical processes require high temperatures, it is of interest to note that the tensile strength of soft cast iron remains practically constant from 100 to 1,000 deg. F., while the ultimate strengths of steel and wrought iron decrease rapidly beyond 450 deg. F. Reports from fire underwriters and fire engineers indicate that cast-iron columns will withstand 1,500 deg. F. without bending and still carry the super-imposed load, while steel columns fail at about 1,000 deg. F. Cast-iron retorts are extensively used in the chemical and allied industries at temperatures between 1,200 and 1,500 deg. F., although the life of the equipment is, of course, shorter than at lower temperatures.

Japanese Rubber Industry.—The Japanese rubber industry has made great strides since the outbreak of war. It is expected, says the *Japan Chronicle*, that orders for rubber goods will flow in from Europe, and, indeed, the exports of rubber tires during the present year have been enormous. A further development of the industry is looked for in the shape of a combination of large and small rubber factories. The desirability of this scheme seems now to have been accelerated by the receipt of large orders from Siberia. The *Chronicle* continues:

> The Okura firm is said to have recently received from the new Siberian Government orders for about 400,000 yen ($199,400) worth of rubber tube and 200,000 yen ($99,700) worth of rubber sheet. The company has now given these orders to the Mitado, the Toyo, the Nippon, and the Meiji rubber companies, which are regarded as the best rubber works in Japan, apart from foreign enterprises established here, the Okuragumi guaranteeing payment. In this connection it is said that these have decided to fill the Russian orders in co-operation with one another, so as to avoid unnecessary competition—or so as to be able to compete with a Kobe company. Their co-operation is said to extend as far as exchange of stocks and of orders for the purpose of securing efficiency and economy.
>
> This co-operation is said to portend amalgamation at an early date, so as to put the rubber industry in Japan on a firm foundation. They are also expected to extend their combination to other factories after this first step.

Recent Chemical and Metallurgical Patents

British Patents

Complete specifications of any British patents may be obtained by remitting 25c. each to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Purifying Saccharine Liquids.—Sugar liquids are decolorized and freed from mineral substances by means of alumina or magnesia or analogous substances occurring naturally, such as bauxite or magnesite. The material, mixed with carbon or carbonaceous matter, is ignited and granulated. The liquor to be treated is filtered through the material or may be agitated with it and filtered through a filterpress. Aluminum nitrate or chloride, or calcium or sodium phosphate may be added to the liquor before treatment. (Br. Pat. 134,607—1919. J. J. Hood, London; J. Clark, Hutton, and P. G. Clark, London. Jan. 7, 1920.)

Plastic Composition.—Ground vegetable ivory is mixed with casein, lime and water and, optionally, sodium silicate, and the product is fused for making buttons, etc. An example of proportions is 12 parts ground vegetable ivory, 3 parts casein, 2 parts lime, ½ part sodium silicate. (Br. Pat. 134,619—1919. G. C. Devonshire, London, and E. T. Ford, Birmingham. Jan. 7, 1920.)

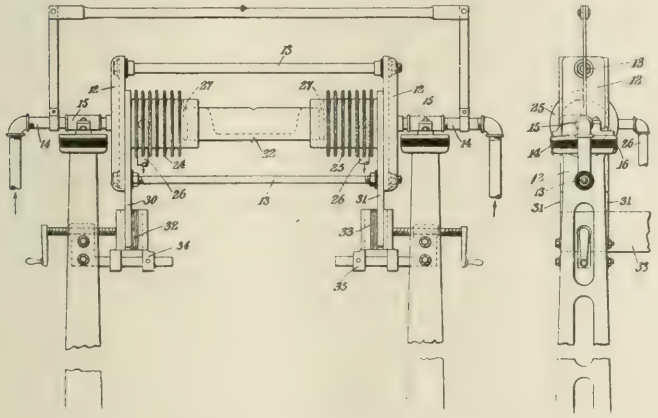
Cracking Hydrocarbons.—In cracking hydrocarbons and more particularly in converting tar oil into benzol and mineral oil into benzine, by passing a mixture of hydrocarbon vapors and steam over a heated carbonaceous material such as coke, the operation is effected in a zone of high temperature with zones of lower temperature on either side. The apparatus consists of vertical or inclined retorts through which the vapor mixture is passed upward. The central zone is heated to 500-1,200 deg. C. and the top and bottom of the retorts are kept at about 300 deg. C. The central zone extends about one-sixth to one-half of the total length of the retort, and the total height of the packing to between one-half and three-quarters of the total length. The low temperature zones may be packed with porcelain, etc. The temperature at the bottom of the retort is maintained by pre-heating the vapor mixture, and the temperature and extent of the central zone are regulated by manipulating dampers in the flues. Carbolic and creosote oils require a shorter high-temperature zone and a smaller admixture of steam than anthracene oil. The proportion of oil to water varies between 1 : 2 and 2 : 1 by volume. (Br. Pat. 135,197—1919. Naamlooze Vennootschap Nederlandsche Lichte Olie Maatschappij, Amsterdam. Jan. 21, 1920.)

American Patents

Complete specifications of any of the United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

High-Phosphorus Pig Iron From Glauconite.—THOMAS C. MEADOWS, of New York City, patents the process of charging a blast furnace with a suitable mixture of iron-potassium minerals (such as glauconite) with an iron-bearing phosphate rock, together with fluxes such as iron ore, lime rock, or silica sand, according to the exigencies of the case. As a result he procures a high-phosphorus pig iron and volatile products rich in potash. Potassium-carbon-nitrogen compounds might be recovered if drawn from the furnace near the focus before they have been broken up by reducing the descending charge. (1,322,038; Nov. 18, 1919.)

Electric Furnace.—A compact and easily operated tilting electric furnace of the resistance type has been designed by WILLIAM H. BRISTOL and M. J. JOHNSON; the features of interest are shown in the figure. The furnace is supported on pedestals and can be rotated on trunnions resting in insulated bearing 15. Water-cooled electrodes 24 and 25 are attached to the end plates 12, which are spaced by the distance rods 13. The electrodes are cooled by water which flows in through pipes 14 and out through pipes 26. One particular feature of the furnace is the method of



making contact between the carbon resistor 22 and the electrodes 24 and 25. The resistor is slipped into place through the open top of the electrodes and contact is made by inserting a graphite plate 27 between the face of the electrodes and the resistor. This effectively reduces the arcing which is usual in furnaces of this type. Another feature is the method of carrying the current from the busbars to the electrodes. Conducting plates 30 and 31 attached to the electrode are so arranged that they may be clamped by means of the clamps 34 and 35 to the conductor bars 32 and 33. This does away with the use of flexible cables. The resistor is enclosed in heat-insulating material not shown in the illustration. (1,323,576, Dec. 2, 1919; assigned to the Bristol Co. of Waterbury, Conn.)

Purification of Crude Anthraquinone.—Crude anthraquinone, produced by the oxidation of anthracene, is a mixture of the following compounds:

	Melting Point Deg. C.	Boiling Point Deg. C.
Anthracene	213	351
Anthraquinone	285	382
Phenanthrene	99	340
Phenanthraquinone	198	360
Methyl anthracene	190	360
Methyl anthraquinone	170	+360

These may be separated by a process described by CHESTER E. ANDREWS, of Pittsburgh, Pa. The crude material is heated in a current of air or other inert gas to a temperature of about 300 deg. C. The substance having the lowest boiling point will tend to vaporize first. The vapors are carried to a condensing chamber consisting of a number of compartments of successively increasing height, separated by screens of wire gauze. The process of separation is completed in these chambers by fractional condensation. By means of suspended weights, accumulations of sublimate may be jarred loose from the screens. (1,324,716; assigned to the Selden Co.; Dec. 9, 1919.)

Treatment of Anthracene Press-Cake.—The process of fractional vaporization and condensation described in U. S. P. 1,324,716 granted to CHESTER E. ANDREWS, of Pittsburgh, Pa., is also used by the inventor for the treatment of crude anthracene press-cake containing 60 to 70 per cent of impurities which consist principally of phenanthrene, methyl anthracene and carbazol. The press-cake is first treated with sufficient sodium hydroxide solution to convert the carbazol into its sodium salt. The mass is then heated to 250 deg. C. in a current of air. The vapors condense in the following order: Anthracene, methyl anthracene, phenanthrene. The residue (the sodium salt of carbazol) is dissolved in water, filtered, recrystallized, and acidified to precipitate carbazol in a relatively pure state. (1,324,717; assigned to the Selden Co.; Dec. 9, 1919.)

Nitrogen-Hydrogen Mixture.—For the production of ammonia by catalysis, the nitrogen-hydrogen mixture should be as free as possible from O_2, H_2O, sulphur compounds and CO_2, but for some catalysts small amounts of CO do not appear to be injurious except as diluents. Such a mixture may be prepared by the following method, devised by CARLETON ELLIS, of Montclair, N. J. Air and steam are blown through a gas generator fed with coal or coke low in volatile hydrocarbons. The gas obtained has the composition: Hydrogen, 15 per cent; carbon monoxide, 20 per cent; carbon dioxide, 2 per cent; nitrogen, 63 per cent; sulphur, etc., traces. After removing CO_2 and sulphur compounds by passing over lime or ferric oxide, and CO by compression, this "water-producer gas" will contain hydrogen and nitrogen in the ratio of approximately 1 : 4 by volume. This is preferably enriched, before using, by the addition of electrolytic hydrogen, in order to bring the ratio of hydrogen to nitrogen up to 1 : 3. Byproduct hydrogen from electrolytic chlorine cells may be purified by passing over platinized asbestos, whereby the oxygen and chlorine unite with the hydrogen to form water and hydrochloric acid, which may be easily removed by condensation or by passage over lime. (1,327,029; assigned to Clinton S. Lutkins; Jan. 6, 1920.)

Dyes From Halogenated Hydroxynapthoquinones.—By adding three to four parts by weight of bromine to a solution of one part by weight of juglon (5-hydroxy-α-napthoquinone) in fifteen to twenty parts of glacial acetic acid, ALVIN S. WHEELER, of Chapel Hill, N. C., obtains 2.3.8-tribrom-5-hydroxynaphthoquinone, having a melting point of about 170 deg. C. The sodium salt of this compound may be made by dissolving in ether and shaking this solution with an aqueous solution of sodium carbonate. The salt, which separates out as a purplish deposit, is soluble in water, and dyes silk and wool directly. The sodium salt of dichlorjuglon has similar properties as a dyestuff. (1,327,260; Jan. 6, 1920.)

Sodium Carbonate From Alkaline Brines.—Theoretically, in the treatment of Searles Lake brine for the recovery of alkali by precipitating sodium bicarbonate, the subsequent conversion of the latter salt into sodium carbonate should liberate enough CO_2 to precipitate an equivalent amount of bicarbonate. Losses of CO_2 are, however, unavoidable. NATHANIEL T. BACON of Peace Dale, R. I., suggests that the precipitation be started with flue gas, the purer CO_2 being reserved for final treatment. (1,330,573; assigned to the Solvay Process Co.; Feb. 10, 1920.)

Book Reviews

QUANTITATIVE ANALYSIS. By *Edward G. Mahin, Ph.D.*, professor of analytical chemistry in Purdue University. 2nd edition, revised and enlarged. 605 pp. 122 figs. New York: McGraw-Hill Book Co., Inc. Price, $3.50.

The scope of this work is so complete as to cover practically all the phases of quantitative work required of a student in a thorough modern course in chemistry. In the present edition, methods have been revised in accordance with the latest standardized procedures and new methods have been included. The treatment of each subject is exceptionally clear and there is complete freedom from any tendency toward "cook-book" style. The theory of each procedure is discussed fully, using the principles of physical chemistry wherever applicable, so that the analyst is enabled to approach a problem with a full appreciation of the limitations of the method, the possibilities of error and methods of avoiding the latter.

For the benefit of those who are unfamiliar with the earlier edition of Prof. Mahin's work, the following summary of the topics treated may be of interest:

The main divisions of the book are two—general quantitative analysis and analysis of industrial products and raw materials. A short introductory chapter on general principles is followed by a seventy-one page discussion of the methods and apparatus used in gravimetric analysis. The experiments in the next chapter include, in addition to the usual determinations, the separation of chlorine, bromine and iodine by selective oxidation. Chapter IV is devoted to the theory and practice of electro-analysis, including the use of the mercury cathode. The next three chapters cover the manipulations of volumetric analysis, the theory of indicators and the preparation of standard solutions, and prepare the student for the experiments. Chapter X takes up the important subject of oxidation and reduction in relation to volumetric analysis. Part I concludes with a discussion of titrations involving the formation of precipitates.

Rock analysis is considered first in Part II, followed by chapters on fuels (coal and gas analysis), oils, fats and waxes (burning oils, lubricating oils, edible fats and oils), and water analysis from the industrial and sanitary standpoints. Chapter XV treats the chemical and metallographical analysis of iron, plain steel and alloy steels and the chemical analysis of brass, bronze and bearing metals. The following chapter on agricultural materials covers fertilizers, milk, cream, condensed milk, butter and butter substitutes. A section on the fire assay of gold and silver ores completes the text. Four place tables of logarithms and antilogarithms, and a good index add to the usefulness of the volume.

ALAN G. WIKOFF.

Obituary

Dr. J. J. ELBERT, a technologist with the American Cyanamid Co., died suddenly at his home in Tuckahoe, N. Y., on Feb. 27. He was a graduate in chemical engineering of the Massachusetts Institute of Technology and of the University of Berlin. Dr. Elbert, after returning from abroad, was general manager of the Fibre Finishing Co., Worcester, Mass. He then associated himself with the General Chemical Co., being located in its Laurel Hill laboratories for nearly a year and later transferred to the Delaware works at Marcus Hook, Pa. For the past four years he was with the American Cyanamid Co., first as technologist, later as superintendent of the Warners plant. When the Muscle Shoals plant was ready for operation, Dr. Elbert was made assistant superintendent in charge of ammonia production, nitric acid and ammonium nitrate divisions. With the closing down of that plant, he returned to New York, where he again entered the technical department of the American Cyanamid Co. He was a member of the American Electrochemical Society and the American Chemical Society.

FRANKLIN MURPHY, former Governor of New Jersey and head of the Murphy Varnish Co., passed away Feb. 24, after an operation.

Personal

Dr. LEO H. BAEKELAND is traveling through South America in the interests of the establishment of closer relations between North and South American universities. He expects to be back in this country late in April or early in May.

R. E. COLLUM, petroleum technologist of the U. S. Bureau of Mines, has changed his headquarters from San Francisco to Dallas, Tex., where he will be in charge of the Bureau's office.

ARTHUR L. DAY, formerly the director of the Geophysical Laboratory, Washington, has announced that he will sever his connection with the Corning Glass Co. on April 1 and resume active direction of the work of the Geophysical Laboratory. GEORGE W. MOREY of the same institution is expected to return to Washington to resume his research work there about the first of May. During and since the war period he has been with the Spencer Lens Co. in its optical glass work.

DAVID F. GOULD, formerly assistant chemist in the research laboratory of the Mexican Petroleum Corporation, Destrahan, La., is now research chemist with the chemical department of The Barrett Co., Frankford, Pa.

HERMAN A. HOLZ, president of Holz & Co., Inc., New York, manufacturer of metallurgical testing and research apparatus, recently left for an extended trip through Europe to study the latest European developments in metal-testing methods and in the design of testing equipment.

N. L. BOWEN will sever his connection with Queen's University, Kingston, Ont., at the end of the present college year, to take up his former position at the Geophysical Laboratory, Washington.

R. E. HALL has resigned from the Geophysical Laboratory to accept a position with the Firestone Tire & Rubber Co., Akron, Ohio.

Dr. P. E. LANDOLT, of the Research Corporation, New York, delivered a lecture on "The Cottrell Electrical Precipitation Process" Saturday evening, March 20.

Dr. HORACE C. PORTER, formerly of the Bureau of Mines, later chemical engineer with the Koppers Co., Pittsburgh, and since the close of the war associated with the Chemical Service Laboratories, Inc., of West Conshohocken, Pa., has established an office and laboratory at 1833 Chestnut St., Philadelphia, for consulting work on fuels. Dr. Porter will make a specialty of carbonization, coking, gas and byproducts, valuation of coals, fusibility of ash, and fuel research.

E. GYBBON SPILSBURY has returned from Brazil, where he has spent the last few months in exhaustive examination of the iron and manganese resources and possibilities of utilizing native coal for their reduction.

ARTHUR L. WALKER, professor of metallurgy, Columbia University, is delivering a course of lectures on non-ferrous metallurgy before classes of the new engineering school at Harvard University. The first lecture was delivered the middle of February.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 22, 1920.—The market remains quiet. Copper dropped off ¼c. in the last week, but strong inquiries developed. Tin declined sharply, from 63c. to 61½c. for spot.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent	31@32
Antimony, wholesale lots	11.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	61.50
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	8.87½
Zinc, spot, New York	8.70
Zinc, spot, E. St. Louis	8.37½

OTHER METALS

Silver	oz.	$1.21
Cadmium	lb.	1.50
Cobalt	lb.	1.50
Magnesium (f. o. b. Niagara Falls)	lb.	1.60
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	93.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	33.50
Seamless bronze tubing	34.50
Seamless brass tubing	32.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	22½@23½
Aluminum, sheet scrap	22 @22¾
Aluminum clippings	25½@26½
Copper, heavy machinery comp	15 @15¼
Copper, heavy and wire	13¾@14¼
Copper, light and bottoms	12 @12½
Copper, heavy cut and crucible	15 @15½
Brass, heavy	7 @7¼
Brass, casting	10 @10¼
Brass, light	5¾@6¼
No. 1 clean brass turnings	7¾@7¾
No. 1 comp. turnings	11¼@11½
Lead, tea	5¼@5¼
Lead, heavy	7 @7½
Zinc, scrap	4¼@4½

The Iron and Steel Market

Pittsburgh, Pa., March 19, 1920.

The trade has given considerable attention to the steel ingot production report for February, made public a trifle over a week ago and referred to in last report. It may be recalled that the report indicated that steel ingots were produced during February at the rate of 44,200,000 gross tons per annum.

It is somewhat like the case of a single equation with one known quantity and two variables. The steel actually was produced, but reports during February were that mills were operating at far below capacity, say at not over 80 per cent on an average, while the most acceptable estimate of capacity, as mentioned in this report a week ago, was about 50,000,000 tons. Thus the actual production was 88 per cent of the estimated capacity, but if production were only 80 per cent of capacity the capacity would be 55,000,000 tons. The common opinion in the trade is that there was no great exaggeration of the curtailment in output occasioned by the weather, by the poor transportation service and by some minor contributing causes, but that rather the capacity is going to be found greater, on the test that favorable manufacturing conditions will eventually permit, than has been estimated on the basis hitherto used, that of taking 1916 production as the average capacity for that year and allowing conservatively for the new construction.

The argument furnishes another illustration of the errors that may be fostered by trying to interpret isolated facts into terms of steel market conditions and prospects. For steel mills to be operating at far below capacity in February constituted an augury that steel would be scarce, while for capacity to be found materially greater than had been assumed constitutes an augury that steel will be in better supply as the temporary barriers to full production disappear. That they will disappear is, of course, obvious.

Steel Scarcity Less Widespread

In the past week many indications have developed of the steel scarcity being less widespread than formerly. Not a few manufacturing consumers find themselves well supplied now, through the combined influence of mill productions being larger, mill accumulations being reduced as car supplies improved, and the time in which steel is in transit being reduced. There had been many cases of steel being two or three times as long in transit as the normal experience. At the present time receipts are therefore greater than shipments.

The pressure for prompt deliveries of steel has sensibly decreased of late. Stocks for sale are practically nil, and there is little unsold steel for delivery between now and July 1, yet there is a perceptible softening in prompt delivery prices in general. From the relatively new viewpoint, that there is no real "runaway market" in steel prices but that prompt delivery prices simply contain a delivery premium over basis prices for late deliveries, the delivery premiums are declining. The only noteworthy actual decline is in sheets, which in the past ten days have not commanded over 8c. in actual mill sales, for early shipment, while in the last week of February there had been a number of sales, of relatively small lots of course, at 10c. basis. The Industrial Board schedule, whose anniversary is about here, set sheets at 4.35c., and that price not only has been adhered to by the Steel Corporation but will, in all probability, be announced April 15 or shortly afterward as the corporation's price for second half deliveries to manufacturing consumers and third quarter deliveries to jobbers. The prices mentioned refer to common black, 28 gage, but the fancy priced sales of late have not been of common black but of special finish sheets, chiefly for the automobile trade, at the base prices mentioned plus regular extras for finish.

Prices on Bars, Shapes and Plates

Mention has been made in these reports of the likelihood that some large independents would soon open their order books on bars, shapes and plates for third quarter deliveries to regular customers at not over 3c., 3.10c. and 3.25c. respectively. It is now well assured that the prices will not be higher than just mentioned, and they may be somewhat lower, particularly to large customers. Thus the forward delivery market of the independents is not advancing, though it remains at well above the Steel Corporation level, bars and shapes as just quoted being $13 a ton and plates $12 a ton above the Industrial Board schedule, effective March 21, 1919.

The Steel Corporation shows no disposition whatever to advance its prices, and thus eventually, unless fundamental conditions on which the policy is based change, the independent prices will come down to the corporation level. That will not be for some time to come, as delivery premiums, involving really early deliveries, must first greatly decline if not disappear entirely, and such a decline has only started.

Pig Iron

The pig-iron market presents interesting possibilities. Most of the information available as to this district indicates that the market is soft, with prospects that interesting inquiries would bring out lower quotations. There is no delivery premium, an unprecedented condition when there is a high market. Some Eastern steel works are offering basic iron as far west as Pittsburgh, and a large valley interest, which used to buy pig iron when operating full, expects this time to have a surplus for sale instead.

On the other hand, reports from the Philadelphia and Buffalo markets are of tight conditions and a visible scarcity of iron. It is between buying movements in Pittsburgh and at such times the market prospects are frequently not clearly defined. The advance which sent pig iron from $18 in August, 1916, to over $50 in the following July began with sales in a dull market at cut prices. The present local

market appears to be quotable, as for the past two or three weeks, at $42 for bessemer, $41.50 for basic and $42 for foundry, f.o.b. valley furnaces, freight to Pittsburgh being $1.40, but should important business develop these quotations might be found to have been largely nominal.

Steel

There is not much inquiry for billets, but considerable tonnages could probably be sold if early deliveries could be offered. For both billets and slabs the market for prompt shipment seems to be $65 to $70, with small billets at perhaps $10 more. The especially fancy priced sales of sheet bars, at $90 and thereabout, appear to have ceased, the market being quotable generally at $70@$80, depending on the standing of the buyer. One interest has covered regular customers for second quarter at $60, but that is not a market price, representing a sort of compromise in consideration of the fact that the Steel Corporation is still taking care of its customers as far as it can at the old Industrial Board price of $42.

Ferro-Alloys

Producers have advanced ferromanganese, formerly $160, to $180 as minimum, some quotations of $200 being out. These prices are for second half, delivered, 78 to 80 per cent. Earlier deliveries run up to $225 or higher, but involve only very small lots. English is out of the market, there being no fresh quotations, though with such high domestic prices English is likely to become a factor again. Electrolytic ferrosilicon is $80@$81, delivered, for 50 per cent and $140 for 75 per cent. Bessemer ferrosilicon is $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. furnaces at Jackson and New Straitsville, Ohio.

Chemical and Allied Industrial Markets

New York, March 20, 1920.

General conditions remain practically unchanged, with the spot market a little tighter if anything. Any price movement recorded has been upward, especially in the alkali group. Under the influence of the more favorable rate of exchange foreign inquiry has picked up slightly.

General Chemicals

Ethyl alcohol has advanced again and the present low mark is $5.25 per gal., with difficulty in obtaining any material even at this price. In sympathy with ethyl grade, *methyl* has also advanced, the nominal quotation for 95 per cent being $2.25, while actual sales are reported as high as $3.50, and prices as high as $5 have been received for 97 per cent pure. *Denatured* has been advanced 20c. a gal., present quotations reading $1 for 188 and 96c. for 190 proof. This advance was brought about by the loss of two tank steamers of molasses, belonging to a controlling factor in this market, from which several million gallons of alcohol were to be obtained. *Methyl* alcohol is on the advance due to unfavorable labor conditions among the unskilled labor of the South, but it is the opinion of one large factor in the market that this condition will be easier around the beginning of May. *Sodium nitrite* fell back and although there is very little material on the spot market contract prices are going back to normal. Spot prices range from 50c.@60c. per lb. *Sodium bichromate* holds firm at 33c.@35c. per lb., some small supplies on the spot market going at a slightly higher price. *Oxalic crystals*, under pressure of heavy demand, advanced 3c. per lb., the present quotation being 43c.@48c. per lb. for spot and 35c@42c. for carlots on contract. *Barium chloride* is slightly easier, $140@$150 being the spot price and $125@$135 per ton for contracts. It is reported that one large producer who has been out of this market for some time past has come back, and with larger supplies the present scale of prices should be broken.

It is reported that producers are completely sold out on *acetic acid*, glacial, 99½ per cent. The spot market is somewhat tighter with $15@$15.50 per cwt. the best quotation. This condition will continue till the end of the summer, by which time it is hoped manufacturers will be caught up on their contracts. *Sal soda* holds firm at $1.25@$1.35 per cwt. for carlots and $1.40@$1.50 on spot. Buying on spot market increased during the past week, which forced material in second hands up slightly. *Sodium borate* holds firm on contract price at 8½c.@8¾c. per lb., while the spot market advanced to 9c.@9½c. *Formaldehyde* is still at a premium on the spot market, being listed at 90c.@$1 per lb. The nominal market price of 38c.@40c. still solds, but there is no material to be had at these prices on contract.

Coal-Tar Products

The coal-tar products market remains in the same position in which it was last week. Very few price changes have occurred and except for further advance of spot materials there is very little to report. It is the opinion of those engaged in this industry that there is no relief in sight from the current high prices. The demand continues heavy, with very little material being offered for immediate delivery. *Salicylic acid* holds firm at 55c.@60c. per lb. for U. S. P., while the *technical* grade, under the influence of more active demand, increased to 45c.@50c. per lb. The spot market on *aniline oil* continues cramped, but prices are holding firm at 34c.@45c. per lb., while the *salts* are practically unobtainable, with a nominal quotation of 42c.@48c. per lb. All grades of *beta naphthol* are very scarce and prices ranging from 75c.@$1 per lb. are being offered. Quotations on *H acid* remain nominal, as there is practically no material available on the spot market.

Waxes

The wax market has dropped slightly during the past week due to the arrival from abroad of several shipments of beeswax and carnauba. Spot material in these two lines dropped, with 38c.@40c. per lb. being asked for natural crude yellow beeswax, while *carnauba*, No. 3, North Country, dropped to 43c.@45c. per lb.

Flotation Oils

There has been a general advance in flotation oils during the past week, caused by shortage of supplies. Manufacturers are not able to meet the demand because of the inefficiency of the laborers. *Pine oil*, steam dist., sp.gr. 0.930-0.940, is quoted at $1.65 per gal.

Naval Stores

The market continues quiet with a further drop in the *rosins*. It is reported that the difficulty the producer in the South is having with labor has caused a shortage, which, coupled with decreasing domestic demand and very inactive foreign inquiry, accounts for the present declining market. B-D grades are listed at $17.50@$18, E-I grades at $17.50@$19 and WG-WW at $22@$22.50 per 280 lb.

Turpentine is quoted higher than it ever has been before, not excepting war prices. Supplies are extremely low in Savannah and no relief is expected until the new crop arrives. The jump of 15c. during the past week places turpentine at a nominal quotation of $2.20 per gal. It is the general opinion of those engaged in the trade that the limit has not been reached but will continue upward till relief from the new crop is received.

Vegetable Oils

The oil market during the past week remains in practically the same position. *Linseed* oil, raw, carlots, is firmer at $1.84 per gal., while boiled, carlots, is bringing $1.87. *Cottonseed* holds firm at former levels with the usual fluctuations during the week but ending at the same price. *Ceylon* grade, in bbl., 18c.@19½c. per lb. and *Cochin* grade, 20½c.@23c. per lb.

Ores and Semi-Finished Products

The *tungsten* bill which has been before the Senate for consideration for some time has again been sidetracked. There has been practically no business on this item and as low as $6 has been received on *wolframite*. The *manganese* market holds firm under the pressure of demand for ferromanganese.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	....–.....	$0.60 – $0.65
Acetone	lb.	$0.13 –$0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.25
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent. carboy †	cwt.	12.00 –14.00	15.00 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –.....	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –.....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½ – .07
Molybdic, C. P	lb.	.....–.....	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.06½ – .07	.08 – .09½
Oxalic, crystals †	lb	.35 – .42	.43 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –.....	–.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 –22.00	.....–.....
Sulphuric, 60 deg., drums	ton	.....–.....	.....–.....
Sulphuric, 66 deg., tank cars	ton	22.00 –25.00	.....–.....
Sulphuric, 66 deg., drums	ton	.....–.....	.....–.....
Sulphuric, 66 deg., carboys	ton	.....–.....	.....–.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –30.00	32.00 –.....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –.....	34.00 –.....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –.....	40.00 –.....
Tannic, U. S. P	lb.	.....–.....	1.35 – 1.45
Tannic (tech.)	lb.	.....–.....	.42 – .55
Tartaric, crystals	lb.	.....–.....	.69 – .74
Tungstic, per lb. of WO	lb.	.....–.....	1.20 – 1.40
Alcohol, Ethyl (nominal)	† gal.	5.25 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	† gal.	2.35 – 2.75	.....–.....
Alcohol, denatured, 188 proof (nominal)	† gal.	.....–.....	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	† gal.	.....–.....	.96 – .98
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾ – .02	.02¼ – .02½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03¼ – .03½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15 – .16	.17 – .19
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	.....–.....
Ammonium sulphate	lb.	.05 –.....	.06 –.....
Amylacetate	gal.	.....–.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	.....–.....	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	.....–.....
Barium chloride	† ton	125.00–135.00	140.00 – 150.00
Barium dioxide (peroxide)	lb.	.26 – .27	.28 – .30
Barium nitrate	lb.	.11 – .12	.13 – .14
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)	..	.....–.....	.....–.....
Blue vitriol (see copper sulphate)		.....–.....	.....–.....
Borax (see sodium borate)		.....–.....	.....–.....
Brimstone (see sulphur, roll)		.....–.....	.....–.....
Bromine	lb.	.85 – .95	–.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 –.....
Calcium carbide	lb.	.....–.....	.04½ – .05
Calcium chloride, fused, lump	ton	20.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	3.50 – 3.75	4.00 – 4.50
Calcium peroxide	lb.	.....–.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	.....–.....	.75 – .80
Calcium sulphate, pure	lb.	.....–.....	.25 – .30
Carbon bisulphide	lb.	.06 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	.....–.....	.80 – 1.05
Caustic potash (see potassium hydroxide)		.....–.....	.....–.....
Caustic soda (see sodium hydroxide)		.....–.....	.....–.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.	.....–.....	2.00 – 2.05
Copperas (see iron sulphate)		.....–.....	.....–.....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	.....–.....	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		.....–.....	.....–.....
Epsom salt (see magnesium sulphate)		.....–.....	.....–.....
Formaldehyde, 40 per cent (nominal)	† lb.	.38 – .40	.90 – 1.00
Glauber's salt (see sodium sulphate)		.....–.....	.....–.....
Glycerine	lb.	.....–.....	.24½ – .26
Iodine, resublimed	lb.	.....–.....	4.10 – 4.30
Iron oxide, red	lb.	.....–.....	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –.....	1.25 – 1.75
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	.....–.....	.13 – .17
Lead nitrate, crystals	lb.	.....–.....	.70 – .80
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	.....–.....	1.50 –.....
Magnesium carbonate, technical	lb.	.....–.....	.13 – .14
Magnesium sulphate, U. S. P	100 lb.	3.40 – 3.55	3.60 – 3.75
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –.....	.15 –.....
Nickel salt, single	lb.	.16 – .17	.17½ –.....
Phosgene (see carbonyl chloride)		.....–.....	.....–.....
Phosphorus, red	lb.	.....–.....	.60 – .65
Phosphorus, yellow	lb.	.....–.....	.35 – .37
Potassium bichromate	lb.	.32 – .33	.34 – .37
Potassium bitartrate (cream of Tartar)	lb.	.....–.....	.56 – .60
Potassium bromide, granular	lb.	.....–.....	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –.....	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.16 – .20	.21 –.....
Potassium hydroxide (caustic potash)	lb.	.25 – .32	.35 – .42
Potassium iodide	lb.	.....–.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –.....	.21 –.....
Potassium permanganate	lb.	.....–.....	$0.65 – $0.95

† (See New York market letter).

		Carlots	Less Carlots
Potassium prussiate, red	lb.	1 00 – 1 05	1 10 – 1 20
Potassium prussiate, yellow	lb.	.34 – .36	.40 – .70
Potassium sulphate	ton	$225 00	.....–.....
Rochelle salts (see sodium potas. tartrate)		.....–.....	.....–.....
Salammoniac (see ammonium chloride)		.....–.....	.....–.....
Sal soda (see sodium carbonate)		.....–.....	.....–.....
Salt cake	ton	21 00 – 22 00	.....–.....
Silver cyanide (nominal)	oz.	.....–.....	1.25 –.....
Silver nitrate (nominal)	oz.	.....–.....	.77 – .82½
Soda ash, light	100 lb.	2 50 – 2 60	– 3 00
Soda ash, dense	100 lb.	2 70 – 2 75	– 3 10
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium bicarbonate	† 100 lb.	2 40 –.....	2.75 – 3 00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7 00 – 7 50	8.00 – 10 00
Sodium bisulphite Powered	lb	.05¾ – .06½	.07 – .07
Sodium borate (borax)	† lb.	.08½ – .08¾	.09 – .09
Sodium carbonate (sal soda)	† 100 lb.	1.25 – 1.35	1.40 – 1.50
Sodium chlorate	lb.	.10 –.....	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –.....	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	5.00 – 6.00	6.10 – 6.25
Sodium hyposulphite	lb.	.....–.....	.03¾ – .04
Sodium molybdate	lb.	2 50 –.....	3.25 –.....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4 00
Sodium nitrite	† lb.	.....–.....	.50 – .60
Sodium peroxide, powdered	lb.	.....–.....	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.05 – .06
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.....–.....	.05 – .06
Sodium sulphite, crystals	lb.	.03½ –.....	.04 – .06
Strontium nitrate, crystals	lb.	.25 –.....	.28 –.....
Sulphur chloride	lb.	.05¾ –.....	.06 –.....
Sulphur, crude	ton	22.00 –.....	.....–.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –.....	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –.....	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –.....	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –.....	.46 – .50
Tin oxide	lb.	.50 – .60	.65 – ....
Zinc carbonate, precipitate	lb.	.....–.....	.20 –.....
Zinc chloride, gran	lb.	.13 –.....	13½ – .15
Zinc cyanide	lb.	.49 –.....	.50 – .60
Zinc dust	lb.	11½ – 12½	.13 – .15
Zinc oxide, U. S. P	lb.	.....–.....	.19 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	† lb.	.34 — .45
Aniline salts	† lb.	.42 — .48
Anthracine, 80% in drums (100 lb.)	lb.	.75 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.25 — 1.35
Benzidine, sulphate	lb	1.00 — 1.15
Benzoic acid, U.S.P	lb.	.90 — 1.10
Benzoate of soda, U.S.P	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .29
Benzyl chloride, 95-97%, refined	lb	.35 — .40
Benzyl chloride, tech	lb	.25 — .35
Beta naphthol benzoate	† lb.	.50 — .65
Beta naphthol, sublimed	† lb.	.70 — .90
Beta naphthol, tech	† lb.	.45 — .55
Beta naphthylamine, sublimed	lb	2.25 — 2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 — 1.00
Cresylic acid, 50%, first quality, drums	gal	.60 — .70
Dichlorbenzol	lb.	.07 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline (nominal)	lb.	.95 — 1.50
Dinitrobenzol	lb.	.26 — .37
Dinitroclorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.32 — .36
Dinitrotoluol	lb.	.38 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine (nominal)	lb.	.55 — .65
H-acid (nominal)	† lb.	1.70 — 1.80
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.12 — .15
Monoethylaniline	lb.	1.50 — 1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.06 — .08
Naphthaline, flake	lb.	.07 — .08
Naphthaline, balls	lb.	.08½ — .10
Naphthionic acid, crude	lb.	.70 — .85
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.30 — .35
Nitro-toluol	lb.	.20 — .30
Ortho-amidophenol	lb.	3.75 — 4.25
Ortho-dichlor-benzol	lb.	.15 — .20
Ortho-nitro-phenol	lb.	.80 — 1.25
Ortho-nitro-toluol	lb.	.25 — .40
Ortho-toluidine	lb.	.25 — .45
Para-amidophenol, base	lb.	2.50 — 3.50
Para-amidophenol, HCl	lb.	2.50 — 3.25
Para-dichlor-benzol	lb.	.12 — .18
Paranitraniline	lb	1.00 — 1.35
Para-nitro-toluol	lb	1.35 — 1.50
Paraphenylenediamine	lb.	2.15 — 3.00
Paratoluidine	lb.	1.75 — 2.50
Phthalic anhydride	lb.	.65 — .75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 — .25
Pyridin	gal.	2.00 — 2.50
Resorcin, technical	lb.	4.25 — 4.50
Resorcin, pure	lb.	6.50 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	† lb.	.45 — .50
Salicylic acid, U. S. P.	† lb.	.55 — .60
Salol	lb	.90 — 1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.22 —	$0.27
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow †	lb.	$0.38 —	$0.40
Beeswax, refined, yellow †	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.65 —	.78
Carnauba, No. 3, North Country (nominal) †	lb.	.43 —	.45
Japan	lb.	.17 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11½
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.23 —	.26
Stearic acid, double pressed	lb.	.28 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.47
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	†280 lb.	$17.50	—$18.00
Rosin E-I	280 lb.	17.50	— 19.00
Rosin K-N	280 lb.	19.45	— 21.00
Rosin W. G.-W. W.	280 lb.	22.00	— 22.50
Wood rosin, bbl.	280 lb.	15.50	— 17.50
Spirits of turpentine	gal.	.....	— 2.20
Wood turpentine, steam dist.	gal.	.....	— 2.15
Wood turpentine, dest. dist.	gal.	.....	— 1.95
Pine tar pitch, bbl.	200 lb.	8.40	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 15.00
Retort tar, bbl.	500 lb.	15.00	— 15.50
Rosin oil, first run	gal.	.93	— .95
Rosin oil, second run	gal.	.96	— .97
Rosin oil, third run	gal.	1.10	— 1.15
Rosin oil, fourth run	gal.	.....	— 1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.31 —	.32¼
Plantation—First latex crepe	lb.	.48¾ —	.50
Ribbed smoked sheets	lb.	.48½ —	.48¾
Brown crepe, thin, clean	lb.	.45 —	....
Amber crepe No. 1	lb.	.46 —	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.23¾ —	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18 —	.19¼
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½ —	.23½
Corn oil, crude, in bbls.	lb.	.17 —	.22
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.18
Cottonseed oil, summer yellow	lb.	.18½ —	.19
Cottonseed oil, winter yellow	lb.	.22 —	.24½
Linseed oil, raw, car lots	gal.	1.84 —	
Linseed oil, raw, tank cars	gal.	1.77 —	
Linseed oil, boiled, car lots	gal.	1.87 —	
Olive oil, commercial	gal.	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15½ —	.17½
Palm, Niger	lb.	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22½ —	.24
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined, in bbls.	gal.	1.70 —	
Rapeseed oil, blown, in bbls.	gal.	1.65 —	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½ —	.23
Soya bean oil, tank cars, f.o.b. Pacific coast	lb.	.16¾ —	.20

FISH

Winter pressed Menhaden	gal.	$1.18 —	....
Yellow bleached Menhaden	gal.	1.22 —	....
White bleached Menhaden	gal.	1.25 —	....
Blown Menhaden	gal.	1.30 —	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	..... —	.....
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal)	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	52.00 —	5[illegible].00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.07
Graphite, crucible, 88% carbon content	lb.	..... —	.08½
Graphite, crucible, 89% carbon content	lb.	..... —	.08½
Graphite, crucible, 90% carbon content	lb.	..... —	.09
Graphite, crucible, 91% carbon content	lb.	..... —	.08½
Graphite, crucible, 92% carbon content	lb.	..... —	.09½
Graphite, crucible, plus 92%	lb.	..... —	.12
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine nominal	lb.	1.45 —	....
Shellac, orange, superfine	lb.	1.50 —	1.60
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick net ton	75-80 at Chester, Penn.
Chrome cement net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay 1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality 1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in. net ton	80-85 at Chester, Penn.
Silica brick 1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	170.00 —	200.00
Spiegeleisen, 16-20% Mn.	gross ton	50.00 —	70.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	85.00 —	95.00
Ferro-silicon, 75%	gross ton	150.00 —	175.00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.25 —	6.75
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

COLUSA—B. L. McCue, city clk., will soon receive bids for the construction of a filtration plant, etc. Estimated cost, $38,000.

EL CENTRO—Mr. Rice, city engr., has prepared plans for the construction of a series of settling basins 2 mi. from here. Bonds amounting to $150,000 will probably be voted upon to defray expenses of this project.

FOREST—The Kate Hardy Mining Co. plans to construct a crushing plant, etc. Estimated cost, $30,000.

SELMA—The town plans an election to vote on $65,000 bonds to construct outfall sewer and septic tank. E. P. Todd, city clk.

WILLIAMS—The Bd. Supervs. are preparing plans for the construction of a water system, cost, $22,000 and a sewage disposal system, cost, $18,800. The town will vote bonds for the project. A. Givan, Sacramento, engr.

WILMINGTON—The California Barium & Chemical Co. engaged A. C. Martin, archt., 430 Higgins Bldg., Los Angeles, to prepare plans for the construction of a group of factory buildings for the manufacture of dyes, chemical sugar and other products. Smelting equipment, etc., will be installed in same. Address James O. Sword, Higgins Bldg., Los Angeles.

Connecticut

NEW BRITAIN — Landers, Frary & Clark, Commercial St., plan to build a 1-story, 50x104-ft. manufacturing plant addition. Estimated cost, $25,000. Max J. Unkelbach, 162 Main St., archt.

Illinois

CHICAGO—The Alemite Die Casting & Mfg. Co., 341 West Chicago Ave., had plans prepared for the construction of its new plant on the northeast corner of Belmont and Washtenaw Aves.

CHICAGO—The Western Petroleum Refiners Association, 14 East Jackson Blvd., is having plans prepared for the construction of a pipeline from the Kansas, Oklahoma and northern Texas fields to terminate in a large refinery here. Estimated cost, $25,000,000.

Indiana

KOKOMO—The Como Chemical Co. is building a large plant for the production of aluminum salts and heavy chemicals. H. M. Gray, pres.

Iowa

MADRID—The city awarded the contract for the construction of a sewage disposal plant, to Ward & Weighton, 516-17 Davidson Bldg., Sioux City, at $38,125.

Kansas

SALINA—The city has awarded the contract for the construction of a sewage disposal plant, to Amerman & Snyder, at $18,390.

Louisiana

BATON ROUGE—The Constantin Refining Co., New 1st Natl. Bldg., Tulsa, Okla., has purchased a 600 acre site about 2½ mi. north of here and plans to build a 20,000-bbl. oil refinery on same. Estimated cost, $2,000,000.

MANSFIELD—The Hagan Producing & Refining Co. plans to build an oil refinery. Estimated cost, $1,000,000. Address John W. Hagan, Tulsa, Okla.

SHREVEPORT — The Associated Producing & Refining Co. has purchased a 37-acre site and plans to build a 1,000-bbl. oil refinery with an initial unit on same. Estimated cost, $100,000.

SHREVEPORT — The Great Southern Producing & Refining Co., 1007 Hume-Mansur St., Indianapolis, Ind., plans to build a 1,500-bbl. oil refinery near here. Estimated cost, $250,000.

Maine

PORTLAND—A. S. Hinds, West St., has awarded the contract for the construction of a 4-story laboratory on Forest Ave., to Blackstone & Smith, 185 Middle St. Estimated cost, $500,000.

Maryland

BALTIMORE—The Emery Steel Castings Co., 603 Continental Bldg. and 210 North Garrison Lane, is in the market for electric furnaces and complete equipment for a steel foundry. Louis J. Emery, genl. mgr.

DUKES (Adelina P. O.)—The West Virginia Paper & Pulp Co., 200 5th Ave., New York City, is having plans prepared for the construction of two 2-story paper-manufacturing buildings. Estimated cost, $300,000. Lockwood, Greene Co., 101 Park Ave., New York City, archts. and engrs.

Massachusetts

BOSTON—Boston College, 688 Boylston St, is having plans prepared for the construction of a 3-story science building. Chemical equipment will probably installed in same. Estimated cost, $150,000. Maginnis & Walsh, 100 Boylston St., archts.

FITCHBURG—The Fitchburg Paper Co., 804 Main St., has awarded the contract for the construction of a paper mill, to the Casper Ranger Constr. Co., 20 Bond St., Holyoke. Estimated cost, $400,000.

WEST DUDLEY—The Burmus Paper Co. has awarded the contract for the construction of a 2-story, 50x220-ft. manufacturing building, to the H. Wales Lines Co., 134 State St., Meriden, Conn. Estimated cost, $60,000.

WEST ROXBURY (Boston P. O.)—The town of Brookline, Water Dept., is having plans prepared for the construction or a 2-story, 40x40-ft. laboratory. Estimated cost, $25,000. Stricland & Law, Pemberton Sq., Boston, archts.

Michigan

KALAMAZOO — The Kalamazoo Sanitary Mfg. Co. is in the market for equipment for the manufacture of pottery for sanitary plumbing ware.

Montana

HARLEM—The city plans an election April 5 to vote on $45,000 bonds to construct a filtration plant, etc. C. P. Wells, 804 1st Natl. Bank Bldg., Great Falls, engr.

New Jersey

TRENTON — The Natl. Porcelain Co., Southard St., received bids for the construction of a 2-story, 51x72-ft. porcelain plant, from Hiram Hughes, 1145 Indiana Ave., $19,310; Trenton Bldg. Corp., 1430 Riverside Ave., $20,975; Edward A. Lee, 511 Tyler St., $21,000.

TRENTON—The Thermoid Rubber Co., Whitehead Rd., has awarded the contract for the construction of a 1-story, 150x200-ft. rubber mill to the N. A. Bugbee Co., 206 East Hanover St. Estimated cost, $75,000.

New Mexico

ESTANCIA—The town plans an election April 6 to vote on $10,000 bonds to construct an outfall sewer and septic tank. C. H. Calkins, engr.

New York

HARRISON—The Diana Paper Co. had plans prepared for the construction of a 60x94-ft. addition to present plant. Estimated cost, $10,000. Charles E. Eaton, 307 Sherman Bldg., Watertown, engr.

MARCY — The State Hospital Comn., Capitol, Albany, received bid March 17 for the construction of a mortuary, laboratory and tuberculosis hospital building at the Utica State Hospital, here, from the Peter Keeler Bldg. Co., 425 Orange St., Albany, $186,270.

MASSENA—The Massena Farmers' Cooperative Corp. has awarded the contract for the construction of additions and repairs at the Erwin factory to C. I. Allen. The company is in the market for milk-handling and laboratory equipment. Estimated cost, $15,000.

SCENECTADY—The Mica Insulator Co., Dock St., has awarded the contract for the construction of a 4-story, 50x120-ft. factory, and a 1-story addition to present building, to the Turner Constr. Co., 242 Madison Ave., New York City. Estimated cost, $125,000.

SYRACUSE—The Will & Baumer Co., Liverpool, plans to build a 3-story, 72x255-ft. candle factory on Liverpool Rd. Estimated cost, $200,000. Guy L. Noble, Union Bldg., archt. and engr.

WATERTOWN—The Taggart Bros. Co., 595-597 Main St., West, will build a 1-story, 67x200-ft. addition to paper mill plant. Estimated cost, $40,000. Work will be done by day labor.

Ohio

CLEVELAND—The city plans to construct a reservoir, filter house, etc. at Baldwin, cost, $2,000,000; and at East Side filter plant with necessary pumping equipment, including filter basin, etc., cost, $5,000,000. A. V. Ruggles, City Hall, engr.

CLEVELAND—The Cleveland Automobile Co., East 131st St., has awarded the contract for the construction of a 1-story, 80x80-ft. heat-treating plant on London Rd., to John Gill & Son, 1301 Citizens Bldg. Estimated cost, $60,000. Noted March 3.

Oklahoma

ADA—A. L. Brown plans to construct a large brick plant. Large deposits of the shale for making this product lie south of here. Estimated cost, $75,000.

Pennsylvania

NEW HOPE — The New Hope Paper Mills has awarded the contract for the construction of a 2-story, 60x144-ft. paper mill, to C. R. Randall, 43 North Hermitage Ave., Trenton, N. J. Estimated cost, $25,000.

Texas

TEXAS CITY—The White Oil Corp., 501 5th Ave., New York City, plans to build a 15,000-bbl. oil refinery on an 800-acre site recently acquired here. Estimated cost, $2,000,000.

Wisconsin

BURLINGTON—The Burlington Brass Wks. is having plans prepared for the construction of a 1-story, 100x140-ft. foundry. Edmund B. Funston, Robinson Block, Racine, archt. and engr.

SHEBOYGAN.— The Wisconsin Textile By-products Co., Calumet Rd., is having plans prepared for the construction of a 2-story, 60x87.6-ft. addition to present building and a 60x72.6-ft. building. Estimated cost, $30,000. W. C. Weeks, Ontario Ave., archt.

British Columbia

VICTORIA—The Sidney Rubber Roofing Co., Sidney, plans to construct a factory. Estimated cost, $200,000. R. W. Mayhew, mgr.

Ontario

CHATHAM—The city will vote upon bylaw appropriating $37,000 to construct a rapid sand gravity filtration plant with chlorination apparatus. F. P. Adams, City Hall, engr.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROCHEMICAL SOCIETY, NEW YORK SECTION, will hold a meeting on March 26, the subject of which is "Peace Uses for War Products."

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PETROLEUM LEAGUE will hold a meeting in Chicago, March 26 to 29.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theatre: "Helium," Monday, March 29, at 4 P.M., Dr. R. B. Moore, chief chemist, U. S. Bureau of Mines (*Lantern*); "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 P.M., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE CONNECTICUT VALLEY SECTION of the American Chemical Society will hold a meeting Saturday, March 27, at the Hotel Elton, Waterbury, Conn. Prof. Joseph W. Richards, of Lehigh University, will speak on "The Principles Underlying the Electrochemical Industries." The Scoville Manufacturing Co.'s laboratory will be visited after the meeting.

THE ELECTRIC FURNACE ASSOCIATION will hold a meeting in Boston April 8 to 10, together with the American Institute of Electrical Engineers and the American Electrochemical Society. The subject is "Electrically Produced Alloys and Power for Electrochemical Purposes." Headquarters will be at the Copley-Plaza Hotel.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INTERNATIONAL MINING CONVENTION will be held in Seattle April 7 to 10.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS INSTITUTE OF AMERICA will hold a meeting in Cleveland, Ohio, July 13.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE PENNSYLVANIA SAFETY CONGRESS for 1920 will be held at Harrisburg, Pa., March 21 to 25 inclusive.

THE SOCIETY OF INDUSTRIAL ENGINEERS will hold its national spring convention March 24 to 26 at the Bellevue-Stratford Hotel, Philadelphia.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 14 to 16.

New Publications

GEOLOGY AND OIL POSSIBILITIES OF THE NORTHERN PART OF OVERTON COUNTY, TENN. AND OF ADJOINING PARTS OF CLAY, PICKETT AND FENTRESS COUNTIES. Bull. 24, published by the State Geological Survey, Nashville, Tenn.

BRITISH INDUSTRIAL RECONSTRUCTION AND COMMERCIAL POLICIES, by Fred W. Powell; Special Agents Series No. 193, Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C.; sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., 10c.

SOLID LUBRICANTS, Bull. No. 4, Department of Scientific and Industrial Research, 15 Great George St., Westminster, S. W. 1, England; price 6d net. The bulletin is a summary of existing literature and not a statement based upon actual research work.

STATE OF ILLINOIS, Department of Registration and Education, Division of the State Geological Survey, has issued Bull. No. 4, on Oil Investigations in 1917 and 1918.

INDUSTRIAL RESOURCES OF THE PHILIPPINE ISLANDS. This is a 40-page pamphlet published by the Bureau of Science, Department of the Interior of the Government of the Philippine Islands, Manila. It covers chemical technology, limestone and silicate industries, non-metallic and mineral resources, fisheries, etc.

THE MISSISSIPPI VALLEY ASSOCIATION, 10 South LaSalle St., Chicago, has issued the report of its Foreign Trading and Banking Committee in a pamphlet entitled "Foreign Trade Survey, Our Share and How to Get It." The work is submitted after four months of exhaustive research as an aid to business concerns in doing their share of the world construction program. The economic and legal aspects are presented. The Association will welcome inquiry on the subject.

FIRST ANNUAL REPORT OF THE SECRETARY OF THE STATE BUREAU OF MINES AND GEOLOGY, for the period April 20 to Dec. 31, 1919. Published by the State of Idaho, under the direction of the Bureau of Mines and Geology.

THE PRODUCTION OF COPPER, GOLD, LEAD, NICKEL, SILVER, ZINC AND OTHER METALS IN CANADA, during the calendar year 1918. Published by the Department of Mines, Ottawa.

COST REPORTS OF THE FEDERAL TRADE COMMISSION, "Copper." Published at the Government Printing Office, Washington, D. C.

BANK AND PUBLIC HOLIDAYS THROUGHOUT THE WORLD. Published by the Guaranty Trust Co., New York.

THE MINERAL INDUSTRY OF UTAH, by Robert S. Lewis and Thomas Varley; Bull. No. 12, Utah Engineering Station, Department of Metallurgical Research. Published by the University of Utah, State School of Mines, in Co-operation of the U. S. Bureau of Mines. Copies may be obtained, free of charge, by applying to the Director, State School of Mines, University of Utah, Salt Lake City, Utah.

COMBINING FOR FOREIGN TRADE. Published by the Guaranty Trust Co., New York City.

THE ENGINEERING FOUNDATION has published a progress report to the United Engineering Societies outlining the work accomplished through co-operation with the National Research Council.

BIBLIOGRAPHY SERIES, published by Arthur D. Little, Inc., Boston: No. 1, Chemical Warfare, reprinted from "Special Libraries," November, 1919; No. 2, The Production of Alcohol From Sulphite Waste Liquors, reprinted from *Paper*, Dec. 3, 1919; No. 3, Industrial Research, reprinted from "Special Libraries," January, 1920.

STRATIGRAPHY AND CORRELATION OF THE DEVONIAN OF WESTERN TENNESSEE, by Carol O. Dunbar. Bull. No. 21, published by the State Geological Survey, Nashville, Tenn.

THE NORTON CO., Worcester, Mass., has published a booklet on "Little Known Facts About Grinding." These are a series of brief articles by Howard W. Dunbar treating commonplace facts concerning grinding, and reprinted from *Grits and Grinds*, the periodical of the Norton Co.

COAL RESOURCES OF DISTRICT V (Saline and Gallatin counties), by Gilbert H. Cady. Bull. No. 19 (Co-operative Mining Series), published by the Department of Registration and Education, Division of the State Geological Survey, Urbana, Ill.

THE U. S. COUNCIL OF NATIONAL DEFENSE has published a booklet which is entitled "Readjustment and Reconstruction Information."

NEW U. S. TARIFF COMMISSION PUBLICATIONS: Tariff Information Series No. 15, Costs of Production in the Dye Industry 1918-1919; No. 13, The Acids of Paragraph 1 and Related Materials Provided for in the Tariff Act of 1913. A general economic survey of the industries producing citric, oxalic, formic, lactic, gallic, boric and tartaric acids.

NEW FEDERAL BOARD FOR VOCATIONAL EDUCATION PUBLICATIONS: Bull. No. 39, Coal-Mine Gases; Bull. No. 43, The Labor Audit, a Method of Industrial Investigation.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS: I: 11, Gold, Silver, Copper, Lead, and Zinc in the Eastern States in 1918, by James M. Hill (Mineral Resources of the U. S., 1918, Part I), published Jan. 26, 1920; I: 12, Gold, Silver, Copper, Lead and Zinc in Nevada in 1918, by V. C. Heikes (Mineral Resources of the U. S., 1918, Part I), published Jan. 27, 1920; Bull. 694, Bibliography of the Metals of the Platinum Group, Platinum, Palladium, Iridium, Rhodium, Osmium, Ruthenium, 1748-1917, by James Lewis Howe and H. C. Holtz; Bull. 705, Conservation Through Engineering, by Franklin K. Lane, which is an extract from the Annual Report of the Secretary of the Interior.

NEW BUREAU OF MINES PUBLICATIONS: Miners' Circular No. 22, Dangerous and Safe Practices in Bituminous Coal Mines, by Edward Steidle; Miners' Circular No. 26, Miners' Safety and Health Almanac for 1920, compiled by R. C. Williams, published in co-operation with the United States Public Health Service; Tech. Paper 232, Absorption as Applied to Recovery of Gasoline Left in Residual Gas From Compression Plants, by W. P. Dykema and Roy O. Neal; Tech. Paper 236, Abatement of Corrosion in Central Heating Systems, by F. N. Speller; Tech. Paper 237, Safe Practice in Using Wire Ropes in Mines, by O. P. Hood and R. H. Kudlich; Tech. Paper 257, Waste and Correct Use of Natural Gas in the Home, by Samuel S. Wyer; Bull. 175, Experiment Stations in the Bureau of Mines, by Van H. Manning; Bull. 181, Abstracts of Current Decisions on Mines and Mining, by J. W. Thompson; Report of Committee on Standardization of Petroleum Specifications.

NEW BUREAU OF STANDARDS PUBLICATIONS: Circular No. 87, Recommended Specifications for Zinc Oxide, Dry and Paste; Circular No. 88, Recommended Specifications for Leaded Zinc Oxide, Dry and Paste; Scientific Paper No. 331, A Relation Connecting the Derivatives of Physical Quantities, by Mayo D. Hersey; Scientific Paper No. 333, Optical Conditions Accompanying the Striae Which Appear as Imperfections in Optical Glass, by Lieutenant Commander A. A. Michelson; Scientific Paper No. 334, New Forms of Instruments for Showing the Presence and Amount of Combustible Gas in the Air, by E. R. Weaver and E. E. Weibel; Scientific Paper No. 338, Some Optical and Photo-electric Properties of Molybdenite, by W. W. Coblentz and H. Kahler; Scientific Paper No. 339, Standardization of the Sulphur Boiling Point, by E. F. Mueller and H. A. Burgess; Scientific Paper No. 341, Airplane Antenna Constants, by J. M. Cork; Scientific Paper No. 342, Reflecting Power of Stellite and Lacquered Silver, by W. W. Coblentz and H. Kahler; Scientific Paper No. 344, Spectral Photoelectric Sensitivity of Silver Sulphide and Several Other Substances, by W. W. Coblentz and H. Kahler; Scientific Paper No. 345, Measurements of Wave Lengths in the Spectra of Krypton and Zenon, by Paul W. Merrill; Scientific Paper No. 352, Thermal Expansion of Insulating Materials, by Wilmer H. Souder and Peter Hidnert; Scientific Paper No. 358, Concerning the Annealing and Characteristics of Glass, by A. Q. Tool and J. Valasek; Scientific Paper No. 359, Efflux of Gases Through Small Orifices, by Edgar Buckingham and Junius David Edwards; Scientific Paper No. 363, Preparation and Reflective Properties of Some Alloys of Aluminum With Magnesium and With Zinc, by R. G. Waltenberg and W. W. Coblentz; Tech. Paper No. 142, Materials and Methods Used in the Manufacture of Enameled Cast-Iron Wares, by Homer F. Staley; Tech. Paper No. 143, A Study of the Deterioration of Nickel Spark-Plug Electrodes in Service, by Henry S. Rawdon and A. I. Krynitzky; Tech. Paper No. 144, Properties of American Bond Clays and Their Use in Graphite Crucibles and Glass Pots, by A. V. Bleininger; Tech. Paper No. 149, Estimation of Nitrates and Nitrites in Battery Acid, by L. B. Sefton; Tech. Paper No. 154, Determination of Cellulose in Rubber Goods, by S. W. Epstein and R. L. Moore.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, March 31, 1920 *Number* 13

How Shall the Government Nitrate Plants Be Operated?

IF THERE is serious and substantial opposition to the idea of the Government operating the nitrogen-fixation plants at Muscle Shoals, it has not been disclosed in organized form at the present writing. On the other hand, there is a growing sentiment in favor of the plan, seeing that two other nations, Germany and Chile, are officially engaged in the nitrogen industry and realize the importance of nitrogen in national welfare. If the United States is to enter these ranks, what shall be the business and commercial machinery for its accomplishment? Shall the War Department undertake the job on account of the close relation between nitrates and munitions? Or shall it fall to the lot of the Department of Agriculture in view of the peace-time importance of nitrogen for fertilizer? Or shall the Department of the Interior be the medium, on the score that nitrogen fixation is a conservation measure and is closely linked with the development of water power?

None of these queries brings an unqualified affirmative answer. And for reasons which we believe will be obvious. A better plan, in our judgment, is contained in the proposal to organize the United States Fixed Nitrogen Corporation, all the stock of which shall be owned by the United States and which shall be free to conduct its business without the restrictions and red tape incident to departmental operation. This corporation would have a working capital with which it must achieve success or failure, and it could not come hat in hand to Congress for annual appropriations with which to conduct its business. Once organized and financed, it would have to stand or fall by its results. It would be free to work like other corporations, and have similar responsibility to its single stockholder, the United States. It would conduct research simultaneously with the development and operation of its plants, and would keep pace with developments in the art of nitrogen fixation so that in emergency the Government would find itself fully informed and in possession of a trained personnel.

Bills proposing such a corporation have already been introduced in both houses of Congress, and hearings have been held by the Senate Committee on Agriculture and Forestry, to which the Senate bill was referred. The House bill has not yet been considered, but it is identical with that of the Senate. The Senate hearing, which is reported elsewhere in this issue, was unusually well organized. The Secretary of War appeared in favor of the bill, and made an exceptionally good statement, showing a grasp of the situation most commendable in a high official. He was supported by officers of the Nitrate Division of the Ordnance Department and by civilian chemists and engineers. There was little discussion of the detailed provisions of the bill itself, the evidence being confined mainly to the necessity of operating the plants and the benefits which would accrue to the country in such an event. Our own discussion of the bill will be reserved to a later date after further study.

In the meantime we favor the general plan as outlined, and expect to present more detailed statements explaining why a United States Fixed Nitrogen Corporation is apparently the best medium for Government operation of the plants at Muscle Shoals. Not the least impressive argument for the plan is the proposed method of financing the corporation without appropriating new funds, the necessary capital being found in the sale of a part of our reserve of Chilean nitrate, which could be safely reduced if the nitrate plants were in regular operation.

Is Pearlite a Special Form Of Widmanstättian Structure?

DR. GIOLITTI elaborates a hypothesis on the crystallography of ferrite which is very suggestive, and which he has found useful in his own practice for many years. For this reason, if for no other, it is undoubtedly worth the careful consideration of those familiar with the eminent Italian's ideas. Unquestionably they will think back over their own experience and justify it, or condemn it, as the majority of instances are marshalled on one side or the other.

Briefly, his idea is this: Many facts seem to indicate that the crystalline habit of beta iron is massive, that of alpha iron laminar. Given correct cooling conditions, then, a micrograph will show rounded particles of ferrite in low carbon iron, and thin striations in the higher carbon areas.

Some recently published illustrations bear out the theory quite strikingly. For instance FOLEY and later CLAYTON have published brief communications in the *Bulletin* of the American Institute of Mining and Metallurgical Engineers, showing pronounced Widmanstättian structure within the pearlite grains of low-carbon nickel-steel ingot runners. Such grains are notably higher in carbon within than at their surfaces, and doubtless the ferrite precipitated directly as alpha iron at temperatures below Ar_1, and, by this new hypothesis, should have a plate-like habit. Yet this structure in FOLEY'S metal, strangely enough, is confined to a thin shell immediately below the outer skin. Why should ferrite from one pearlite grain accumulate in parallel bandings, while that from a closely adjacent grain be finely divided, almost emulsified?

CLAYTON'S photographs are especially interesting in showing swirls of curved ferrite, which he ascribes to

the supposed influence of pre-existing rounded grains of austenite. Could they not more plausibly be regarded as the early stages of growth of a true pearlite grain, with its characteristic laminated structure?

Conceive an undercooled particle of austenite containing approximately eutectoid composition and a nucleus of ferrite to appear somewhere near its center. Reaction spreads outward from this germ with relatively high velocity as from a detonator, alternately producing shells of cementite and ferrite as the wave of transformation passes outward. The succeeding shells would become supersaturated with carbon and with iron alternately, and a characteristic onion-like structure results from the attempt to maintain equilibrium. It seems that a structure should be produced which is somewhat independent of the cleavages existing in the austenite, and might well appear exactly like the swirls photographed by CLAYTON, especially when reinforced by the plate-like crystalline habit postulated by GIOLITTI.

Such speculations as these are extremely attractive to the metallurgist of philosophical propensities, and are not without importance to the ultra-practical, since it is well known that Widmanstättian structure is an undesirable constituent in steels to be used under impact or alternating loads. Yet to know how to avoid it, it is best to know what it is.

Exit the National Laboratory Foundation

PROBABLY few of our readers are familiar with the brief existence of a project known as the National Laboratory Foundation; and if we reverse the usual order by recording its demise without having first announced its birth, it is because we were skeptical of the proposition and preferred to watch its course before approving it. Always there was the feeling that a Senegambian was concealed somewhere in the proverbial woodpile. There was no lack of laudable purpose or commendable object, which was to provide laboratory facilities for invention and research, especially for those who had limited resources. But the original sponsors for the scheme—who were they? and what motives animated them? As far as we were aware none of them was known to science, but they were astute enough to gain for their scheme the tacit approval of famous and reputable men in various fields of scientific endeavor. That those men finally proved quite as astute in fathoming the unethical depths of the plan and refusing to further its success is much to their credit. Just what they discovered we do not know in detail, but doubtless they were led to wonder why a contract had been made with one individual for the payment of a commission on the collection of the proposed endowment. That they discovered evidence of an entangling alliance with the National Institute of Inventors and the National Inventors Sales Corporation, and "their personnel, policies and methods," is disclosed in resolutions condemning the plan and disavowing further responsibility for it. The National Laboratory Foundation was launched with much speaking and dining; it was wrecked on the rocks of personal advantage and private gain. Superficially it was a fine plan, but science and invention would have been scandalized by its success. There is still an opportunity for service by such an institution, but its sponsors, like CÆSAR'S wife, must be above suspicion.

Our Greatest Chemical Industry

COAL utilization is undoubtedly the greatest chemical industry of this country; in fact, it is perhaps our greatest industry of any sort. It includes byproduct coking, locomotive- and stationary-boiler problems, the operation of city gas works, and a multitude of other forms of direct coal utilization in industries, as well as a vast number of byproduct problems of the widest possible interest. Just now there is a very striking development in this great industry that probably has been overlooked by most of our chemical interests. This relates to the city gas works or the coking of coal for municipal gas supply.

Recently two large gas companies have announced plans for installing coking plants for the production of coal gas which is to replace carbureted water gas; and this is only a beginning, with no end of the changes in sight. In 1915, for example, 550 plants produced 136 billion cubic feet of water gas. In more recent years the quantities produced have been even greater and a very large proportion of this water gas, which was made from coke or anthracite and gas oil, must be eliminated and coal gas or coke-oven gas made from bituminous coal substituted. This is essential because of the tremendous increase in the cost of all petroleum products which is making practically prohibitive the purchase of gas oil for water-gas manufacture.

The Washington Gas Light Company announced recently its plans to build a plant to produce 10,000,000 cu.ft. of coke-oven gas per day. The immediate cause of this change was the increase in the price of oil from 7½ cents per gallon on recent contracts to over 12 cents a gallon for offerings now available; and there is some uncertainty whether sufficient quantity is available even at this higher price. Similarly, the Peoples' Gas Light & Coke Co. of Chicago has arranged to build a large coke-oven plant with a capacity of at least 12,000,000 cu.ft. of coke-oven gas per day. These are only two of the significant changes; many more are inevitable throughout the country unless unexpected reductions in the price of petroleum occur in the immediate future. In fact, we can expect that within a few years a hundred billion cubic feet of water gas will be replaced by coke-oven or coal gas.

The production of this gas from byproduct and retort processes will range from 5,000 to 10,000 cu.ft. of gas per ton of coal carbonized, averaging perhaps 7,000 ft. per ton, taking together all the processes that are likely to be used. On such a basis we can foresee the prospective use of 12,000,000 to 15,000,000 tons of coal for carbonization in these plants.

The byproduct production from this large tonnage will be a considerable factor in many industrial lines. There will be 8,000,000 to 10,000,000 tons of coke made, much of it suitable for metallurgical use, the rest probably going into the markets as a substitute for anthracite, especially in the Central and Western territory, where anthracite is now selling at prices much above those demanded a number of years ago.

If such a tonnage of coal is handled, the production of ammonium sulphate will be from 125,000 to 150,000 tons per year above the present production. This represents a very large percentage increase in our supply. But at present the fertilizer industry is finding it necessary to replace many of its organic nitrogen sources such as tankage, dried blood, fish scrap, etc.,

by other nitrogen sources, since these organic ammoniates have reached prohibitive prices. Therefore we can confidently expect the fertilizer industry to absorb readily such portion of this sulphate as may be offered to it.

The same factors which have brought about this tendency to change from water gas to coal gas have, of course, resulted in shortage of motor fuels. Consequently the light oils that we can expect from the carbonization of increasing quantities of coal, amounting to perhaps 30,000,000 to 40,000,000 gal. a year, will very readily be absorbed in the motor fuel industry. As a matter of fact the quantity in prospect will probably not amount to more than a very few per cent of the total motor fuel demand of the country.

Tar production in any such quantities as will follow from great changes in coal-gas production will require rather new industrial chemical developments. Of course our extensive road-building program will afford a large demand for tar, but it is probable that much of the 100,000,000 gal. or more of this material will find its market as a substitute for fuel oil rather than directly in any of the chemical industries.

Although these estimates of byproduct production are based upon a rather extreme assumption of change in character of gas-making processes, and therefore cannot be expected to materialize except during a period of years, yet they represent a very real tendency in our economic system and any one who ignores the trend of these times is likely before long to become very much out of touch with our industrial situation.

The Annual Report Of the Steel Corporation

THE annual report of the United States Steel Corporation, issued in the usual pamphlet form of about fifty pages, 9 x 11 in., in the past week, may be scanned or studied from various viewpoints. From the economic viewpoint an interesting fresh piece of information is that $52,000,000 was deducted from the profits of 1919 as allowance for the Federal taxes, against $274,000,000 for 1918, the decrease being due partly to the rates provided in the law of 1918 being higher for 1918 than for subsequent years, and partly to the total profits having been less. The earnings remaining for 1919, after payment of subsidiary company bond interest, amounted to $143,589,063, a fact known approximately in January, when the report for the fourth quarter was issued, while the tax information is entirely new, since the quarterly report for 1919 differed from those of the two years preceding in containing no statement of the tax allowance. The earnings of $143,589,063 compared with $199,350,680 for 1918, $295,292,180 for 1917 and $333,574,178 for 1916, the corporation's record year. Prior to the war, however, the record was about $160,000,000, made in both 1906 and 1907.

Thus it is seen, from the economic viewpoint, that the Federal income and excess-profits taxes do not bear heavily upon the steel industry, nor upon the consumers of steel, should it be held that the tax is, or should be, passed on to the buyer, for the $52,000,000 tax allowance for 1919, if allocated entirely to the 12,000,000 tons of steel products sold by the corporation, amounts to only $4.34 per ton, the ton which is used being chiefly the gross ton.

From the economic viewpoint there is another very interesting thing in the report. There was $87,091,515 of new construction in the year, and $48,793,661 of this was charged to property account, the remaining $38,297,854 being charged to profits, before the earnings were arrived at. A portion of the latter amount, the exact sum not being stated, represented the cost of making useful for the production of peace material certain facilities the construction of which had been undertaken for war purposes, while the other part was charged off from income on account of the cost having been "extraordinary" because of the existence of "war conditions."

Specifically the report states that the cost of the construction "over what the estimated cost of constructing and installing would have been in the pre-war period was charged off to income." Before the war, which some economists insist has permanently lowered the value of the dollar very greatly, this certainly meaning that properties left intact should be valued in many more dollars than formerly, the Steel Corporation's property account stood at $1,600,000,000. The total expenditures on construction in 1919 amounted to $87,000,000, between 5 and 6 per cent as much. Far from rating its old properties as worth more dollars, by reason of alleged changed conditions, the corporation is not content to charge to property account the entire amount of these relatively modest expenditures, made under what it calls "war conditions," though as a matter of fact the Armistice was signed before the year began.

From the financial viewpoint, one observes that the Steel Corporation, after making allowance for the Federal taxes and after the deductions from income just referred to, had earnings sufficient to take care of all charges and dividends and still leave a surplus of $26,159,781, this being done on an output which is stated to have been 74.5 per cent of capacity, when it has been commonly held in the steel industry that operation under 80 or 85 per cent of capacity is distinctly uneconomical. In the report the corporation renews its expression of confidence in the propriety of the Industrial Board steel prices of March 21, 1919, to which it still adheres. It has higher wages to pay now, as well as increased costs in other respects, but on the other hand it is assured of full operation as far as physical conditions permit, this providing a more economical operation as well as a larger number of tons upon which to make profits.

From the purely physical standpoint, it is interesting to note the statement that operations averaged 74.5 per cent of capacity, when the output of steel products, weighed in the form in which they were sold to outsiders, was 11,997,935 tons. Thus the corporation's estimate of its capacity is 16,200,000 tons per annum, or 52,500 tons per working day. The corporation's record output was in 1916, when physical conditions, while satisfactory for most of the year, distinctly limited output in the closing weeks, and in that year the output was 15,460,792 tons, equal to precisely 50,000 tons per working day. Mill outputs usually increase from time to time even without definite improvements, while there have been some new installations. Thus the present estimate of 52,500 tons as capacity is obviously conservative, and is likely to be exceeded in the near future, as transportation conditions, the only important barrier to full operation, are improved.

Readers' Views and Comments

Atomic Structure of Metals in Solid Solution

To the Editor of Chemical & Metallurgical Engineering

SIR:—There has been recently some discussion in your columns of an article of mine on the atomic structure of metals in solid solution (CHEM. & MET. ENG., vol. 21, pp. 566-70).

Dr. Jeffries (CHEM. & MET. ENG., vol. 22, p. 100) does not take up the important aspect of the paper, i. e., the agreement between the observed values for the maximum electrical resistance of the binary alloys Ag-Au, Au-Cu, and Cu-Ni, and the values calculated by means of the theory advanced. He makes the suggestion that an alloy of equi-atomic percentages of Ag and Au might be expected to show a sharp break in resistance at the melting range, but he quotes no experimental evidence in its support. So far as I was able to inform myself, there is no datum on this point, either for Ag-Au or any other binary solid solution alloy immediately above the liquidus and immediately below the solidus. Naturally, measurements made on such a system in the melting range where two phases, liquid and solid, are present, would have no definite physical significance.

It is of interest, however, to call attention here to the fact that Northrup (*J. Franklin Inst.*, vol. 182, pp. 477-509) has measured the resistance for the eutectiferous system Sn-Bi and finds for the eutectic composition (58 atomic per cent Sn) no appreciable break in the temperature-resistance curve at the melting point, but simply a point of inflection. Dr. Jeffries' suggestion might be interpreted as applying here with equal force, but the experimental evidence disproves its validity. I can see nothing, other than a direct measurement, which can discredit the assumption that the temperature-resistance curves for binary solid solution alloys, in both the liquid and solid "amorphous state," lie along the same smooth curve.

As an argument against the tenableness of my theory Dr. Jeffries has drawn attention to the existence of heats of crystallization and of fusion in the case of the alloys in question. I would be interested to be referred to such measurements as these in the literature. I admit that cooling curves show the existence of a definite point of inflection at the liquidus, and of a very ill-defined point at the solidus. But these data have not yet been interpreted to give any quantitative idea of the quantities of heat involved in solidification. There are other processes operating in the melting range, particularly the well-known diffusion phenomena, which might be involved in the observed heat effects but which are distinct from the true heat effects of fusion and crystallization.

It was not argued that in passing through the melting range there does not occur a change from the liquid to the solid state, a process involving as its most noticeable accompaniment a change in viscosity. No one has yet claimed any direct relation between viscosity and the existence or non-existence of the crystalline state. Consider, for instance, the substances described as liquid crystals.

The electrical data establish with a degree of certainty, based on an unusual quantitative agreement between the theoretical and observed values of electrical resistance, that the binary solid solution alloys of maximum resistance have a structure in the solid state identical with that of the liquid state so far as metallic conduction is concerned. Now, there are few, if any, properties which are so intimately dependent upon the atomic structure of an alloy as is its electrical resistance. Electron distribution determines largely the atomic combinations, and it is a most important factor in determining the electrical resistance.

We are now brought to an important point of Dr. Jeffries' criticism, and one which was also discussed more fully in Dr. Donald P. Smith's (CHEM. & MET. ENG., vol. 22, p. 340) more recent, excellent comment on the subject of my paper—namely, the existence even in the solid solution alloys of maximum resistance (approximately equi-atomic proportions) of what appears to be a crystalline structure, when examined microscopically as a polished and etched specimen. I take it to be understood that the existence of a "granular" or non-homogeneous structure obtained by an examination of alloys which have been more or less rapidly cooled through the melting interval, and which show the "cores" and dendritic formations caused by the inherent nature of the freezing of solid solution alloys (i. e., difference in composition between liquid and deposited solid at all points other than at a maximum or minimum on the freezing curve) has no bearing upon the present discussion. Homogeneity of structure, obtained by thermal treatment, is a first consideration. I am unwilling to admit that in the case of such a homogeneous structure the appearance of what are called "grains" by the metallographist is conclusive evidence of the existence of a crystalline structure, in the true meaning of the word. I can conceive of the existence of a granular structure in a perfectly amorphous solid.

It might be well to call attention to the fact that it has been quite customary to attribute a definite melting point to a crystal, to distinguish it from a mixture. However, a binary solid solution crystal, if such, perchance, exists at equi-atomic concentrations, does not melt at a constant temperature. Hence, the "crystalline" structure of solid solution alloys must be of a different type from that of ordinary crystals, and the crystallization phenomena at the melting range must be correspondingly modified. According to my theory, based on an independent quantitative relation which exists regardless of the validity of the theory, crystallization in binary solid solution alloys of maximum resistance is modified to such an extent that the atomic structure of the solid alloy is identical with that of the liquid. If it is conclusively shown that the solid alloys are crystalline, then I will modify my theory to the extent of assuming that the same type of crystalline structure exists in the liquid alloys.

I do not fully understand the significance of Dr. Jefries' reference to "the directional and deformational characteristics of solid solution alloys." The components of the systems studied belong to the cubic system. Hence the only directional characteristic to be expected is that of the three crystalline axes, determinable only in the case of idiomorphic crystals. Since we are not dealing with idiomorphic crystals, and I do not believe they have been observed in the cases under considera-

tion, I am unwilling to admit without further evidence that slip-bands are dependent upon or are determined by cleavage planes corresponding to the existing direction of these axes. Cleavage planes are found in some amorphous bodies.

According to recent investigations of Tammann (*Nachr. Kgl. Ges. Göttingen*, 1916, pp. 199-265; 1917, pp. 345-72, 385-425), the difference between a "mixed crystal" and a chemical compound depends upon the electrons surrounding the positive core. For solid alloys of the systems Ag-Au and Cu-Au it was found that the atoms were present in the free state, while Au-Zn alloys form a compound in equi-atomic proportions. These conclusions were reached from experiments on galvanic potential. Moreover, certain well-defined limits of resistance to galvanic attack were found, with respect to the composition, of such solid solution alloys as Au-Ag and Au-Cu. There may well be a certain relation between these observations and the formation of an increasing amount of solid amorphous metal with increase of concentration.

I wish finally to call attention to a misprint in Dr. Smith's discussion. In the first paragraph, Ag-Cu should read Au-Cu.

ALEX. L. FEILD.

Niagara Falls, N. Y.

The Technical Engineer's Judgment of the Oxy-Acetylene Process

To the Editor of Chemical & Metallurgical Engineering

SIR:—The writer is interested to note the article in your issue of Feb. 4, 1920, entitled "The Technical Engineer's Judgment of the Oxy-Acetylene Process," by Alfred S. Kinsey. In the paragraph on "Forge Welding," Mr. Kinsey states:

"Up to the advent of autogenous welding the engineer had only his experience with the forge weld upon which to base his calculations and judgment. In a way this proved somewhat unfortunate for the new method of welding, as the forge weld has nearly lost its value as a dependable means of joining metals. Imagine two pieces of steel being brought to a soft plastic condition in a forge fire charged with sulphur from the fuel, an excess of oxygen from the indifferently operated bellows or fan blower, the cinders and refuse of the fuel, and one can readily realize the cause of weak forge welds. Such welds never were reckoned to have a tensile efficiency of more than about 50 per cent, and many observations of welds which had failed showed crystallization and even entrapped cinders. Navy yards and many other large shops had practically abandoned the forge weld, preferring the expensive substitute of machining a job out of the solid when it was possible to do so. Serious failures of forge welds were too common."

Mr. Kinsey is absolutely correct in his judgment of a forge weld as made by the process which he so aptly describes, but he seems to lose entire account of the fact that other processes of forge-welding, with improved methods of heating, have been developed since the days of the prehistoric blacksmith, which eliminate the very causes which he speaks of as being detrimental to a good weld—such as sulphur from the fuel, cinders and refuse, excess of oxygen by the blower, etc.

There are several advantages in joining metal together in its "plastic" condition which are completely overlooked by Mr. Kinsey in his article—such as the fact that the metal is not heated up to the point where it will absorb either oxygen from the air or carbon from the acetylene arc, as is the case from the carbide flame; that its chemical characteristics after being welded are not materially changed; and the vigorous working which it gets, which actually reduces areas and thereby distinctly changes the granular construction, greatly assists in the welding of the two pieces together under a hammer.

The advent of modern apparatus for heating the plates under an absolutely controlled condition of temperature, and the working under heavy, high-power-driven hammers, thus assuring a complete working of the metal and the breakdown of the crystalline structure, have made it possible to make forge welds whose efficiency and general dependability are far above any that can be made by the oxy-acetylene or any other known process. The range of thickness encompassed by the autogenous-welding process is extremely limited, whereas the forge-welding as done by modern apparatus is applicable to very heavy plates, and has been used successfully under pressures and temperatures far above any that have ever been attempted for autogenous-welded receptacles.

When the autogenous-welding process can be developed up to the point where it can make a cylinder, for example, 5 in. in diameter, of 1½-in. plate, to stand a working pressure of 500 lb. and a temperature of 900 deg. F., and prove absolutely dependable for such service, it will then be safe to say that it has reached the point where it is as dependable as forge-welding by modern processes.

The old-fashioned forge weld as described in Mr. Kinsey's article is acknowledged to be just as unreliable as the autogenous weld made under relatively the same unfavorable conditions, and a long series of experiments and a thorough training in technique have been necessary to develop either of them to the point where they are today.

F. E. JOHNSON, JR.,
Vice-President.

The M. W. Kellogg Co.,
New York City.

Distribution of Apparatus and Reagents for Laboratory Courses

Prof. W. L. Estabrooke, of the department of chemistry of the College of the City of New York, described in a late number of *Science* the operation of the Freas system in distributing apparatus and reagents in a general chemistry laboratory. By this plan each student receives on his first day all the apparatus and chemicals he will need for the course and he is given just enough of each chemical to perform his experiments plus a slight excess. Should he be careless and need more he must go to the storeroom and sign for his needs, which are charged up to his breakage and "excess chemicals" deposit.

The prices on his list are the same as those charged at the nearest apparatus house, so he has no temptation to take things home. And it provides a great inducement for clean and orderly work, as well as effecting a great saving in chemicals.

It also increases the amount of work done in the given time during the course, compared with the still common, old side-shelf reagent system. In one laboratory Prof. Estabrooke computed that a student was likely to walk from thirteen to twenty-six miles during one term to go from his bench to the side shelf and back to procure needed chemicals.

Senate Hearings on U. S. Fixed Nitrogen Corporation Bill

HEARINGS on the bill to establish the United States Fixed Nitrogen Corporation were begun before the Senate Committee on Agriculture and Forestry Monday morning, March 22. This is a bill authorizing the Secretary of War to designate five persons for the purpose of organizing a corporation "to purchase, acquire, operate and develop . . . United States nitrate fixation plants numbered 1 and 2, located, respectively, at Sheffield, Ala., and Muscle Shoals, Ala." All of the capital stock of the corporation is to be owned by the United States, the common stock being issued for the properties acquired from the United States, and the preferred stock for the sum of $12,500,000 with which to complete and operate the plants and develop the art of nitrogen fixation. The plan was proposed to the Secretary of War by Arthur Glasgow, who made recommendations regarding the utilization of our nitrate plants, on the return of our military and agricultural commissions from Europe last fall. The object is to maintain the plants in peace-time operation for the production of nitrogen fertilizer compounds, and at the same time enhance their military value through the experience gained in operation and in contemporaneous research in the science and art of nitrogen fixation.

Secretary Baker was the first witness before the committee. He stated that three plans were open to the Government in disposing of the plants: First, to scrap them and secure what salvage value they represent, which would be admittedly low; second, to keep them in stand-by condition for the use of the War Department in emergency; or third, to operate them on a peace-time basis for the production of nitrogen fertilizer compounds. He showed that the pre-war requirements of the United States in Chilean nitrate amounted to 500,000 tons per annum, and that with the plants producing ammonium sulphate and other nitrogen compounds at their full capacity we would still have to import from Chile. Being questioned as to the proposed products of the plants, the Secretary stated that these probably would be ammonium sulphate, ammonium nitrate, calcium cyanamide and possibly ammonium phosphate. He said he was not converted to the extensive use of cyanamide as a fertilizer and would not like to see the plant make this as its only product. For this reason it would be necessary to add equipment for the manufacture of other nitrogen compounds.

Plan for Securing Necessary Funds

The most important development in the Secretary's testimony was the proposal, originally suggested by Colonel Burns, that the $12,500,000 necessary for financing the proposed corporation be obtained from the sale of half of the present reserve stock of Chilean nitrate now held by the War Department. The safe reserve of nitrate which it is considered necessary to carry in this country is 300,000 tons, and the War Department has now sold from its supply down to that figure. With the nitrate plants in operation, however, it would be safe to reduce this reserve to one-half, or 150,000 tons, and the sale of that quantity at present prices would provide the money for financing the new corporation. This would make it unnecessary for Congress to appropriate new funds for this purpose, as proposed in the original draft of the bill. The Secretary, therefore, suggested to the committee an amendment striking out the appropriation clause and substituting authorization to sell 150,000 tons of Chilean nitrate from the present reserve stock and subscribe the proceeds to the capital stock of the corporation. This is evidently regarded as a strong point in favor of the general plan, because it will forestall objections against new appropriations of public funds.

Additional advantages to be gained from the sale of a part of the reserve stock of nitrate were presented by General Williams and Colonel Burns. It appears that part of the reserve is carried in Government storage warehouses at interior points and part in commercial warehouses at the seaboard. The latter must eventually be transported to interior points and new warehouses must be constructed for its storage. General Williams stated that the sale of 150,000 tons of the reserve would obviate the expenditure of about $1,800,000 in new construction and freight. Colonel Burns stated that the cost of storage of 150,000 tons of nitrate for six months, partly in Government and partly in commercial warehouses, would cost over $100,000, all of which would be saved if the nitrate were sold.

The Secretary stated that one important reason why the Government should plan to operate these plants is that the whole question of nitrogen fixation is in a state of flux and that a vast amount of development and research work must be prosecuted before we know what products are best for various fertilizer purposes. He felt that the Government, which has no private interests to advance or special products to promote, could operate the plants and conduct research in such a disinterested way as to be of the greatest benefit to the country.

Plans Presented by General Williams, Colonel Burns and Prof. White

General C. C. Williams, Chief of Ordnance, reviewed for the committee the general pre-war situation in this country regarding nitrogen compounds, and followed that with a brief history of the development of nitrate plants. Plant No. 1, using the synthetic ammonia process, was experimental and was not in successful operation at the time of the armistice. Plant No. 2, using the cyanamide process, was practically completed at armistice, and had been built because it was based on a proved process in which American engineers had had experience. The cyanide plant at Saltville, Va., was built to make cyanide for poison gas, but was experimental, and the process proved too costly as a method of fixing nitrogen for commercial purposes. In summarizing the present situation, General Williams suggested a program as follows: Proceed with development and research in the art of nitrogen fixation; make No. 1 Plant effective through such research and development; operate No. 2 Plant with the production of appropriate nitrogen compounds; and complete the Wilson dam at Muscle Shoals for the production of the necessary electric power.

Colonel Burns reviewed for the committee the history of the use of nitrates in military operations, and pointed out the need of nitrates in the manufacture of explosives, fertilizers and chemicals. His written statement will be printed in the record.

Methods of nitrogen fixation were outlined by Prof.

Alfred H. White, formerly an officer in the Ordnance Department. Eliminating the arc process as one requiring tremendous quantities of cheap power, the two processes which have gained commercial importance are the cyanamide and synthetic ammonia. These two processes were briefly described, and the technical difficulties of the synthetic process were compared with the simplicity and high degree of perfection of the cyanamide process.

Data Presented by Prof. White

Prof. White presented many interesting charts and figures showing the world's production of inorganic nitrogen, growth in fixation of inorganic nitrogen, and future development of nitrogen fixation in the United States. Tables I and II contain the essential facts.

TABLE I. WORLD'S PRODUCTION OF FIXED INORGANIC NITROGEN EXPRESSED IN METRIC TONS OF NITROGEN

	1908	1913	1917	1920
Chilean nitrate	300,000	390,000	392,000	500,000
Byproduct ammonia	212,000	343,000	364,000	410,000
Atmospheric nitrogen:				
Cyanamide process	2,500	60,000	200,000	325,000
Arc and miscellaneous process	3,000	18,000	30,000	32 500
Haber process	.....	7,000	110,000	308,000

TABLE II. WORLD'S PRODUCTION OF ATMOSPHERIC FIXED NITROGEN IN METRIC TONS OF NITROGEN

	1909	1913	1917	1920*
Arc and miscellaneous process	3,000	18,000	30,000	33,600
Cyanamide process	2,500	60,000	200,000	325,000
Haber process	.....	7,000	110,000	308,000
	5,500	85,000	340,000	666,600

* Estimated maximum in possible production.

Other interesting data presented by Prof. White dealt with the domestic sources of fixed nitrogen in the various countries compared with the population. The United States is near the bottom of the list, coming ahead of only Italy and Austria. The following figures express tons of nitrogen per million of population: Germany, 8,760; Norway and Sweden, 7,250; Great Britain, 2,240; Canada, 2,200; France, 1,850; Switzerland, 1,840; United States, 1,480; Austria, 630, and Italy, 630. In closing, Prof. White stated that the field for nitrogen fixation in the United States was clearly one for Government operation if there ever was one, for both Germany and Chile are in the business on that basis and will struggle to dominate the world's supply of nitrates. The field is not an attractive one for private capital.

Report of Colonel Joyes

Colonel J. W. Joyes of the Ordnance Department, who made a trip to Europe as chairman and member of the U. S. Fixed Nitrogen Commission, made a report of some of his observations and studies in foreign countries, particularly in occupied German territory. Germany has a present capacity for fixing nitrogen of about 300,000 tons by the Haber process, 120,000 by the cyanamide and 150,000 by coke ovens and gas works. He gave figures (Table III) on capacity in different countries probably available for commercial production of fixed nitrogen.

Colonel Joyes stated that inspection of Germany's Haber plant at Oppau indicated great need of further improvement for satisfactory operation. He was impressed with the fact that labor and supervision forces must be quite large, although the expense for these items had not been large due to the low wages paid up to 1914. It has been stated that ammonia was made in this plant for four cents per pound in 1914-15, but Colonel Joyes was convinced that present costs would be at least two and one-half times as much.

TABLE III. PROBABLE COMMERCIAL PRODUCTIVE CAPACITY OF WORLD NATIONS OF FIXED NITROGEN IN METRIC TONS OF NITROGEN

	Haber	Cyanamide	Arc	Total
Germany	300,000	93,000	...	393,000
France	.....	40,000	1,000	41,000
Italy	.....	12,000	1,000	13,000
Scandinavia	.....	28,000	30,000	58,000
Austria	.....	22,000	.....	22,000
Switzerland	.....	7,500	.....	7,500
Japan	.....	12,000	.....	12,000
Canada	.....	12,000	.....	12,000
U. S. (Plant No. 2)	.....	40,000	.....	40,000
Total	300,000	266,500	32,000	598,500

Assuming the same plant set down in the United States in a favorable location, cost of production of ammonia under present price conditions would be approximately:

	Cost of Ammonia — Short Ton		Pound	
Operation and upkeep	$209 to $163		$0.105 to $0.082	
Amortization	75	50	.038	.025
Interest	45	45	.022	.022
Sales	2	1		
	$331 to $259		$0.165 to $0.129	

Interest is figured at 6 per cent on $750, which is the assumed per-ton cost of the plant. Upkeep is taken at 10 per cent and amortization at 10 per cent.

The organization of the German Stickstoff Syndikat, or nitrogen syndicate, and the method of government operation and control, was described in some detail by Colonel Joyes. The capital stock of this syndicate is held by three different groups of industrial companies, each of which has a member on the board of directors, the government having the fourth. There will also be a board of managers, the chairman of which will be appointed by the government. The management will determine the production of various nitrogen compounds and their distribution.

Statement of Colonel Lamb

Colonel A. B. Lamb, late of the Ordnance Department and now in charge of the Nitrate Division's research laboratory at American University, Washington, made a statement in which he stressed the necessity of continuing research in the art of nitrogen fixation. Starting with the assumption that the United States must meet foreign competition in nitrogen fixation as a matter of national welfare and safety, if for no other reason, he outlined briefly the different possibilities in producing nitrogen-bearing compounds such as ammonium sulphate, ammonium chloride, urea, ammonium phosphate, etc. The location of the Muscle Shoals plants near deposits of phosphate rock and potash-bearing minerals and a source of cheap water power afforded an opportunity to develop new fertilizer materials in addition to nitrogen. Research has been the fundamental factor in industrial development in Germany and elsewhere and must be continued in this country. It is not enough to know what the Germans or any other people are doing, or what their formulas and methods are; that is only part of the story, to be supplemented with local experience and the training of skilled operatives.

Statements by Major Gaillard and Others

A statement by Major D. P. Gaillard, Ordnance Department, covered the demand and supply of inor-

ganic nitrogen in the United States and the necessity for fixing atmospheric nitrogen. He showed that the diversion of the organic ammoniates, such as cottonseed meal and tankage, from use in fertilizer to feed for animals, was taking that source of nitrogen away from the fertilizer industry. His statement was supplemented by instructive charts and figures. His estimate of the domestic peace-time consumption of inorganic nitrogen in 1924 was 294,500 tons, with an estimated domestic supply of 122,500 tons, leaving a deficiency of 172,000 tons. By 1930 the consumption is estimated to be 438,000 tons with a supply of 184,500, leaving a deficiency of 353,500 tons. If the Government nitrate plants are put in operation and produce 45,000 tons of nitrogen in 1924 and 55,000 tons by 1930, there will still be deficiencies of 127,000 and 198,500 tons respectively.

In addition to the foregoing testimony the printed record of the hearings probably will contain a statement by George J. Roberts on the estimated cost of operation at Muscle Shoals and a justification of the capital requirement of $12,500,000 requested in the bill. The recommendations of Mr. Glasgow mentioned in the beginning of this report will also be included.

Engineering Advertisers' Association

At the meeting of the Engineering Advertisers' Association of Chicago held March 9 at the Auditorium Hotel, the following officers were elected for the ensuing year: President, A. H. Hopkins, adv. mgr., C. F. Pease Co.; vice-president, J. J. Arnsfield, adv. mgr., Fairbanks-Morse Co.; secretary, G. S. Hamilton, adv. mgr., American Steam Conveyor Corp.; treasurer, E. I. Pratt, adv. mgr., Kellogg Switchboard & Supply Co.

Increased production is the topic of the hour and the Engineering Advertisers' Association in its efforts to improve the methods of advertising and selling engineering products will accomplish an object worthy of attainment and vital to every one. The present membership of the association is one hundred. Any man engaged in advertising or selling engineering products is eligible to membership.

President-elect Hopkins earnestly suggested that the members continue the splendid co-operative spirit that has marked the first year of the Association and emphasized the importance of the work to be done.

Immigration Conference

A national immigration conference will be held April 7 in New York City in the Engineering Societies Building, 29 West 39th St. National leaders in American industry and finance will discuss the shortage of foreign-born labor and the loss of production due to unrest among the workers, and measures will be taken for united action to relieve this condition.

Invitations to attend this conference have been issued by the Inter-racial Council to more than a thousand of the directors of industrial concerns, especially those employing foreign-born labor, and to others interested in this problem from the standpoint of finance or national welfare, including racial leaders. Topics to be discussed will include pending bills on immigration, and a constructive policy will be proposed and voted upon. All industrial executives are invited to be present. Further details may be secured by addressing Coleman du Pont, chairman of the board, the Inter-racial Council, 120 Broadway, New York City.

Further Changes Proposed in Dye Bill

AN AMENDMENT which removes the embargo clause in the dye bill has been introduced by Senator Moses of New Hampshire. It is known that the amendment has many friends among Senators.

Additional Duties Instead of Embargo

Practically the whole of the bill, with the exception of section 500 (which enumerates the commodities in the three groups and their respective duties), has been revised. Instead of prohibiting the importation of articles in groups II and III, the amendment permits their entry, but on such articles as are being manufactured and offered for sale on a substantial scale in the United States another duty must be paid in addition to the duties provided for in section 500. This additional duty is equal to the difference between (1) the sum of the dutiable value of the article plus all nondutiable costs, charges and expenses incident to importation, and any duty imposed by section 500, and (2) the fair wholesale selling price in the United States of a like article or satisfactory substitute of domestic manufacture plus 20 per cent of this price. In connection with this section:

> The term "fair wholesale selling price" of an article means the lowest wholesale price sufficient to insure the maintenance in the United States of the production of such article by an efficient plant operating on a scale reasonably adequate to supply ordinary domestic demands; and the term "satisfactory substitute" means an article capable of giving results in use substantially equal to the article for which it is proposed as substitute. The Secretary of the Treasury shall from time to time determine what is such "fair wholesale selling price" and such "satisfactory substitute."

Tariff Commission to Protect American Industry

Whenever the Tariff Commission, after proper investigation, decides that any article in this act is being imported under conditions which constitute a menace to the industry in this country, the Secretary of the Treasury will be notified and importation of the product will be prohibited until further notice from the Tariff Commission.

Whenever the Tariff Commission has reason to believe that a person is offering for importation any products in violation of this section, but has not information sufficient to determine whether it should certify that fact to the Secretary of the Treasury, the Secretary of the Treasury shall, upon request, forbid entry to such products until the Commission completes the necessary hearings; but the Secretary of the Treasury shall permit conditional entry of such products under bond.

Treasury Department to Secure Data

The Secretary of the Treasury has the right to inspect factories and accounts of any domestic producers of artcles in groups II and III. The information secured in this way shall be confidential and shall not be published except in the form of totals or averages which do not disclose the operations of individual manufacturers. In the present form of the bill this power is delegated to the Tariff Commission.

Another amendment, by Senator Spencer of Missouri, adds the following items to the bill: Camphor, natural and synthetic, crude and refined, 25 per cent; caffeine, $1.50 per lb.; chloral hydrate, 15c. per lb.

Crystallography of Alpha and Beta Iron

A Complete Classification of the Various Microscopic Appearances of Hypo-eutectoid Steels Based Upon the Hypothesis That Alpha Iron Has a Plate-like Habit While Beta Iron Has a Granular Habit

By FEDERICO GIOLITTI

NICOLAS BELAIEW, writing in the *Revue de Métallurgie*, 1910, p. 510, on "An Artificial Reproduction of Widmanstättian Structure in Carbon Steel," has brought to a successful conclusion the long and interesting series of attempts to reproduce the structure of meteoric iron in the laboratory. Osmond and Cartaud had already established the conditions of its formation as being extremely slow cooling, as compared to that of ordinary laboratory experiments. Such slow cooling gives time for a more or less complete decomposition of the non-magnetic solid solution existing in iron-nickel alloys at high temperatures, to the effect that the excess constituent is deposited along crystallographic planes parallel to faces of a regular octahedron. Belaiew, in turn, was able to reproduce in pure steels containing about 0.50 per cent carbon a completely analogous structure by the combination of a long high heat followed by extremely slow cooling. A glance at the micrograph, Fig. 1, showing one of his laboratory samples, and Fig. 2, meteoric iron from Tazewell, is sufficient.

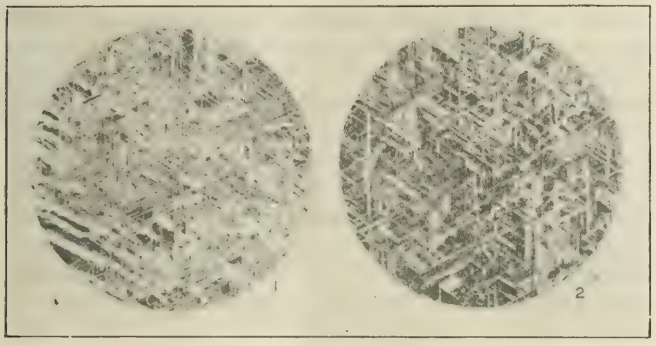


Fig. 1. Widmanstättian structure in Belaiew's alloy No. 8; Carbon 0.55 per cent. × 4.5.

Fig. 2. Widmanstättian structure in Tazewell meteorite. × 3.

Widmanstattian Structure

This author calls attention to the essential similarity between the equilibria of iron and nickel as determined by Osmond[1] (Fig. 3) and the well known iron-carbon diagram (Fig. 4). Inspection shows that both non-magnetic iron-nickel alloys and iron-carbon solid solution (austenite) decompose after solidification and on slow cooling into their constituents, of which the substance camacite corresponds to ferrite, taenite to cementite, and the eutectoid plessite is equivalent to the eutectoid pearlite. Consequently the phenomena attending a cooling of corresponding alloys are similar: primary crystallization passes through a mushy stage forming interlocked dendrites, whose habit in both cases is ordinarily the regular octahedron. Further cooling—extremely slow for meteorites — favors a uniform orientation of the individual crystallites forming the solid solution into masses which are essentially huge allotriomorphic crystals. Upon cooling to the point where solution is saturated, secondary crystallization takes place; for low-nickel alloys, camacite separates from a constantly enriched solution, which latter finally breaks up into the eutectoid plessite. For low-iron alloys, ferrite first separates and the enriched austenite finally reaches eutectoid composition and reverts to pearlite.

Belaiew then points out that on extremely slow cooling one can expect super-cooling and spontaneous crystallization in large masses; a crystallization, it is important to note, from an already crystalline substance, under which condition it is commonly admitted that the subsequent phase collects along the crystalline planes of the precedent phase. He therefore argues that Widmanstättian structure depends entirely upon the orientation of the crystalline mass and in steels is independent of their carbon content. Therefore Osmond has been able to develop the same appearance in slowly cooled "burned" Swedish iron, and Belaiew also found very pronounced Widmanstättian structure in slowly cooled hyper-eutectoid steel.

Structure of Great Crystals and Reticular Structure

Two years later *Stahl und Eisen*[2] printed an abstract of Chapter III of a Russian treatise by Captain Belaiew, "On the Crystallization and Structure of Slowly Cooled Steels," in which he notes the occurrence and describes the mode of formation of three distinct crystalline habits in such metal. He points out that during original

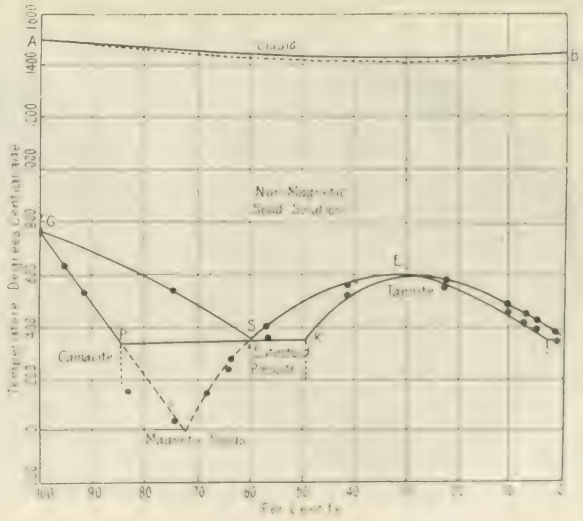


Fig. 3. Osmond's diagram for Fe: Ni alloys; reproduced from Gulliver; "Metallic Alloys."

[1] *Compt. Rend.*, 1899, vol. 128, p. 304.

[2] 1912, p. 1,273.

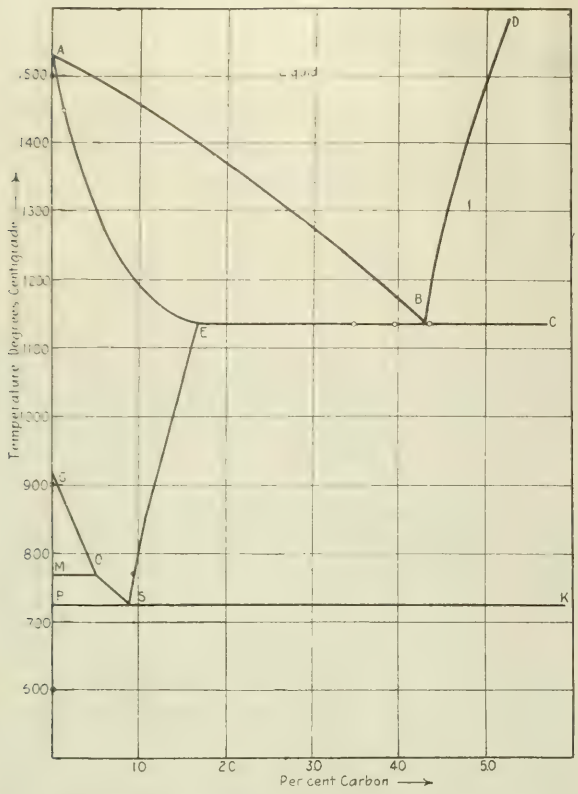


Fig. 4. Howe's diagram for Fe:C alloys; reproduced from Howe, "Metallography of Steel and Cast Iron."

solidification it is well known that the time in the mushy state and the difference in carbon concentration axis to center are ordinarily greater, the higher the carbon in the melt. (In other words, the liquidus *AB* and the solidus *AE* in Fig. 4 markedly diverge as carbon increases.) Slow secondary crystallization resulting from the austenitic dendrites formed during the mushy stage then causes:

First, excess ferrite to separate where there is the least and cementite where there is the most carbon in a non-uniform solid solution. Therefore ferrite appears at the axes of such hypo-eutectoid dendrites and cementite at the contacts of hyper-eutectoid dendrites. This results in what Belaiew calls "structure of great crystals," and is illustrated in Figs. 5 and 6.

Second, in solid solutions rendered homogeneous by long annealing or very slow cooling, ferrite (or cementite) is excluded to the borders of the primary crystals if the slowness of cooling from Ar_3 to Ar_1 is sufficient in comparison with the size of the dendrites so that the excess constituent can migrate the necessary distance. In such cases the microscopic appearance often seen in well-made commercial steels results. Belaiew calls it "reticular structure" (Fig. 7), whose network veins are the thicker the further the carbon content in the steel from the eutectoid.

Third, in homogeneous solid solutions cooled somewhat too rapidly for the excess constituent to reach the periphery of the austenite crystals, the bulk of it remains inside the original austenite grains, but seeks the crystallographic planes of octahedral primary crystallization, forming Widmanstättian structure (Fig. 1).

Belaiew goes on to point out that two or three of these structures may appear in the same piece of steel—for instance, network surrounding Widmanstättian areas is quite common. Apparently excess constituent preferably crystallizes about foreign inclusions such as slag and graphite, or on the walls of cavities. By very long cooling cementite sometimes crystallizes in its characteristic needle-like forms, following only the directions impressed by the octahedral austenite, in which case an aggregation of crystals results and not crystalline groups.

Structure From Equalized Austenite

After reading the articles of which the foregoing is a review, I communicated a paper to the Academy of Science of Turin on March 30, 1913, giving some observations on a piece of metal whose structure did not correspond to Belaiew's dicta. The sample in question consisted of a piece of sheet steel which had formed a heat-treatment muffle, whose interior had been filled with wood charcoal, and whose exterior had been constantly bathed by oxidizing gases. It had been heated about five months continually from 900 to 1,050 deg. C., never, even for a short time, falling below the lower temperature. It had been cooled in the furnace setting, requiring about 4½ days to drop from 1,000 deg. C. to 150 deg. C.

Its average analysis follows:

Mn	0.40	Si	0.011
P	0.059	C	0.32
S	0.011		

Carbon, of course, varied uniformly from about 1 per cent at the inside to practically zero at the outside, due

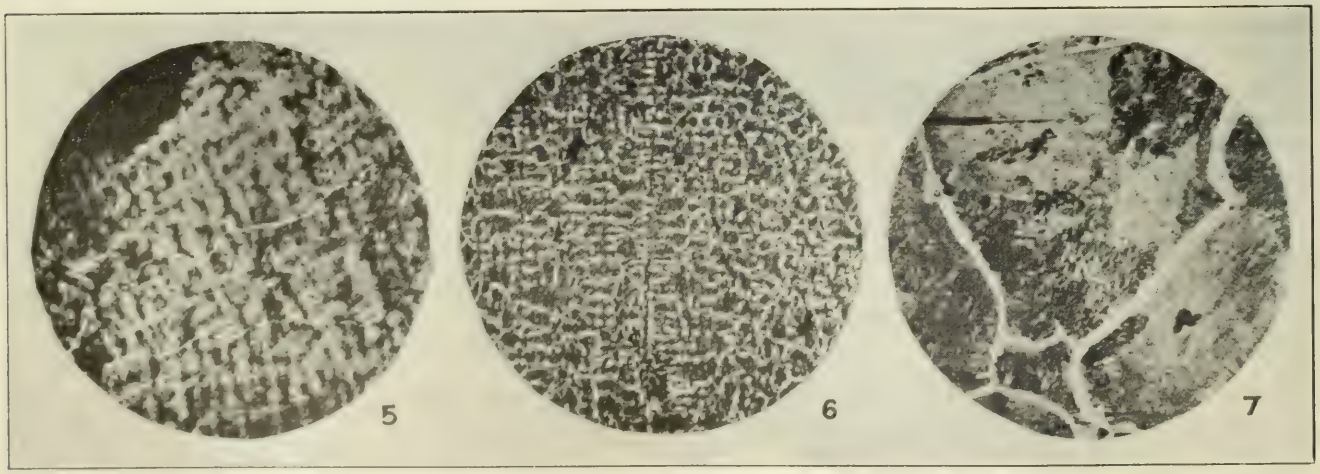


Fig. 5. Belaiew's "Structure of Great Crystals." Carbon 2.27 per cent. × 8.

Fig. 6. Network of ferrite between the dendrites (Belaiew). Carbon 0.60 per cent. × 9.

Fig. 7. Belaiew's "Reticular Structure." Carbon 0.62 per cent. × 110.

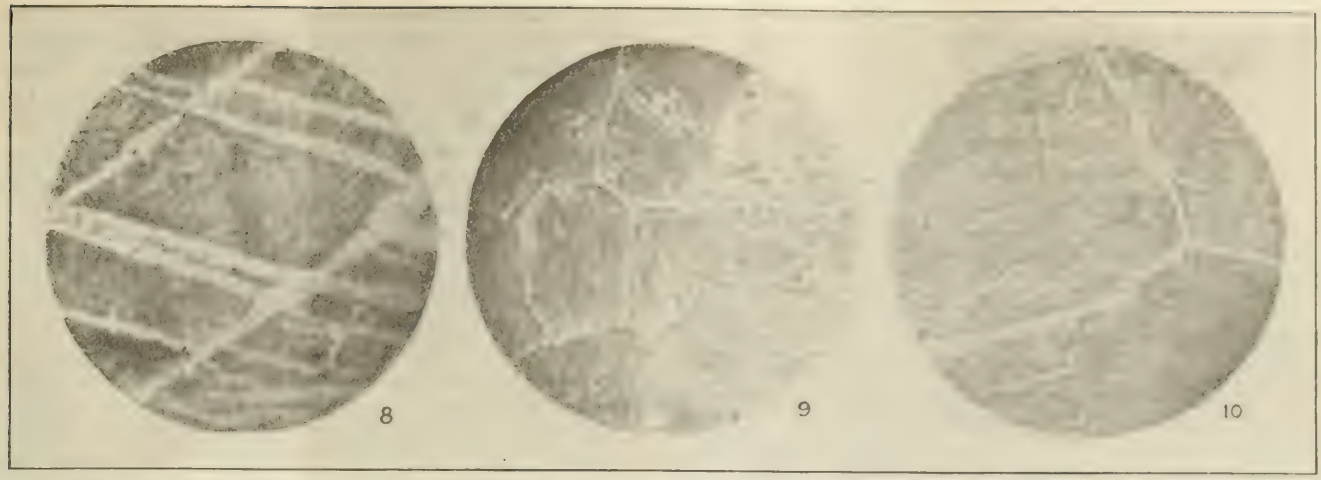


Fig. 8. Widmanstättian structure in cementation muffle. Etched in 5 per cent picric acid in alcohol. × 60.

Fig. 9. Sample from cementation muffle reheated 8 hours to 1,000 deg. C., and air cooled. Picric acid etching. × 60.

Fig. 10. Same treatment as Fig. 9, but cooled in furnace. × 60.

to the fact that during use the carbon oxides had diffused continually through the metal.

Its very long sojourn at temperatures well within the austenitic area (*AGOSE*, Fig. 4) had given opportunity for even slowly moving soluble segregations to equalize their distribution throughout the metal. Continual diffusion of $CO:CO_2$ in equilibrium had also undoubtedly obliterated any non-uniformity in carbon which existed between axes and edges of the dendrites of primary crystallization and inherent by the mode of solidification. While it is not strictly true to say that the austenitic crystals were absolutely uniform in carbon concentration, since the plate is high in carbon at its inner edge and carbon free at its outer, still this uniform gradient across the plate is entirely independent of the older non-uniformity caused by solidification of mixed crystals.[2]

Consequently Belaiew's conditions for the "structure of great crystals" are absent. Furthermore, the cooling from Ar_3 to Ar_1 was much slower in the furnace than that occurring in moderate sized pieces of cast steel in air which ordinarily exhibit Widmanstättian structure. Belaiew's views would require such a piece to have a "reticular" structure, yet Fig. 8, at 60 magnifications, shows a field of this metal having very coarse crystals and perfectly developed Widmanstättian structure!

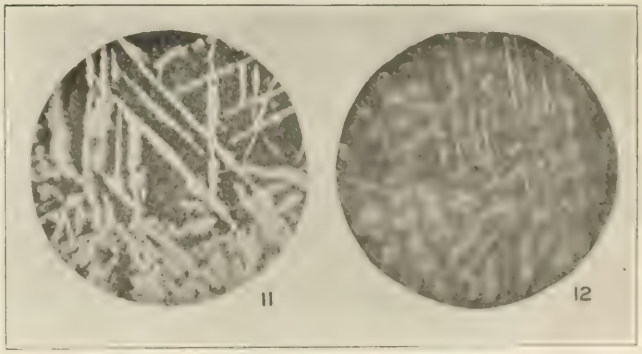
Two 300-g. pieces like Fig. 8 were reheated for 8 hr. to 1,000 deg. C., one air cooled (½ hr. to 150 deg. C.) and the second furnace cooled (4 hr. to 150 deg. C.). At the end their microscopic appearances at 60 magnifications were as Figs. 9 and 10 respectively, thus demonstrating that at least for this particular steel very slow cooling favors perfect Widmanstättian rather than reticular structure. One should remember, however, that the history of the steel was quite different from the ordinary heat-treated pieces, whose time in the zone of gamma iron is too short for total equalization of all carbon, phosphorus and other elements forming solid solutions.

Two Crystalline Habits Distinguished

All cross-sections of the steel plate previously described, which when studied showed a wide range in carbon, also exhibited two distinct forms of ferrite crystals, the one characteristic of regions containing less than 0.4 per cent, where the ferrite existed in rounded grains common to ordinary soft steel, and the other characteristic of higher carbon regions, where the ferrite existed as needles or striations in concordant groups, an appearance common to Widmanstättian structure. Both these crystalline habits are shown in Fig. 11, at 20 diameters.

Considering the history of the specimen, it is certain that all crystals of ferrite have formed from a solid solution free of "nuclei" of low-carbon content, and all have separated under precisely the same cooling conditions. The only difference in the condition of formation is that the rounded grains formed first, and at a higher temperature. In other words, the rounded particles separated from austenite as β iron along the line *GO* (Fig. 4) down to about 760 deg. C., while the plate-like laminations formed themselves as α iron along the line *OS* at a temperature below 760. In the first case the crystals of β iron were largely developed and then transformed bodily into α iron at 760 deg. As cooling continues, the last traces of excess ferrite separate themselves directly as α iron, but meeting with already-formed germs of crystallization, they deposit upon them, following their form.

Granting this, the first crystalline appearance separating from *uniform* low-carbon austenite and developing in large part above 760 deg. C. should be that characteristic of β iron—not rigorously in all crystallographic particulars, but possessing those morphological external characters of crystalline forms upon which depend many mechanical properties of the metal. The second crystalline appearance, separating from uniform austenite con-



Figs. 11 and 12. Microstructure of cementation muffle where carbon concentration passes 0.4 per cent. Etched in 5 per cent picric acid in alcohol. × 20.

[2] I use the term "mixed crystals" in the European sense, meaning to us what "solid solution" means to Americans.

taining somewhat more than 0.5 per cent carbon and developing entirely below 760 deg. C., should be that characteristic of α iron.

Confirmatory Observations

A few of many possible confirmatory observations may be cited to substantiate the theory just advanced that β iron has a roundish, granular habit, while α iron has a flat plate-like habit, which I think satisfactorily explains the origin of all characteristic appearances of hypo-eutectoid steels.

Figs. 11 and 12 represent the structure, magnified 20 times, of that zone of the steel plate where the carbon content passes the point *O* (Fig. 4), from low carbon at the bottom nearly to eutectoid at the top. In each of these figures the features just explained may be seen; grains of ferrite in the low-carbon area which precipitated as β iron, and needles in the higher carbon area, which precipitated as α iron. Along the border zone between the two types of crystals one clearly sees some which may be called "composite," which have simultaneously the morphological characteristics of both series. By the theory, they should have roundish nuclei of β iron upon which form needle-like appendices of α iron. Actually this occurs, according to the well-supported hypothesis that slowly forming crystalline material of a second series deposits itself by preference on pre-existing nuclei, reproducing those contours only in cases where the originally formed mass is sufficiently preponderant in comparison with that of the later additions.

If my hypothesis be true, one must expect that should the crystallization process be disturbed by forging or other mechanical work, a barrier would be presented to the deposition of the α plates upon β granules, copying and preserving the roundish forms, and in such cases one would find α and β forms separating out in large part independently, and finally appearing side by side. Actually, Portevin and Bernard[4] show excellent micrographs of this kind, three of which are reproduced in Figs. 13, 14 and 15. Those authors, however, ascribe the appearance of Widmanstättian bands in forging to the fact that the pieces were held for a long time in the heating furnace at a temperature above 900 deg. C. (in Belaiew's "zone of granulation"), and the subsequent cooling was rapid enough that the excess ferrite collected along the octahedral planes of the pre-existing austenite.

Consider the case of a mass of uniform austenite. After relatively rapid cooling my theory would call for a final appearance analogous to that of mechanically disturbed crystallization. This is exactly the case in regions of low-carbon content in Figs. 9 and 10.

Classification of Non-segregated Metal

On the hypothesis that ordinary slowly cooled steel has superimposed in it two processes of crystallization, the final structure of steel depends mainly upon the uniformity of austenite, the speed of cooling through the critical range, the mechanical disturbances, and the carbon content.

1. For steels which have undergone treatment for *total* equalization of carbon, axis to periphery of each primary dendrite, the following classification holds:

A. Cooling very slow (furnace cooling) and undisturbed mechanically.

a. Carbon less than 0.35 per cent. Nuclei of β iron are prominent. Only those portions separating at temperatures less than 760 from a residue of enriched austenite come down as α iron, and even this tends to deposit on pre-existing masses of iron, also now transformed to α iron but pseudomorphous after β. Only in case the α iron formed in the second phase of cooling should be in preponderance can they develop in a noticeable measure by the side of the β appearances. (Figs. 11 and 12).

b. Carbon more than 0.4 per cent. All ferrite crystallizes directly into α iron, assuming its characteristic form well known as Widmanstättian structure (Fig. 8).

B. Cooling slow, and undisturbed mechanically.

a. Carbon less than 0.35 per cent. Crystallization takes place again in two steps as described above in *A,a*, separating as β and α iron successively. But in this instance the α iron cannot be so strongly influenced by the preformed β iron as formerly, and independently segregates into its own form. (Fig. 10.) Naturally the smaller speed of cooling will not permit α and β crystals to reach such large dimensions or perfect form, and the Widmanstättian structure degenerates into distorted striations.

b. Carbon more than 0.4 per cent. The structure still shows Widmanstättian bands but much more

[4] "On the Structure of Some Forged Pieces; the Relation of Mechanical Properties and Widmanstättian Structure." *Revue de Métallurgie*, 1912, vol. 9, p. 544.

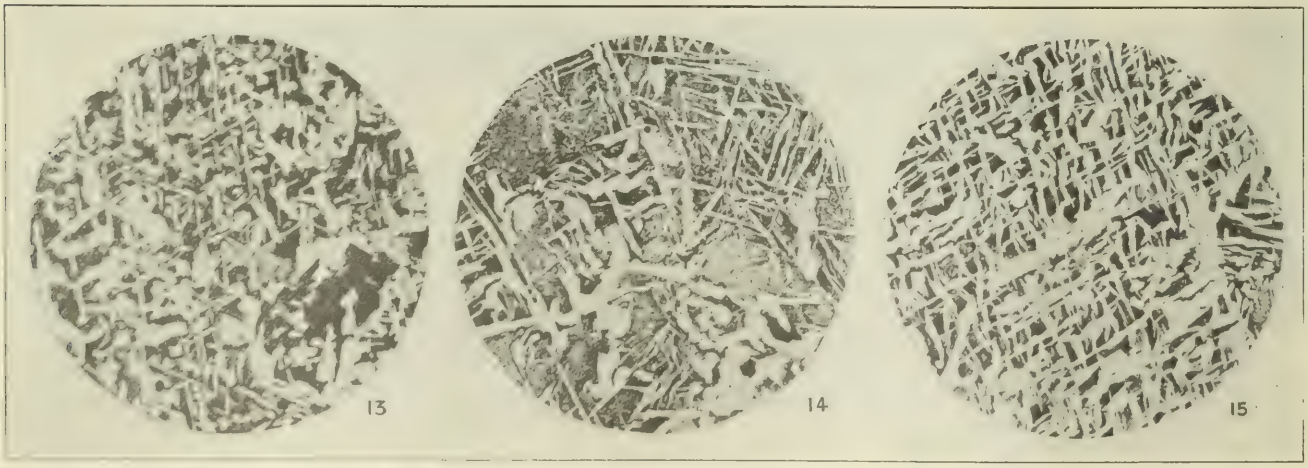


Fig. 13. Unannealed forging with 0.25 per cent carbon. (Portevin and Bernard). × 140.

Fig. 14. Unannealed forging which failed in service. (Portevin and Bernard.) × 50.

Fig. 15. Unannealed forging which failed in service. (Portevin and Bernard.) × 90.

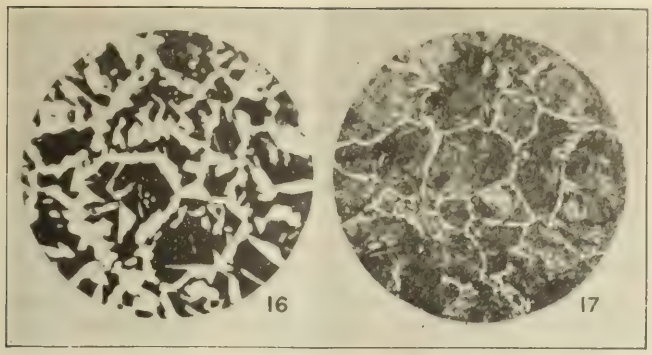


Fig. 16. Carbon steel (0.33 per cent) heated to 1,000 deg. C. and slowly cooled in furnace. (Hall, from Sauveur's "Metallography of Iron and Steel.") × 100.

Fig. 17. Carbon steel (0.50 per cent); heated to 1,000 deg. C. and cooled in air. (Burger, from Sauveur's "Metallography of Iron and Steel.") × 100.

imperfectly, in proportion to speed of cooling. If it is somewhat fast, the deformation of the ferrite crystals is sufficient to mask the plate-like structure.

C. Cooling slowly, with mechanical work finished very hot. Crystallization takes place analogous to *A,a* and *B,b*, but the effect of primary β crystals is less marked; the deformation separates efficaciously the elements formed in either phase. (Fig. 14.) In case the mechanical work is continued through the transformation range, all crystals are broken up and their original forms destroyed.

D. Cooling rapidly, with mechanical work, as in small drop forgings or stampings. Resulting forms are analogous to *C*, but the various crystalline elements are very small and often so poorly developed that it is difficult to distinguish one from the other.

Classification of Partially Equalized Metal

2. Some steels have had a prolonged annealing at high temperature, or a preliminary heating followed by a reheating at a lower temperature, yet the carbon content of the austenite crystals has not been completely equalized. Even in this case the phenomena proceed in a manner analogous to case 1, depend upon the same principal conditions, and are only modified by the presence of local difference of carbon concentration in each austenite crystal.

A. Cooling very slow (furnace cooling) and undisturbed mechanically. The first iron separates at those places where the carbon concentration is least, which ordinarily coincide with the nuclei of primary austenite. On account of the slow cooling over the temperature range corresponding to the separation of proeutectoid substance, the first portions separating have a maximum influence as nuclei on the accumulation of subsequently born material. It follows that the crystals of ferrite copy the form and disposition of the axes of the primary austenite, and there results that called "structure of large crystals" by Belaiew. In hyper-eutectoid steels cementite forms at the periphery of primary dendrites, *mutatis mutandis.*

B. Cooling slow, and undisturbed mechanically.

a. Carbon less than 0.35 per cent. The action is analogous to 2,*A*, just above, precipitated iron adapting itself readily, automatically, to the globular form of ferrite crystals, characteristic of slowly cooled, soft steels. In the final structure there can simultaneously appear the two characteristic forms of ferrite, separating in two phases. (Fig. 16.)

b. Hypo-eutectoid steels with an average composition of more than 0.35 per cent carbon. With low-carbon nuclei, germs of β iron may form, and crystallization is then completed by direct formation of α iron. However, if the average carbon is higher, crystallization of the excess constituent may initiate itself direct as α iron along the axes of primary austenite crystals. The characteristic development of α iron in elongated forms when the process is slow and uninfluenced by previous centers of crystallization operates so that ferrite develops into a spatial meshwork usual in steels containing from 0.40 to 0.75 per cent carbon when cooled after manufacture. (Fig. 17.) In other words, the plate-like habit of α iron is suppressed by the influence of low-carbon axial nuclei if moderate time is given for migration of the crystallites. But if cooling is somewhat more rapid or the piece is hot-worked the germinal influence is interfered with and plate-like laminations appear alongside the meshes.

It may be noted that the structures described immediately above in 2,*B,a* and 2,*B,b* may both appear in the same piece should the difference in carbon concentration in the original austenite crystals be such that it is considerably less than 0.40 per cent at the axes, and as much more at the peripheries.

c. In hyper-eutectoid steels cementite separates as a rule at the high-carbon peripheries, crystallizing in deep-seated interiors only in case temperature drop is too rapid to allow sufficient migration.[5]

C. Slow cooling, with mechanical work. The disturbance is essentially shown by the elimination of the characteristic action of excess-constituent nuclei formed during solidification from the melt. Consequently theory and practice agree that the final metal contains the same structural elements as if slowly cooled without working, but they are independent of each other. (Figs. 13, 14 and 15.)

D. Rapid cooling, with mechanical work. This operates same as *C* immediately above, but each crystalline element is of smaller dimensions so that the two fundamental formations are distinguished with difficulty.

Conclusion

Hypo-eutectoid steels, especially, can therefore be classified and their structure explained by the hypothesis that β iron assumes a granular and α iron a laminar habit. Belaiew's observations also conform rather better than to his own explanation. Thus, his idea that ferrite is ejected to the periphery of homogeneous austenite on very slow cooling is not confirmed by study of a really uniform metal, which then actually gives Widmanstättian structure. His metal was probably somewhat non-uniform, and the reticular network resulting therefrom is better explained by case 2,*B,b*. This of course does not exclude the hypothesis that the peculiar Widmanstättian orientation should be closely related to the octahedral form of austenite, nor to derived elements like martensite. Furthermore Belaiew's remark that undercooling is partially responsible for Widmanstättian structure in slowly cooled steels is not justified by the steel plate I have examined. Here such structure is formed nearby nuclei in low-carbon regions, and under absolutely the same heat treatment, even forming a continuation of the nuclei themselves.

[5] See Howe & Levy, "The Life History of Pro-eutectoid Cementite," International Congress for Testing Materials, 1912, vol. 2, p. 1.

Observations on Catalyzers in Paint and Varnish Manufacture*

By F. P. Ingalls

CATALYZERS are useful industrially not only to bring about chemical reactions which otherwise would not occur but also to accelerate some which otherwise would be too slow. It is this second phase of the subject that is of special interest in the manufacture of paints and varnishes and concerns directly those highly important compounds known as "driers."

Without attempting to discuss the various kinds of paint or varnish, it is a general fact that when ready for application, whether it be by brushing, dipping or spraying, they are essentially liquid in form, although the consistency may vary considerably. This allows of easy application and is highly desirable, but by far more important is the facility with which they become solid after application and by simple exposure to the air are thus transformed into valuable protective coatings.

In paints this solidification, commonly known as "drying," takes place in the vehicle, and while the pigments may exercise a profound influence on the properties of the finished paint, there is no good evidence that the pigments themselves undergo any material change during the process. In varnishes, of course, the question of pigment does not enter.

This drying ensues from oxidation of the oil, accompanied usually, but not always, by evaporation of the volatile "thinner" which may be present, but only the oxidation of the oil is of interest to us at this time.

The liquids capable of oxidation and suitable for our requirements are few and occur among those substances designated as oils. Many oils absorb oxygen from the air by direct exposure, but only a few are transformed thereby into the kind of solid substance desired. Of these few, linseed oil is of paramount importance, and since its behavior with driers is so typical of all the others and consideration of them would take much time, we shall confine our remarks to the action of driers on this oil almost exclusively.

When linseed oil is exposed to the air it absorbs oxygen, increases in weight and volume, passes through a stage of highly increased viscosity and finally becomes a solid, tough, rubbery mass. The rapidity of this oxidation, perhaps indeed even its extent, is dependent upon a number of conditions, chief among which are the temperature and extent of surface exposed, especially the latter. Exposed in layers 0.001 to 0.003 in. in thickness, on glass plates, at a uniform temperature of 75 deg. F., it requires from about six to fifteen days (according to thickness of layer, quality and kind of oil) for the film to become "dry to touch," and in ordinary parlance is then said to be "dry," although it is very well and generally known that the film continues to harden progressively for a very long and indefinite time thereafter. Obviously, this reaction is very slow.

Action of Pigments on Oil Drying

If various pigment colors be incorporated with the oil by a process of mechanical grinding, and the mixture so obtained be spread out in thin layers as above, we observe some very remarkable differences in the drying time. Some pigments, as for instance umber, will shorten it to less than 24 hr., while others will lengthen it into weeks, as in the case of carbon blacks; and certain of the aniline-color tannate lakes (made from magenta or methyl violet) may inhibit the oxidation of the oil to such an extent that even after months of exposure there remains only a sticky, gummy film in nowise acceptable as a good paint coating.

This quickening effect of umber has long been known; just how long is a matter of some doubt, but certainly for two or three hundred years. White lead, one of the most ancient of pigments, has also long been recognized as an accelerator of this drying process; but without attempting to follow the historical development, we may come down to the early half of the nineteenth century when good "boiled oil" and "oil varnishes" which dry in 24 hr. or less had become commercial commodities.

Boiled Oil Oxidation Theory

Because the best of these were prepared by heating the oil with metallic oxides, notably litharge and red lead, and because the oil was still further oxidized by the air during the heating process, there became prevalent a theory that the normal drying time was shortened by virtue of the fact that the oil so treated was already well oxidized and only a limited exposure was necessary to complete the process. This theory, although not now tenable, contained an element of truth, in that coatings with such oils gave harder films than most others made at that time and was further supported by numerous instances where oil which had merely been heated rather strongly in the air showed greatly increased drying power. Without direct knowledge of how this heating was done, nor under what circumstances, we may now assert quite positively that the increased drying power was due to some other circumstance than mere heat and the attendant air oxidation.

In 1867 Mulder undertook to explain the drying of oils, especially linseed, not only by itself but in conjunction with a number of substances introduced as driers.[1]

Little information or new facts were adduced until Hulb's classic research on the halogen absorption of the drying oils, and while his work was of immense value in the analytical identification and valuation of oils, it did not elucidate greatly the action of driers.

Unsaturated Fatty Acids

It had long been known that oils and fats were glycerol ethers (as they were then called, now esters) of fatty acids, and that these fatty acids were in many cases "unsaturated." This was shown by Chevreul, and his work was available to Mulder, but it was as late as 1890 that Hazura succeeded in identifying at least four unsaturated acids in linseed oil and first clearly brought to light the three fundamental substances upon which the drying power is based, and these acids he called linolic, linolenic and isolinolenic. Prior to this time these acids, together with oleic, which is the fourth, had

*A paper read at the New York Section meeting, Jan. 9, and published by permission of the American Chemical Society.

[1]After several series of experiments carefully conducted (and considerable conjecture which doesn't sound so very wild even today), he leaves the question open in the following words quoted directly from his book which we have before us:

"Worin besteht das Trocknen, das Festwerden? Liegt es in den Oelen allein oder auch in Beimischungen? Was wird nach dem Trocknen erzeugt?

"Ich glaube nicht, dass Jemand es weiss, denn ich habe bis jetzt nirgends eine Antwort auf die Fragen gefunden. Man spricht von Bleiseifen in Bleifarben, aber ist diese Bezeichnung wahr?"

["In what consists the drying, the solidifying? Is it due to the oil only or also to the admixtures? What takes place after drying?

"I do not think anybody knows, as I have been unable to find anywhere an answer to the question. We speak about lead-soaps in lead paints; is this designation correct?"]

been obtained often in the saponification of linseed oil, but all together, and in the absence of any good method of separation they had been bunched together under the name of "linoleic" acid. Even today, because there is no commercially available method of separation and since we get good commercial results without direct separation, this nomenclature is still retained, as we shall see a little later.

This last discovery makes it easy to understand why the more or less scientific development of driers should date from this time, and although this rapid historical sketch lays claim to no sort of completeness, or even rigid accuracy in all detail, it serves, nevertheless, to throw much light on the nature and source of these catalyzers or driers which are our chief topic.

Drying Phenomenon Dependent on Certain Metals

What, then, are these catalyzers or driers? In a word, they are certain metallic salts of one or more of the unsaturated acids which characterize the drying oils. There are several metals which, when so combined, are more or less active, but cobalt, manganese and lead are so superior to all others that they are in a class by themselves. Copper and iron may yield driers of no mean order, but are less active than those named, as well as less desirable in other ways, and are never used commercially except under very special conditions. All others are negligible so far as known at present.

Based on the weight of metal present, cobalt and manganese are much more active than lead, but atom for atom the difference is not so great. Between cobalt and manganese there is comparatively no great difference, and until very recent times, when cobalt became cheap, it was never used commercially, although its activity as a drier was known and had been definitely established as early as 1892 to our certain knowledge.

It is fortunate, however, that we have all three, for the technical results obtained by their use show differences, aside from the mere question of activity, that are quite important, and as a matter of fact, the slower lead holds the position of chief importance, although it is rarely used alone, but more generally in conjunction with either manganese or cobalt and occasionally both.

Mulder showed very conclusively that the activity of umber was due, not at all to the ferric oxide, silicon and silicates, of which it was more than four-fifths composed, but to the manganese oxide, which constituted less than one-fifth. He also showed that with both oxides of lead (litharge and red lead) the full effect was obtained only by heating them in the oil and that only a small quantity (a few per cent by weight) was necessary to achieve this result. When oil is so treated the oxides disappear at a rate largely dependent on the temperature and the fineness of the oxide, and although on subsequent standing a noticeable precipitate falls to the bottom, there is no free oxide either in the precipitate or suspended in the oil; but if the clear oil is analyzed, most of the lead is found there, in soluble form, and the oil will dry in hours where it required days before. What has occurred is readily understood. The oil has been partially hydrolized; the freed acids have united with the lead; those lead salts which are insoluble in the remaining oil have settled out; and the soluble ones are dissolved. It is these soluble lead soaps which accelerate the oxidation. This view is substantiated by a number of significant facts.

If oil be heated with almost any of the normal salts of either lead or manganese, acceleration is observed only with those salts which are readily broken down or dissociated at the temperature used. Wherever the metal is too firmly bound to be at least partially dissociated under the conditions of heating there is little or no acceleration. The sulphates, nitrates, chlorides, etc., are of no value as driers, but the acetates and borates are good driers, especially the borate of manganese, which, however, requires a rather high heat to yield its maximum effect. It might be expected that a substance such as lead tri-ethyl would be a good drier. It is a clear, nearly water white, mobile liquid, containing about 70 per cent of lead and freely soluble in linseed oil. We have a small sample for inspection. It is useless as a drier in the cold, and if it must be heated to decomposition, litharge is cheaper. Finally, if the oil be hydrolized with caustic alkali and the resultant soap made into other soaps by the addition of water-soluble salts of lead, manganese or cobalt, fatty acid salts may be made which contain nearly if not quite the theoretical proportion of metal, and when these are dissolved in plain raw oil the accelerating effect is unsurpassed by any other means. These are the so-called "linoleates" of lead, manganese and cobalt, although we have seen that there are at least four unsaturated acids present, to say nothing of the small proportion of saturated acids which are also present in linseed oil. Linoleic acid as an individual is not recognized here except commercially. Many other "linoleates" have been tried, as for instance cerium, of which we have a small sample for inspection, but practically all are inactive. Cerium and vanadium, however, are powerful catalysts in the oxidation of aniline by sodium chlorate.

Some little further investigation is necessary to show which of these aggregated metallic salts are the most active. The saturated salts are essentially insoluble, form no appreciable part of the finished oil, and may be disregarded. The unsaturated acids are difficult of separation either by themselves or in their salts. We can get oleic acid, however, quite readily and in pure form. When the oleates of lead, manganese and cobalt are used as driers, they have indeed considerable power, but they are not so active as the "linoleates" nor do they remain quite so readily in solution. This leads to the conviction that the salts of the $C_nH_{2n-4}O_2$ and $C_nH_{2n-6}O^2$ acids furnish most of the drying power, but it is not yet clearly proved to what extent these differ in activity from each other.

Drier Metal Linoleates

We have already seen that these linoleates are readily formed when the oil is directly heated with a small quantity of the oxides. If the proportion of oxide is increased, more linoleate is formed, and this may be carried virtually to the theoretical limit, though in practice it is seldom done. Linoleates made in this way are highly oxidized during the process. Although the surface exposed is relatively small, the oxidation is rapid because of the presence of the metallic soap and the high heat (300 to 500 deg. F.) and especially when red lead and manganese dioxide are used. Consequently also they are very dark colored. If the cooking is not too long continued, there results an almost black molasses-candy-like mass which dissolves quite freely in turpentine, and is the basis of the so-called japans or japan driers. They are fully as powerful as the "pre-

cipitated" linoleates and have been in use for a much longer time. Special kinds for many purposes contain added resins of one sort or another, but so far as we know the catalytic power is not increased thereby, although in technical practice the intelligent selection of drier is a matter of high importance.

We see from this that these soaps of the unsaturated acids do not have to remain unsaturated to retain their power. They may at least be quite highly oxidized, and this brings us to the consideration of some other compounds of the same metals with organic acids having little or no obvious relation to those discussed. The first of these are the "resinates"; in other words, those made from common rosin.

Precipitated Resinates

If rosin be dissolved in dilute alkali and precipitated with soluble metallic salts from aqueous solution, we get the "precipitated resinates." If the oxides be heated directly with rosin, we get "fused resinates," and these are also frequently made by melting the precipitated resinates with an excess of rosin. They are driers of good power and quite extensively used. A discussion of their relative merits is out of place here and there are differences of opinion concerning their actual value.

China Wood Oil

Finally, we have the soaps derived from tung oil (china wood oil). Used from time immemorial in China for waterproofing purposes, it has been used in this country only since very recent times. It dries even more rapidly than linseed, but in a very peculiar way which precludes its direct use in paints or varnishes. The film has the appearance of frosted glass, and looks as if some soluble substance had crystallized out, but as a matter of fact the appearance is due to a multitude of very fine wrinkles and is a case of excessive "crimp." It is a very valuable oil, however, and has almost revolutionized the varnish industry because of its very hard film. The acids are unsaturated to about the same extent as those from linseed, as is shown by the iodine number, but in other respects are widely different. Lead, manganese and cobalt soaps of them, however, show similar catalytic activity. In fact, aside from purely technical considerations, we may use the linoleates, tungates and resinates almost indiscriminately either alone or with each other in any kind of drying oil, without noticeable inhibition of individual activity.

Speed of Drying

Concerning the quantity of these driers required to produce the maximum acceleration, much depends on conditions. Unless the metal is in solution or retained in what may be termed the active field, it has little or no power. Whether the solution is crystalloidal, partly colloidal or wholly colloidal is open to discussion, but when a precipitate forms it is (at least relatively) inactive, even though it may retain considerable metal.

Roughly speaking, it is easy to bring the drying time down to 7 or 8 hr. for linseed oil, but to go below this time requires extraordinary drier. With lead alone it is difficult to reach this speed with any amount within reason. With manganese three to five parts in 10,000 will suffice. Cobalt requires about the same, perhaps slightly less. These figures indicate the actual metal in the active field as shown by analysis of the *clear oil*, and may be widely different from the amounts put in when preparing it. The films must be less than 0.002 in. thick and the temperature about 75 deg. F.

It is difficult to establish definite limits of this sort on account of the many variable factors.

Choice of Drier

In conclusion, it is perhaps desirable to say a few words bearing on the technical choice of drier for different uses. It has been noted that lead is slower than manganese or cobalt, but its influence on the character of the film is very favorable. This was noted by Mulder, and he describes it by saying it is "tough, like rubber," while manganese gives a film "tough, like leather." At any rate the film is rounder and fuller, does not expand so much and therefore does not wrinkle up so decidedly in forming, where it happens to be a little too thick. This is known as "crimping." Manganese, on the other hand, dries faster, expands more, gives a coat that looks thin or skimpy, and has a decided tendency to crimp. In general, cobalt films are similar to manganese films. In all cases, however, much depends upon how they are incorporated into the oil.

Both manganese and cobalt impart a darker color to the oil than lead, but on account of their greater activity may be used in much smaller quantity and the difference largely overcome in this way. Further, if the quantity of metal is small, the oil will bleach out on drying; nevertheless in the presence of turpentine high color is liable to develop.

In general practice, therefore, it is customary to use lead for character, and jack it up with manganese or cobalt for speed. A good strong-drying oil will generally show on analysis, in parts per 10,000: lead, 50 to 150, and manganese 5 to 15. When cobalt is found, the quantity is usually smaller than the manganese unless used in its place, in which case the quantity required is approximately the same. It is claimed that cobalt will give a lighter colored oil than manganese for the same speed; this may be true, but much depends upon the method of production.

Whether these substances are true catalysts acting by their mere presence, or whether they depend on a rapid vibratory alternate oxidation and reduction may be elucidated at some future time, but we are certainly fortunate in having them at our disposal in the present.

J. W. Masury & Son,
Brooklyn, N. Y.

Sag Paste for Burns

During the war large quantities of sag paste were purchased by the Government, principally for the treatment of gas burns. The paste was prepared by a large number of manufacturers according to the following formulæ:

FORMULA 66

	Parts by Wt.
Zinc oxide, 100 mesh, U. S. P.	40
Benzoinated lard	20
Refined raw linseed oil	20
Adeps lanae, U. S. P.	20
Coloring matter	1

FORMULA 146

	Parts by Wt.
Zinc oxide, 100 mesh, U. S. P.	45
Benzoinated lard	10
Raw refined linseed oil	30
Adeps lanae, U. S. P.	15

FORMULA XII-A

	Per Cent
Soya bean oil	62
Zinc stearate	38

This paste was put up in collapsible metal tubes in several sizes.

Commercial Development of Fused Silica

An Account of the Development of the Electrothermal Processes of Fusing Glass Sand—Reactions Between Carbon and Silica and Application of Gas Phases to Process—Properties of Product Physically Explained

By JOHN SCHARL* and WALLACE SAVAGE

WHILE fused silica has attracted the attention of many scientists[1] for the past eighty years, it has been within the latter part of the last twenty that it has had any large technical application. This was due primarily to the lack of demand rather than knowledge of methods of fusing. As early as 1849, eighteen years before the invention of the dynamo, Despretz fused silica by passing the current from 600 bunsen cells through a small carbon rod[2] embedded in sand. He obtained a very hard tube with six times the diameter of the original electrode. This tube probably consisted of a core of the various products of reaction between carbon and silica within a mass of fused sand. In 1886 E. H. and A. C. Cowles[3] experimented with fused sand in their well-known granular resistor-type electric furnace. They took out patents on the carbon reduction products obtained from the silica, but did not recognize their composition or application until 1896, when E. G. Acheson[4] put commercial carborundum on exhibition at the World's Fair at Chicago. Immediately after this, the chemistry of the reaction products involved was studied and found to be represented by the following equations and equilibriums:

$$SiO_2 + C = CO + SiO \quad (1)$$

$$SiO + C = SiCO \leftrightharpoons CO + Si \quad (2)$$

$$Si + C \leftrightharpoons SiC \quad (3)$$

In reaction 1, the silicon monoxide is a gas which upon cooling condenses directly into an extremely light powder weighing only 40 oz. to the cubic foot and known in commerce as monox. In reactions 2 and 3 the silicon is in the gaseous state and condenses to the liquid before solidifying. The products produced in the third reaction depend entirely upon the temperature used. Around 1,600 deg. C. amorphous carborundum is said to be produced; above 1,850 deg., the melting point of silica at pressures where the liquid phase exists, carborundum crystals form; and in the environs of 2,240 deg., the reaction goes to the left, producing graphite and silicon gas.

Fused Rock Crystal Ware

In 1901 Shenstone[5] developed a process for making fused silica ware with the oxy-hydrogen flame. He heated Brazilian rock crystal quartz to 1,000 deg. C. and quenched it in cold water, thus breaking up the silica at the points of temperature strain. These pieces, as they did not tend to shatter after this treatment, were fused into pellets by means of the 2,000-deg. oxy-hydrogen flame, and were then drawn into fine rods. The fused silica rods, reheated and in the softened state, were wound on a platinum rod. By this means the operator was able to build up a fused silica tube which could be blown into any form desired without calling for greater skill than has been exhibited by glass blowers for the past 3,500 years.

Almost simultaneously, Heraeus[6] worked out the problem of obtaining molten silica in a form suitable for blowing. He fused rock crystal directly on iridium and later zirconia, with the oxy-hydrogen flame and then applied the usual glass-forming processes.

The ware made from rock crystal is very transparent and is mostly used in thermometer stems and ultra-violet ray tubes, due to its low expansion and non-absorption of short-wave light.

Peculiar Phenomena of Fused Silica

When the crystalline forms of silica are heated, they expand 781 $\times$ 10^{-8} per deg. C. per unit of length on the main axis and 1419 $\times$ 10^{-8} in the cross-section, thus setting up a considerable as well as uneven strain, when suddenly cooled through a large temperature range. If the heating is carried on slowly enough, crystobalite crystals will be formed which at higher temperature will invert to tridymite.

At about 1,400 deg. C. the small content of impurities, which exist in amounts of about 0.2 per cent in the purest silica commercially obtainable, will begin to show signs of weak fluxing activity and the mass will begin to cohere, even though the temperature is at least 450 deg. below the theoretical melting point of pure silica. As the temperature increases, the mass grows more and more viscid until a temperature of about 1,750 deg. is reached, when it begins to sublime. In this, the highest state of fusion obtainable at atmospheric pressure, the thermal expansion of the silica will be about 17 per cent of the original volume of crystal solids. After rapid cooling to atmospheric temperature, the thermal contraction in volume will be found to be only about 0.07 per cent. This remarkable property of a solid maintaining almost the fusion volume throughout so great a temperature range without exhibiting any tension strains is scientifically unexplainable as well as unique with this product. According to Henning and Randall, the coefficient of expansion for fused silica at 200 deg. is 518 $\times$ 10^{-9}; at 900 deg., 538 $\times$ 10^{-9}; and at 1,100 deg., 583 $\times$ 10^{-9}, which indicates that a rod one meter long with a temperature change of 1,000 deg. C. or 1,800 F. will be expanded

*Superintendent Fused Silica Works, General Ceramics Co.

[1] Gaudin succeeded in fusing small beads with a blow pipe and drawing them in 1839. He observed that it was optically inactive. (*Comp. Rend.*, vol. 8, pp. 678, 711.) Gautier produced capillary tubes of it in 1869, which he exhibited in Paris in 1878. (*Comp. Rend.*, vol. 130, p. 816.) Boys obtained fine cords of it by drawing fused beads out by means of an arrow suddenly released from a bow. They were so small in diameter that it was necessary to use a magnifying glass to find them. The cords were used in suspending mirrors in galvanometers, etc. [Eng. Pat. (1889) 4,849.]

[2] *Comp. Rend.*, vol. 28, p. 755; vol. 29, pp. 48, 545, 712, 720.

[3] *Proc. Soc. Arts*, Boston, 1886, p. 74.

[4] U. S. Pats. 492,767 and 560,291.

[5] *Proc. Royal Inst.*, London. *Nature*, May 6, 1901.

[6] Fifth Inter. Cong. App. Chem. D. R. Pats. 175,385, 179,179, 172,466.

upon heating or contracted upon cooling only slightly over one-half millimeter.

Care has to be exerted not to maintain fused silica for long periods at temperatures between 1,150 and 1,400 deg. C., which is its range of devitrification. In all probability this phenomenon is the formation of tridymite crystals and the segregation of the various impurities previously mentioned. The resulting devitrified product is weak mechanically. It expands and contracts like ordinary quartz from fifteen to thirty times as much as fused silica, and if, after heating, it is quenched in cold water, it cracks. The rate of devitrification is very low at 1,150 deg., but increases rapidly toward 1,400 deg. Usually this phenomenon can be counteracted by heating to white heat, temperatures above 1,400 deg. C., and rapidly cooling below 1,150 deg., where it is permanently stable, though well out of its normal slow-cooling crystalline phase. Doubtlessly, the phenomena here exhibited justify the application of the theory of solid solution developed in connection with high flux content glasses to fused silica. In this case the silica should be considered the solvent and the impurities the solutes, which in their amounts and effects on the fusion temperatures are analogous to carbon and the like in steels. The chemistry of the phenomenon of solid solution probably will find no better opportunity for development than is exhibited here, and knowledge of fundamental importance to the science of ceramics should be derived at the same time.

Electrothermal Processes Developed

Immediately after the value of fused silica had become generally known by means of the laboratory ware produced by Shenstone in England and Heraeus in Germany, several technical men undertook to develop a more economical product. Glass-makers' sand was

FIG. 1. DRAWING TUBE ON CHANNEL IRON BENCH

employed in the place of rock crystal, and the electric-resistance furnace instead of the oxy-hydrogen flame. In 1902 Dr. R. S. Hutton[7] reported his investigations of fusing sand, which he found to be most successfully accomplished by means of embedding a graphite rod in sand and heating with a current of high amperage. The fused silica did not apparently react with or adhere to the hot electrode, due to the formation of intervening gases. These undoubtedly consisted of vaporized silica, which, in turn, being in contact with the hot graphite electrode, formed the various carbo-silica reaction gases previously discussed in connection with carborundum. A white opaque tube was obtained, due to the fact that the silica could not be heated to the liquid state and the gas cells originating from the interstices of the sand were locked in similarly to the leavening gases in dough. They were of microscopic size, however, and gave the product a beautiful satin white finish. Day, Shephard and Mehner believed that liquid silica could be produced by fusing the sand under pressure, and a transparent product free from gas inclusions obtained. Their experimental work was not carried to a successful conclusion, though their idea was fundamentally sound. However, what the lowest vapor pressure of liquid silica actually is, and what pressure

FIG. 2. TYPES OF LABORATORY WARE

of silica gas is in equilibrium with the fluid silica of sufficiently low viscosity to release automatically these imprisoned gas cells, are both unknown bits of scientific information.

Development of Commercial Production

Although Hutton had obtained a molten tube of silica which could have been manipulated by most any skilled glass blower in producing all varieties of fused silica ware, no blowing was attempted, even though Shenstone had published a description of his process of blowing fused rock crystal tubes the year before. Elihu Thompson[8] took out the first patent on forming fused sand, in which he claimed the use of shaped electrodes in producing hollow silica ware.

In 1904 Dr. James Francis Bottomley,[9] Sir Arthur Paget and Dr. Robert Salmon Hutton, by applying vitrifacturing engineering, were able to devise a process for obtaining a ware from fused sand, which they produced at Wallsend-on-Tyne, England, under the firm name of Thermal Syndicate, Ltd., and trade named and marked Vitreosil.

In Germany, Ludwig Bolle & Co. for a time acted as distributors for the fused silica products of the Thermal Syndicate, and through this connection Dr. August Voelker, a partner of Bolle, became interested in the industry. In 1907 he took out a series of patents[10] on the basis of which the Deutsche Quarzglas Gesellschaft commenced the production of Sidio Fused Silica. In 1911 the Cölner Fabrik für feuer und säuerefestes Glas took over the Voelker patents and Sidio works and started operating.

Recently the Deutsch - Englische Quarzchmelze-Pankow, Berlin, using the patents of the Thermal

[7] *Trans.*, Am. Electrochem. Soc., 1902.

[8] U. S. Pat. 778,286.

[9] Eng. Pats. 10,670 and 18,434 (1904). U. S. Pats. (1906) 812,399; 822,424; 836,558-9 and R. I. 13,504. *Jour. Soc. Chem. Ind.*, vol. 36, pp. 577-580.

[10] D. R. P. 204,537; 204,853-4. Eng. Pats. (1907) 5,764; (1909) 18,713. U. S. Pats. 989,671; 1,051,035-6; 1,068,716 and 1,107,386-7.

Syndicate, absorbed the interests of the Cölner Fabrik, thereby combining the two processes. In France, fused silica products are manufactured by Le Quartz Fondu, which manufactures in accordance with the process of Dr. August Voelker.

The United States is the only large industrial country that has in the past decade been extensively supplied by imported fused silica products. These materials have found large and important applications in many fundamental industries. Because it has become undesirable as well as inconvenient to remain dependent on imported supplies entirely, the General Ceramics Co. has taken up their manufacture and erected a well-equipped plant in connection with its Chemical Stoneware Works at Keasbey, N. J. The company is thus prepared to build every part that goes into high-grade

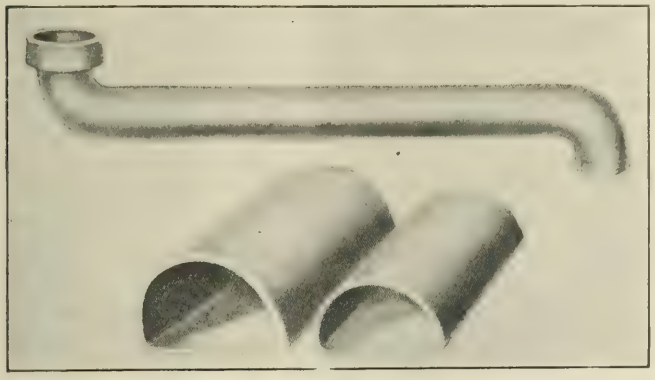


FIG. 3. MUFFLES AND CONDENSER PIPES

acid-plant installations, in the stoneware portions of which it has experienced marked success.

Previously to beginning operations on fused silica, about a year was spent in perfecting the equipment. The electric furnaces used are of extremely simple design, consisting of no more than an inch Acheson graphite rod about 3½ ft. long embedded in the highest grade glass sand obtainable. As soon as the patent applications have been allowed, the details of both the methods of fusing and blowing will be published. In making tubes, the fused tubular mass is drawn out to the length which gives the desired diameter and then laid on a flat runway of channel iron to straighten before cooling. (Fig. 1.) Iron molds of similar construction to those used in making bottles are used in forming all the usual types of blown ware from the hot stock. In these latter operations, the usual procedure of the modern glass-blowing art is followed. Views of some of the various types of products produced are shown in Figs. 2 and 3. The rough blown ware is finished by grinding with carborundum wheels and air blasts.

Semi-Translucent Fused Silica

If opaque fused silica is quickly heated a second time to over 1,800 deg. C. with either an oxy-hydrogen flame or an electric arc, the cellular structure collapses, giving a semi-translucent product. The hot gases originally occupying these minute cells undoubtedly consisted of a mixture of air and silica vapor. Upon cooling, the silica condensed to the solid state, leaving the air in the cells in a very rarefied state. These voids amount to approximately 6 per cent of the volume of the opaque fused silica. Upon sudden heating and softening, the walls seem to collapse before the silica has time to produce sufficient gas pressure to support them in equilibrium with the external atmospheric air pressure. Fig. 4 illustrates a two-phase Rennerfelt arc furnace in operation producing semi-transparent ware. This ware is a better conductor of heat, is stronger, has greater resistance to abrasion and therefore is more easily kept constant in weight than the first fused opaque ware.

Important Properties of Fused Silica

As every one must appreciate, the most valuable property of fused silica is its resistance to temperature shocks, which, in combination with the fact that it is acid-proof,[11] abraded with difficulty and the only vitreous material that is absolutely insoluble in water, makes it almost as estimable as platinum in both the laboratory and the plant. Combustion tubes of it can be heated to temperatures as high as 1,100 deg. C. at pressures of four atmospheres or *in vacuo* without causing difficulties. At the highest heats the stoppers in the ends of these combustion tubes are transformed to neither charred cork nor fused rubber, due to the low longitudinal heat conductivity at moderate temperatures of this material, which is composed of an accumulation of millions of minute rarefied gas cells. In this property, these cells have certainly contributed a very valuable service to scientific work of a far-reaching nature.

Fused silica is an ideal electrical insulator as well as a permanent one, because it contains no decomposition products, such as soda or potash, which tend to

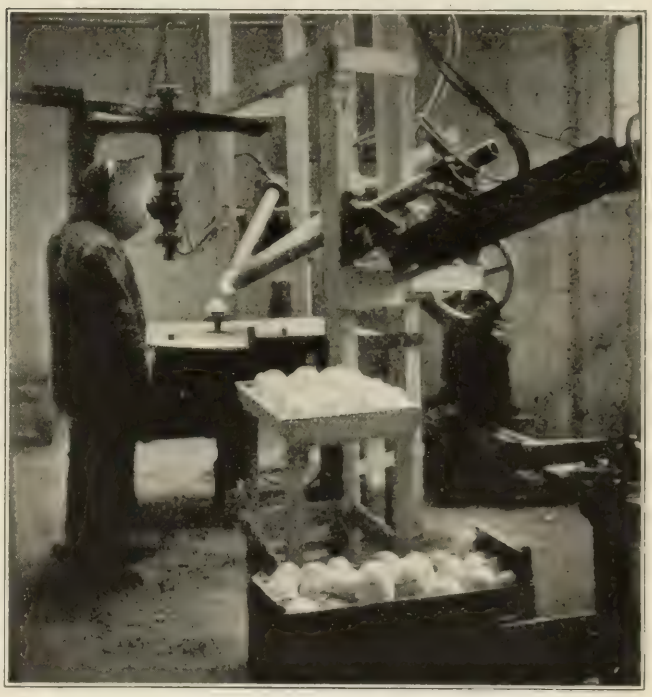


FIG. 4. REFUSION PROCESS FOR PRODUCING SEMI-TRANSPARENT WARE

collect moisture and form solutions of electrolytes on its surface. Its refractory properties stand it in good stead for high-temperature insulation. At the present time, an experimental investigation is being made on methods of producing spark plug insulators of it economically enough to compete with porcelain. It is believed there will be less trouble experienced with short circuits from cracks formed by thermal shocks in the case of fused silica.

[11] Hydrofluoric acid reacts with it, forming SiF_4, H_2SiF_6; and phosphoric acid and other fluxes attack it at temperatures above 400 deg. C.

The Electric Furnace Reduction of Garnet

By M. deKay Thompson and John Davenport
(Analytical Work by Max Knobel)

A SERIES of experiments were made with the object of determining whether the silicon and iron present in abrasive garnet could be removed as ferrosilicon and a slag or aluminous residue produced which would contain a higher percentage of alumina than the original garnet. This residue, on account of its higher percentage of alumina and hardness, should possess good abrasive qualities when used against low-tensile-strength metallic materials. The alloy produced would, of course, have value as ferrosilicon.

Material and Apparatus

The garnet used was from the mine of the United Mineral Co. at South Danbury, N. H. This garnet is the regular red abrasive garnet used in coating paper to make abrasive garnet paper, and it has the following chemical composition:

	Per Cent		Per Cent
Silica	35.0	Calcium oxide	1.3
Alumina	27.0	Magnesium oxide	2.2

Remainder iron oxide.

The garnet grains used were about $\frac{1}{16}$ in. in diameter. Ordinary coke with 10 per cent ash was the reducing agent. The furnace consisted of a square firebrick shaft 18 in. outside diameter and 9 in. inside by 16 in. deep, built up on a piece of boiler-plate. The bottom of the shaft was filled with granular carbon to a depth of about 6 in., and a graphite plate was placed on top of this. In order to give good electrical contact between the boiler-plate and carbon, nine iron rods 2 in. long and driven into the boiler-plate projected upward into the carbon. The bricks were held in place by angle irons and the cracks were filled from the outside with fireclay. A carbon-tar mixture was also used in making tight the bottom where necessary. The tap-hole was formed by means of an iron rod and tap-hole fireclay, as is done in copper blast-furnace settlers. The furnace had a firebrick cover. The boiler-plate formed one electrode, and a 2-in. graphite rod, suspended vertically in the center of the furnace shaft, was the other. A 150-kw. transformer, with voltage regulation in steps of ten volts, served as a source of power.

Method of Operation

The method of operating was to start the arc by means of a small piece of carbon placed between the movable, vertical electrode and the graphite furnace bottom. The charge was then fed in as desired. During operation a bright silicon flame, together with a blue carbon monoxide flame, was given off, and there was considerable volatilization, during a run.

It was difficult to get both the alloy and the slag into solution for analysis. Each was fused in a nickel crucible with a one-to-one mixture of sodium carbonate and sodium peroxide. The nickel crucibles were rapidly destroyed.

Results

The results, as shown in the accompanying table, were encouraging. It will be seen from runs 8 and 10 that the alumina in the slag was about 62 per cent, or the concentration was more than twice that in the original garnet. The ferrosilicon contained 24 per cent to 26 per cent silicon and from 5 per cent to 10 per cent aluminum. It will be noted that all of the iron was removed from the slag and about half of the silicon. A 27 per cent excess of coke (No. 3) gave as complete reduction as 37 per cent excess coke. The addition of sawdust did not make a product which differed in appearance from that made with coke alone. These results were encouraging enough to have this reduction tried on a larger scale.

No.	Duration in Min.	Kw.	Kg. of Garnet	Kg. of Coke	Excess Coke Above Theoretical to Reduce All Fe and Si	Kg. of Alloy Produced	Analysis of Alloy, Per Cent	Kg. of Slag Produced	Analysis of Slag, Per Cent	Per Cent of Garnet Made Into Alloy	Per Cent of Garnet Made Into Slag
1	165	30–40	13.6	3.2	0	2.7	.....	3.9	.....	20.7	28.8
2	120	30–40	18.0	4.1	—5	3.8	.....	8.1	.....	21.2	45.0
3	240	30–50	34.0	10.3	27	11.9	Si26	14.5	$SiO_2$19.3	35.0	41.3
4	135	30–70	20.0	7.3	44	6.7	Si26	8.5	$SiO_2$19.3	33.5	42.5
5	240	50	25.0	9.1	44	..	.....	..	.....	..	..
6	210	50	25.0	7.6	28	8.6	.....	13.8	.....	34.5	55.0
8	190	50	15.0	4.9	37	5.3	Fe62.3 Si25.9 Al11.6	2.9	$SiO_2$29.6 $Al_2O_3$61.5 CaO / MgO 9.9	35.5	19.3
9	180	40	15.0	4.9	37	4.1	.....	4.7	.....	27.4	31.4
10	165	50	30.0	9.8	37	5.9	Fe69.6 Si23.8 Al5.6	....	$SiO_2$18.1 $Al_2O_3$62.1 CaO6.5 MgO2.5	..	..

Remarks:

Run No.
3 1 in. of slag fused solid at bottom; above, several inches of porous material.
4 Fraction of inch of fused slag at bottom, with several inches of porous material above.
5 Charge had 1.5 kg. sawdust. Alloy did not run together.
6 Charge had 1 kg. sawdust.
8 Furnace lined with graphite plates.
10 Furnace 13.5 x 13.5 in. to remove brick walls from heating zone.

The work was therefore carried on at the General Electric plant at Schenectady, N. Y., where even better results were obtained due to the large-scale operation.

It is probable that more silicon could have been removed if the garnet and coke had been ground to a fine powder, well mixed and briquetted with tar as a binder, but this has not yet been tried.

Massachusetts Institute of Technology,
Cambridge, Mass.

Ferromanganese Not Covered by War Minerals Relief Act

The Attorney General of the United States has handed down an opinion to the effect that producers of ferromanganese are not entitled to reimbursement under the War Minerals Relief act, for losses incurred in its manufacture. The opinion was rendered at the request of the Secretary of the Interior in connection with the claim of the Anaconda Copper Mining Co. for $561,346.62 for losses sustained in producing and in preparing to produce ferromanganese. "The claim of the Anaconda company," says the Attorney General, "evidently is based upon the contention that ferromanganese is an intermediate metallurgical product of manganese and is embraced within the provision for payment of losses to producers by reason of the specific mention of intermediate metallurgical products in the act of Oct. 5, 1918, and the adoption of the minerals enumerated in that act in the first paragraph of section 5 of the act of March 2, 1919. There is, however, no basis for this contention, as the intermediate metallurgical products, metals, alloys and chemical compounds covered by the act are all specifically named in the act of Oct. 5, and as there is no reference to ferromanganese, the rule of law *expressio unius exclusio alterius* applies."

How the British Chemists Are Organizing

A Study in Professional Politics and Economic Conditions—British Industry Must Recognize the Importance and Value of the Chemist—Labor Party and Policy Not Attractive to English Chemists

By FREDERICK E. HAMER
Editor, *Chemical Age* (London)

ONE may confidently begin by saying that before the war chemistry, of all the English professions, was the least organized for its own protection and the least appreciated from the national point of view. That undesirable condition has since been substantially modified and improved by two influences. The extent to which military operations in the final stage of the war became dependent on the applications of chemical science has forced upon the public a new sense of the immanence of chemical science throughout practically all industrial processes. On the other side, the ever-rising cost of living, the progressive advances of salary secured by manual workers, and the contrast of their own lot with that of less educated and less responsible classes, have created among working chemists a new sense of class consciousness, and forced upon them the conclusion that relatively to the cost of their education, the responsibility of their work and the vital part that work plays in national industry, their economic condition compares very unfavorably with that of equally or even less educated workers.

Chemists Discuss Problems of Organization

Hitherto the English works chemist has held a sort of half-way position between capital and manual labor. He is not in active opposition or alliance with either interest; nor yet is he sufficiently organized to constitute a definite party to industry himself. Considered as a professional man, he lacks the close and powerful corporate organization which enables the legal and medical professions to safeguard their professional rights and especially to keep out the "quack"; considered as a workman, he hesitates to descend to the trade union basis, and to join with the manual workers whom he directs for the protection of their common interests as employees. So, in a word, the working chemist, economically, hangs suspended halfway between heaven and earth, and he is beginning to look for some more solid and comfortable resting place. Everywhere one turns today chemists are discussing problems of organization. They feel keenly the need and the justice of improved status and improved pay, but so far their views as to how these ends are to be attained are hazy and even conflicting. It may be interesting, therefore, especially in view of the new labor problems arising in the United States, to set out broadly the position as it exists in England today.

To begin with, it should be understood that the English chemist's demand for improved conditions is no piece of mere trade union tactics. The feeling is common to the university chair and the smallest works laboratory. It is based on the conviction that the science of chemistry and all who practice it deserve fuller and more generous recognition all around.

Prof. Henry Louis of the Armstrong College, Newcastle, put the point to me quite frankly some time ago —that when ambitious and capable young men came to him inquiring about chemistry as a profession for life he often felt obliged to warn them of the poor return they might get. John Gray, a managing director of the great firm of Lever Bros., who this year succeeded Prof. Louis as president of the Society of Chemical Industry, told me with equal candor that if we wanted the best chemical brains for the service of industry employers must be more prepared than many are at present to recognize the commercial value of the chemists.

To these testimonies may be added that of Richard B. Pilcher, who has just completed twenty-five years as secretary and twenty as registrar of the Institute of Chemistry. The Institute is essentially a professional and academical body, with powers under its charter to hold examinations and confer degrees. There can be no suspicion of trade unionism about it. yet even the Institute is so much concerned about the economic status of its members that it recently issued a questionnaire on the subject of salaries and working conditions. The results have just been tabulated by Mr. Pilcher, and are shown in the accompanying table.

WORKING CONDITIONS OF BRITISH CHEMISTS

	Average Salaries, Including Bonus					
Age	Industry	Assistants to Private Practitioners	Government Service	Municipal Service (Whole-time)	Teaching	Average
21–24	£268	. . .	£256		£184	£250
25–29	345	. . .	327	£284	270	328
30–34	435	£289	346	290	291	390
35–39	546	. . .	447	360	421	499
40–44	606	484	503	440	400	523
45–49	712	400	545	653	481	592
50–54	883	275	1,290	775	653	789
55–59	609	. . .	586	531	766	571
60 and over	610	. . .	840		888	747

This table is based on 927 individual returns. As the chemists making the returns are all members of the Institute, it may be assumed that they are all of good academical standing, and that the figures are substantially higher than those that apply to the whole body of works chemists. In addition to the comparatively poor financial pay, the chemist has often to work long overtime without extra remuneration, his annual holiday is usually only a fortnight, and he is generally subject, owing to the confidential nature of his duties, to close restrictive covenants.

In addition to the Institute there are two other bodies organized for the special protection of chemists' interests. The National Association of Industrial Chemists is registered as an ordinary trade union, but it deliberately holds aloof from the political Labor party. The British Association of Chemists, though not for-

mally registered as a trade union, professes similar aims, but here also there is a strong objection to merging the interests of chemists in the Labor movement.

Thus, it will be seen, there are in England three separate bodies all claiming to protect the professional rights of the chemist and all founded on different principles. Among the three there is a certain amount of confusion of thought, and just now the problem is how to find some central organization as wide as chemical industry itself which shall become the recognized custodian of the whole profession. One of the most definite suggestions is that there should be a National Register of Chemists, equivalent to the roll of the Law Society or the Register of Teachers, and that steps should be taken either by charter or act of Parliament to prevent any not admissible to the Register from practicing or accepting appointments as a qualified chemist.

The "Black-Coats" (Professional) Class

Quite recently a new and interesting factor has emerged in the shape of a bid from the political Labor party for a compact with the professional class of workers, or "Black-Coats" as they are called. It is no secret that the English Labor party is out to form a Labor Government. Its political power has been growing for some time, but the more intelligent leaders now recognize that manual labor, of which the English Labor party is made up, cannot carry the country unless it has with it the brain workers too.

Recently a conference was held in London with the object of "capturing" the brainworkers for Labor, and the National Association of Industrial Chemists and the British Association of Chemists were invited to join. Both attended, but both declined to merge their identity with the Labor party. For the moment there is no doubt that this represents the general attitude of the British chemical profession. The problem, then, for the future is whether English chemists with other professional bodies will be strong enough to form for themselves what is called a "third party," strong enough to take the necessary action for the protection of their own interests, or whether economic pressure will drive them, as it has driven the National Union of Journalists and other bodies, to throw in their lot unreservedly with the general Labor party.

For the moment, however, strong as the demand among working chemists is for improved economic conditions, there is an equally strong objection to adopting some of the leading doctrines of organized labor. In the first place, in spite of the suave assurances of the more educated labor leaders, labor is essentially and as many fear increasingly a class movement. It refuses to recognize that prosperous national industry is the combined result of co-operative effort and organization. It selfishly assumes that industry and profit are as assured as tomorrow's sunrise, and all that labor has to do is to get as much out of it as possible, while putting as little into it as may be. The Whitley Councils, which have been formed for the joint development by employer and employed of British industry, have already degenerated into cockpits for debates over wages and shorter hours, and instead of developing the co-operative spirit have in many cases merely accentuated the conflict between capital and labor.

Another common fallacy is that labor, by which is meant mere manual labor, produces all the wealth of the country. The part which the capitalist, the organizer, the inventor, the chemical and the civil engineer, and last of all the patient research worker who may at any moment revolutionize existing processes of production by some new discovery—all these count for nothing in the estimate of labor. And it is easy to understand why men who live by their minds' work refuse to subscribe to such a wooden and unimaginative theory of industry.

Another point in labor policy which is viewed with grave suspicion is the Prussianizing of labor. One of the popular cries of a few years ago was the right of every man to work. Now no man must be allowed to work unless he is in the union, and in one particular union which happens for the time being to be the most powerful, and there is a ruthless insistence on the division and subdivision of labor into endless little water-tight compartments, each of which is an exclusive preserve. The effect of the application of this principle to chemical and scientific work generally is delightfully satirized by a well-known consulting chemist, Ivor James:

"The organic chemist would have to cease thinking inorganically; the analyst would not soar researchwise; the professor would surrender his consulting practice, and the lecturer his private tuition; Carius tubes would be the perquisite of the glassworker's union; to tighten or loosen the bolts of an autoclave an engineer —in common parlance, a fitter—would be present, accompanied by his invariable shadow, the mate, bearing a spanner; electro-analysis or electro-reduction would necessitate an electrician—of what variety we do not know, but certainly he would have to be there; and if by chance the unfortunate chemist happened to wash his apparatus, the laboratory steward would complain to the bottlewasher's union, and monsieur would be reprimanded with an intimation that the incident was anathema and must not occur again. The position would be ridiculous, but the ridicule would be just."

Chemists Shun Intellectual Bondage

But perhaps what the intellectual worker most objects to in modern labor is what is known as the "ca'-canny" policy. In practice this means that the bricklayer, whatever his capacity, must not lay more than a certain number of bricks an hour; that the compositor must not set more than a certain number of lines; that the barber must not shave more than the prescribed number of customers, and so on all through industry. This is bad enough applied to the purely mechanical trades, for it cuts down the producing capacity of the best artisan to the pace of the slowest and least efficient, and kills the honest workman's personal zest in his work. It is waste of time for the apprentice to attend technical classes and master the art or science of his craft if when he becomes a full-grown workman his union encases him in the iron fetters of a standardized output. But applied to science, to research, to every form of intellectual work, it is a deliberate sterilizing of potential brain power, a suppression of personal initiative, a bondage of all the forces of thought and energy that make for human progress.

Little wonder, then, that English chemists, eager as they are to see an improvement in their conditions and prospects, decline open eyed to enter into such an intellectual bondage, and prefer to work out their own salvation on more liberal and humane lines. That is the problem to which they are now addressing themselves, and developments of great interest may be expected in the next few years.

Aluminum Rolling-Mill Practice—III Ingot Heating and Mill Calculations

Specifications and Some of the Uses for Sheet Aluminum Are Noted, Followed by a Discussion of Furnaces for Heating Ingots Preparatory to Slabbing — Tables and Examples of Calculations Are Given Whereby Individual Orders May Be Rolled With Minimum Allowance for Scrap*

BY ROBERT J. ANDERSON AND MARSHALL B. ANDERSON

MANY applications of aluminum sheet have been made, and uses for the metal in this form have increased rapidly in recent years. Aluminum and 1.5 per cent manganese-aluminum alloy sheets are used very largely in motor-car body construction, while substantially pure aluminum in the form of sheets finds considerable employment for fabricating cooking utensils, for building vats and vessels, for aircraft parts, and for various small stampings. Sheet aluminum is also fabricated for motor-car headlights, surgeons' splints, artificial limbs, and soldiers' canteens and field utensils; while in the form of rolled and annealed sheets, the metal is used in printing and lithography. Many other uses are on record, but the main outlet for the metal in sheet form is for motor cars, cooking utensils, vats and tanks, and for small stampings.

In addition to substantially pure aluminum, some of its light alloys, notably duralumin, are rolled into sheets for purposes where greater strength is required than can be obtained with the metal itself. Some of the rolled and annealed light alloys have as great ultimate strength as hard-rolled pure aluminum. The progress made with regard to rolled light alloys of aluminum was marked in connection with the late war, and this will result in further applications of the metal. An alloy containing about 1.5 per cent manganese, whose production has already been described in the early part of this article, is also rolled for so-called hard sheets, and it is employed considerably in motor-car body construction.

Very little scientific work has been performed in the rolling of aluminum, nor is much information available with regard to the rolling of its light alloys for the manufacture of sheets. Some information in connection with rolling rods in the light alloys is on record. The corrosion of aluminum sheets and cooking utensils, as well as of some of the rolled alloys, including duralumin, has been investigated at considerable length, and a fair amount of data is on hand in regard to that matter.

SPECIFICATIONS FOR SHEET

As to specifications for sheet aluminum, few are available. Specifications for substantially pure aluminum sheet, both cold rolled and annealed, and for duralumin are given in Tables VI and VII. Three of these specifications are in condensed form of the complete specifications of the Bureau of Aircraft Production, while the fourth is a provisional specification of the British Admiralty Air Department; new specifications are now being prepared by the Bureau (now the Engineering Division, Aircraft Service), and those given in the tables may be superseded by others in the future. Specifications for sheet aluminum, particularly for deep drawing stock, have never been worked out satisfactorily, to the writers' knowledge. In the case of deep drawing stock, tensile tests and hardness values are practically useless criteria in attempting to determine the "drawability" of a sheet. The only test

TABLE VI. SPECIFICATIONS FOR ALUMINUM SHEET

Bureau of Aircraft Production Specification for Soft Annealed Sheet Aluminum

The following grades of aluminum, conforming to the requirements of the specification for ingot aluminum, may be ordered to this specification:

Grade	Al, per Cent Min.
Standard No. 1	99.0
Standard No. 2	98.0

Test specimens cut in any direction from sheets must have the following physical properties:

American Wire Gage, B. & S. Nos.	Thickness In.	Thickness Mm.	Minimum Tensile Strength Lb. per Sq. In.	Minimum Tensile Strength Kg. per Sq. Cm.	Elongation in 2 In., per Cent (Min.)
10 to 16, incl.	0.102 to 0.051	2.59 to 1.30	12,000	844	30.0
18 to 22, incl.	0.040 to 0.025	1.02 to 0.64	12,000	844	20.0
24 to 26, incl.	0.020 to 0.016	0.51 to 0.41	12,000	844	10.0

Specification for Hard-Rolled Sheet Aluminum

The grades of aluminum may be ordered as above.

Test specimens cut in any direction from sheets must have the following physical properties:

American Wire Gage, B. & S. Nos.	Thickness In.	Thickness Mm.	Minimum Tensile Strength Lb. per Sq.In.	Minimum Tensile Strength Kg. per Sq.Cm.	Elongation in 2 In., per Cent (Min.)
10 to 26, incl.	0.102 to 0.016	2.59 to 0.41	22,000	1,547	2.0

TABLE VII. SPECIFICATION FOR DURALUMIN SHEET

Bureau of Aircraft Production Specification for Aluminum-Alloy Sheet

Sheet under this specification shall have a maximum specific gravity of 2.85 and shall be made from Standard No. 1 aluminum ingot.

Test specimens cut in any direction from the sheets must have the following physical properties:

Temper No. 1	
Tensile strength (min.), lb. per sq.in.	55,000
Kg. per sq.cm.	3,866
Yield point (min.), lb. per sq.in.	25,000
Kg. per sq.cm.	1,758
Elongation (min.) in 2 in., per cent	15
Temper No. 2	
Tensile strength (min.), lb. per sq.in.	50,000
Kg. per sq.cm.	3,515
Yield point (min.), lb. per sq.in.	25,000
Kg. per sq.cm.	1,758
Elongation (min.) in 2 in., per cent	20

British Admiralty Air Department Specification for Duralumin Sheets

The sheets are to be made of duralumin alloy of specific gravity not exceeding 2.85.

Strips cut from the sheets lengthwise are to show when tested in tension not less than—

Thickness of Sheets	Tensile Strength Tons per Sq.In.	Tensile Strength Kg. per Sq.Cm.	Elongation, per Cent on 2 In.
0.05 in. (1.27 mm.) and above	25	3,515	15
Below 0.05 in. (1.27 mm.)	25	3,515	10

*For Parts I and II see CHEM. & MET. ENG., vol. 22, Nos. 11 and 12, March 17 and 24, 1920, pp. 489 and 545.

[8]Anderson, Robert J., "Erichsen Tests on Aluminum Sheet," *Iron Age*, vol. 101, 1918, pp. 950-951; "The Testing of Sheet Aluminum," *Iron Age*, vol. 102, 1918, pp. 148-149.

which can give any definite indication of how sheets will perform in the draw press is the cupping test (Erichsen). This test is of great value for the purpose mentioned and can be rapidly applied. The writers are not aware that this test has been insisted upon to any extent as yet for deep drawing stock, but users of sheet for this purpose will do well to investigate its merits.

Heating Ingots for Rolling

The statement has already been made that aluminum ingots are either rolled directly from the molds after solidification or they are preheated to a definite temperature in ingot-heating furnaces before rolling. We will deal first with the preheating of ingots for rolling.

In order to bring ingots to the desired rolling temperature, they are charged into an ingot-heating furnace and raised to about 425 to 450 deg. C. Rolling temperatures may vary in different works, and may be higher or lower in case light alloys are rolled. The ingot-heating furnace may be either gas- or oil-fired, or it may be heated electrically. A typical furnace is a gas-fired, five-track furnace. In case gas is used for firing, it is advisable to have oil-burning equipment provided, and *vice versa.*

The tracks in an ingot-heating furnace may be made of two ordinary steel rails placed about 1 ft. apart and fastened to the furnace floor. Ingots are pushed from the charging end to the front of the furnace by an ingot pusher, consisting of a ram, with a slow rate of motion, actuated by motor drive. To charge an empty furnace, an ingot is placed upon one of the tracks at the rear of the furnace, the ingot pusher is brought into position, and the ram then pushes the ingot along the track and toward the front of the furnace. In the present case, the ram does not travel far, i.e., it cannot push an ingot from the charging end to the discharge end, but it has an effective working distance of up to 24 in. (0.6 m.) or thereabouts. Hence, tracks are filled by pushing forward a number of ingots together.

Ingot-heating furnaces may be built in various sizes, but a typical furnace will have inside measurements as follows: 35 ft. long, 10 ft. wide, and 4 ft. high (10.7 x 3 x 1.2 m.). Double doors are hung on pulleys with balance weights at each end of the furnace and temperatures are taken by means of three pyrometers placed through the roof. An average furnace, with five tracks holding thirty-three ingots 12 in. (30 cm.) wide, contains 165 ingots when filled.

Heating Ingots Two-High

Attempts have been made to double the capacity of such a furnace by charging ingots two-high, but this is a questionable practice unless the furnace has been expressly designed for that purpose, since heating two-high in an improperly designed furnace leads to higher scrap losses at the hot mill and introduces other difficulties. In some furnaces, when running ingots two-high, it is necessary to overheat the top rows of ingots in order to raise the bottom rows to the rolling temperature. Aluminum becomes increasingly hot short at higher temperatures, and this leads to breakage of ingots, particularly on the first pass. Overheated ingots, i.e., those rolled at too high temperatures, usually result in "fire-cracked" slabs. Furthermore, the higher temperatures of the ingots cause higher roll temperatures, and this results in more roll breakages. Two-high heating of ingots will usually result in non-uniformity of ingot, and consequently of rolling temperatures, which is to be strictly guarded against. If the metal is rolled too hot it is too "tender"; if rolled too cold, it takes too long to break the ingots down. Rolling temperatures in relation to the amount of reduction have not been worked out, but 425 to 450 deg. C. at the furnace is fairly satisfactory for most breakdown operations.

When a track is full, and the hot mill is running, an ingot will be withdrawn from the front of the furnace for rolling; the track will be kept full of ingots by immediately placing a cold ingot on the track at the charging end and pushing up the line of ingots. In actual operation, the ingot-heating furnace is continually kept full of ingots by charging a cold ingot after withdrawing a hot one for rolling. Ingots are withdrawn from the various tracks in rotation so that each remains in the furnace for about the same length of time. Thus, in a five-track furnace, which may hold thirty-three 12-in. ingots per track, the usual method is to push out and roll the thirty-three hot ingots from track 1, filling up with cold ingots as rolling proceeds. Ingots are then rolled from track 2, then from track 3, and so on. By the time the ingots on track 5 have been rolled, those on track 1 are at the rolling temperature. Thus the operation proceeds continuously except in case of breakdown or shutdown at the hot mill. Breakdowns of the ingot-heating furnace itself are rare, since there is practically nothing which can get out of order. The only difficulties at the furnace will come in connection with the fuel supply and the method of firing. When a cold furnace is started, it may require, with gas or oil firing, from 10 to 12 hr. to raise the ingots to the rolling temperature. After the first batch has been rolled, succeeding charges will be in the furnace for about 6 hr.

Furnaces have double doors at both ends, and it is imperative to keep the doors shut at all times except when necessary to charge or withdraw ingots; otherwise, the ingots in the furnace may be unduly cooled by draughts. This is an important point in cold weather if the mill building is not tight. In a five-track furnace with double doors, it is necessary to open both doors at either end when withdrawing or charging ingots on the middle track. A better design would consist of a six-track furnace so arranged that each door would serve three tracks.

When an ingot is to be broken down in the hot mill for the production of slabs, it is withdrawn from the furnace at a temperature of 425 to 450 deg. C., and immediately conveyed on a truck to the mill and rolled. From 30 sec. to 2 min. may elapse prior to the first pass, the elapsed time depending upon the distance from the furnace to the mill and also upon the behavior of the previously rolled ingot. Thus, the hot-mill roller may consider the metal to be too hot, and he will accordingly hold the ingot so as to allow it to cool somewhat before rolling. This appears to be a matter which varies with individual rollers; it may have some bearing upon practical hot-mill operation, but, on the other hand, it may be based upon the vagaries of different rollers.

Breaking Down Without Preheating

In the foregoing, the statement has been made that aluminum ingots are also rolled without preheating in a furnace, by sending them to the hot mill directly from the molds. In this practice about 5 min. are

allowed for cooling to the desired rolling temperature. It is a mistake to roll aluminum in this way. The most self-evident reasons which should deter mill superintendents from so rolling aluminum are these: (1) There is no temperature control; (2) the temperatures are usually unknown; (3) there are wide variations in the temperatures of succeeding ingots; and (4) if a breakdown occurs at the hot mill, production is stopped not only there but at the melting end. Moreover, there is a distinctly greater percentage of defective slabs produced at the hot mill when rolling directly from the molds than when ingots are preheated to a definite temperature. Actual temperature measurements of ingots rolled directly from the molds have been taken at the hot mill, and variations from 370 to 625 deg. C. have been observed. Such variations are altogether too wide. At the lower temperatures, it takes too long to break down an ingot because more passes must be given, as the metal is not so readily worked at lower temperatures. At the higher temperatures the metal is hot short and breaks readily under pressure.

TABLE VIII. THICKNESSES TO WHICH INGOTS ARE BROKEN DOWN HOT FOR VARIOUS SIZES AND GAGES OF ALUMINUM SHEETS

Finished Gage to Be	Finished Width to Be, In	Finished Length to Be, In.	Should Be Broken Down Hot to, In. Thick	Remarks
1 to 4	...	.....	0.500	Finished from the hot mill slab
5 to 7	...	.....	0.300	Finished from the hot mill slab
8 to 9	...	.....	0.250	Finished from the hot mill slab
10 to 11	.....	.....	0.200	Finished from the hot mill slab
12 to 13	...	.....	0.300	Slabbed cold
14	40	124	0.300	Slabbed cold
14	41 to 70	125 to 160	0.400	Slabbed cold
15	.....	.....	0.250	Slabbed cold
16	40	100	0.250	Slabbed cold
16	48	124	0.300	Slabbed cold
16	60	160	0.400	Slabbed cold
17 to 25	.....	.....	0.250	Slabbed cold
26 to 40	.....	.....	0.200	Slabbed cold

(1 in. = 2.54 cm.)

..... indicate practically any length or width.

In general, the hot-mill slabs are cold-slabbed to one-half the original thickness. Gages from 1 to 11, inclusive, are not slabbed.

Table XI gives relation between gages and thickness.

Rolling temperatures are important, and it is a difficult matter to maintain anything like uniformity of temperature in succeeding ingots where they are rolled directly from the molds. In case of emergency, say where a breakdown takes place at the ingot-heating furnace, or there is a gas shortage or difficulty with oil circulation, it might be desirable to roll ingots directly from the molds and thus avoid entirely tieing up production on the hot-mill. But, in general, this method is never the best for hot-mill practice.

Calculations for Sheets

Reasonably exact calculations are required in determining the size and number of ingots to be rolled for a given order of sheets. Sheet orders may be given in different ways; for example, the customer may specify a certain number of sheets of definite gage and size, or, on the other hand, a certain number of pounds of sheets. Orders may, therefore, read as follows: 100 sheets, 16-gage, 40 by 96 in.; or 1,000 lb. of sheets, 18-gage, 44 by 112 in. Sizes in demand vary widely according to market requirements.

Tables VIII, IX, X, XI, XII, XIII and XIV will be found useful in calculating sheet orders. Table VIII gives the thicknesses to which ingots are broken down hot for sheets of various gages and sizes; the figures

TABLE IX. THICKNESSES TO WHICH HOT-MILL SLABS ARE COLD-SLABBED FOR VARIOUS GAGES AND SIZES OF ALUMINUM SHEETS

Finished Gage To Be	Finished Width to Be, In.	Finished Length to Be, In.	Should Be Cold Slabbed to, In	Remarks
1 to 11	...	.....	Not slabbed	Finished from the hot-mill slab
12 to 13	...	.....	0.150	Roughed
14	...	50 to 124	0.150	Roughed
14	...	130 to 164	0.200	Roughed
16	...	110 to 124	0.150	Roughed
16	...	134 to 164	0.200	Roughed
17 to 25	...	.....	0.125	Roughed
26 to 40	...	.....	0.095	Roughed

(1 in. = 2.54 cm.)

... indicate practically any length or width.

Table XI gives relation between gages and thickness.

TABLE X. SCRAP ALLOWANCES FOR FINISH SHEARING ON ALUMINUM SHEETS

Finished Gage to Be	Allowance for Side Shearing, In.	Allowance for End Shearing, In
7 and heavier	2.0	6.0 to 7.0
8 to 10	2.0	8.0 to 10.0
11 to 13	2.0	11.0 to 13.0
14 to 18	2.0	14.0 to 18.0
19 to 20	4.0	19.0 to 20.0
21 to 23	5.0	21.0 to 23.0
24 to 26	6.0	24.0 to 26.0
27 to 30	7.0	27.0 to 30.0

(1 in. = 2.54 cm.)

The figures given include both sides and both ends: for example, in the case of a 16-gage sheet, 1 in. is allowed for shearing on each side, and 8 in. on each end.

Larger end and side scrap allowances are made for the lighter gages, because of the greater tendency of these gages to crack during rolling.

Table XI gives relation between gages and thickness.

TABLE XI. WEIGHTS OF ALUMINUM SHEETS AND SLABS IN VARIOUS GAGES AND THICKNESSES

Sheet Gage, A.W.G.	Thickness In.	Thickness Mm.	Wt., Lb. per Sq.Ft.	Kg. per Sq.M.
0000	0.4600	11.68	6.406	31.28
000	0.4096	10.40	5.704	27.85
00	0.3648	9.16	5.080	24.80
0	0.3248	8.25	4.524	22.09
1	0.2893	7.35	4.029	19.67
2	0.2576	6.54	3.588	17.52
3	0.2294	5.83	3.195	15.60
4	0.2043	5.19	2.845	13.89
5	0.1819	4.62	2.534	12.37
6	0.1620	4.11	2.256	11.01
7	0.1442	3.66	2.009	9.809
8	0.1284	3.26	1.789	8.735
9	0.1144	2.91	1.594	7.782
10	0.1018	2.59	1.418	6.923
11	0.0907	2.30	1.264	6.171
12	0.0808	2.05	1.126	5.498
13	0.0719	1.83	1.002	4.892
14	0.0640	1.63	0.892	4.355
15	0.0570	1.45	0.796	3.886
16	0.0508	1.29	0.707	3.452
17	0.0452	1.15	0.630	3.076
18	0.0403	1.02	0.561	2.739
19	0.0358	0.91	0.499	2.436
20	0.0319	0.81	0.445	2.173
21	0.0284	0.72	0.396	1.933
22	0.0253	0.64	0.353	1.723
23	0.0225	0.57	0.314	1.533
24	0.0201	0.51	0.279	1.362
25	0.0179	0.45	0.249	1.216
26	0.0159	0.40	0.221	1.079
27	0.0141	0.36	0.197	0.962
28	0.0126	0.32	0.176	0.859
29	0.0112	0.28	0.156	0.762
30	0.0100	0.25	0.139	0.679
31	0.0089	0.23	0.124	0.605
32	0.0079	0.20	0.110	0.537
33	0.0070	0.18	0.098	0.478
34	0.0063	0.16	0.087	0.425
35	0.0056	0.14	0.078	0.381
36	0.0050	0.13	0.069	0.337
37	0.0044	0.11	0.062	0.303
38	0.0039	0.10	0.056	0.269
39	0.0035	0.09	0.049	0.239
40	0.0031	0.08	0.043	0.210

Slabs

Thickness In.	Thickness Mm.	Wt., Lb. per Sq.Ft.	Kg. per Sq.M.
1/16	1.59	0.869	4.25
1/8	3.18	1.739	8.49
3/16	4.76	2.609	12.74
1/4	6.35	3.479	16.99
5/16	7.94	4.348	21.23
3/8	9.53	5.218	25.48
7/16	11.11	6.088	29.72
1/2	12.70	6.958	33.97
9/16	14.29	7.827	38.21
5/8	15.88	8.697	42.46
11/16	17.46	9.567	46.70
3/4	19.05	10.435	50.94
13/16	20.64	11.306	55.20
7/8	22.22	12.175	59.44
15/16	23.81	13.045	63.69
1	25.40	13.914	67.93

TABLE XII. SCALE FOR SLAB CUTS

A.W.G. Thickness	Required Length of Finished Sheet																																		
	50	54	60	64	70	72	74	80	84	90	94	96	98	100	110	112	114	116	120	124	130	134	136	138	140	142	144	148	150	152	154	156	158	160	164
	Length of Cuts Made on Shearing, in Inches																																		
1	29	32	35	38	41	42	44	47	50	53	55	57	58	59	64	66	67	69	70	73	76	79	80	81	83	84	85	87	88	90	91	92	93	94	97
2	27	29	32	34	37	38	39	42	44	48	50	51	52	53	58	59	60	61	64	66	69	71	72	73	74	75	76	77	78	79	80	81	82	83	87
3	22	24	26	28	30	31	32	35	37	39	40	41	42	43	48	49	49	50	52	54	56	58	59	60	61	62	63	64	65	66	67	68	69	70	71
4	21	23	25	27	29	30	31	34	35	38	39	40	41	42	46	47	48	49	50	52	54	56	57	58	59	60	61	62	63	64	65	66	67	68	69
5	31	34	37	40	42	45	46	50	53	56	58	60	62	63	69	70	71	73	75	78	81	84	85	87	88	89	90	93	94	95	97	98	99	100	103
6	28	30	33	36	39	40	41	44	47	50	52	53	54	55	61	62	63	64	66	69	72	74	75	77	78	79	80	82	83	84	85	87	88	89	91
7	24	25	29	30	33	34	35	38	40	43	44	45	46	47	52	53	54	55	57	59	62	64	65	66	67	68	69	70	71	72	73	74	75	76	78
8	26	28	31	34	37	38	39	43	45	48	50	51	52	53	59	60	61	62	64	66	69	71	72	73	74	75	76	77	78	79	80	81	82	83	84
9	23	25	27	29	32	33	34	36	38	41	43	44	45	46	50	51	52	53	55	56	59	61	62	63	64	65	66	67	68	69	70	71	72	73	75
10	26	28	31	34	37	38	39	43	45	48	50	51	52	53	59	60	61	62	64	66	69	71	72	73	74	75	76	77	78	79	80	81	82	83	86
11	23	25	27	29	32	33	34	36	38	41	43	44	45	46	50	51	52	53	55	56	59	61	62	63	64	65	66	67	68	69	70	71	72	73	75
12	26	28	31	34	37	38	39	43	45	48	50	51	52	53	59	60	61	62	64	66	69	71	72	73	74	75	76	77	78	79	80	81	82	83	86
13	24	26	29	31	34	35	36	38	40	43	45	46	47	48	53	54	55	56	57	59	62	64	65	66	67	68	69	70	71	72	73	74	75	76	78
14	22	24	26	28	30	31	32	35	37	39	41	42	43	44	48	49	50	51	52	54	42	43	44	45	46	47	48	49	50	51	52	53	54	53	54
15	23	25	27	29	32	33	34	36	38	41	43	44	45	46	50	51	52	53	55	56	59	61	62	63	64	65	66	67	68	69	70	71	72	73	75
16	20	21	24	26	28	29	30	32	34	36	38	39	39	40	37	38	38	39	40	41	33	34	34	35	35	37	37	37	38	38	39	39	40	40	41
17	18	19	22	23	25	26	27	29	30	32	34	35	35	36	39	40	41	42	43																
18	16	17	19	21	23	24	24	26	27	29	31	31	32	33																					
19	14	15	17	18	20	20	21	23	24	25	27	27	28	28																					
20	13	14	15	16	18	18	19	20	21	23	24	24	25	25																					
21	11	12	14	15	16	16	17	18	18	20	21	22	22	23																					
22	10	11	12	13	14	15	15	16	17	18	19	20	20	20																					
23	9	9	10	11	13	13	13	14	15	16																									
24	8	9	10	11	12	12	12	13	14	15																									
25	7	8	9	9	10	10	11	11	12	13																									
26	8	9	10	11	12	12	12	13	14	15																									
27	8	8	9	10	11	11	11	12	12	14																									
28	7	7	8	9	10	10	10	11	11	13																									
29	6	6	7	8	8	9	9	10	10	10																									
30	6	6	7	7	8	8	8	9	9	10																									
31	5	5	5	6	6	6	7	7	7	8																									
32	4	5	5	5	6	6	6	7	7	7																									
33	4	5	5	5	6	6	6	7	7	7																									
34	4	4	4	4	5	5	5	5	5	5																									
35	3	3	4	4	4	4	4	5	5	5																									
36	3	3	4	4	4	4	4	5	5	5																									
37	3	3	3	3	3	4	4	4	4	4																									
38	2	2	2	2	3	3	3	3	3	3																									
39	2	2	2	2	3	3	3	3	3	3																									
40	2	2	2	2	3	3	3	3	3	3																									

Notes to Table:

1. Thickness to which ingots are broken down hot for various sizes and gages of sheets are given in Table VIII.
2. Thickness to which hot-mill slabs are cold slabbed are given in Table IX.
3. Relation between gage and thickness in Table XI.

1 in. = 2.54 cm.

TABLE XIII. SLAB LENGTHS AND WIDTHS FOR 4 X 12 X 17-INCH INGOTS

Area, 6,724 Sq.In. Thickness, 0.095 In.		Area, 6,419 Sq.In. Thickness, 0.100 In.		Area, 5,183 Sq.In. Thickness, 0.125 In.		Area, 4,485 Sq.In. Thickness, 0.150 In.		Area, 3,364 Sq.In. Thickness, 0.200 In.		Area, 2,724 Sq.In. Thickness, 0.250 In.		Area, 2,270 Sq.In. Thickness, 0.300 In.		Area, 1,816 Sq.In. Thickness, 0.375 In.	
Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.	Width, In.	Length, In.
12	560	12	534	12	427	12	373	12	280	12	227	12	197	12	151
13	517	13	493	13	394	13	345	13	258	13	209	13	174	13	139
14	480	14	458	14	366	14	320	14	240	14	194	14	162	14	129
15	448	15	427	15	342	15	299	15	224	15	181	15	151	15	121
16	420	16	401	16	320	16	280	16	210	16	170	16	141	16	113
17	395	17	377	17	301	17	263	17	197	17	160	17	133	17	106
18	373	18	356	18	285	18	249	18	186	18	151	18	126	18	100
19	353	19	337	19	270	19	236	19	177	19	143	19	119	19	95
20	336	20	320	20	256	20	224	20	168	20	136	20	113	20	90
21	320	21	305	21	244	21	213	21	160	21	129	21	108	21	86
22	305	22	291	22	233	22	203	22	152	22	123	22	103	22	82
23	292	23	279	23	223	23	195	23	146	23	118	23	98	23	78
24	280	24	267	24	213	24	186	24	140	24	114	24	94	24	75
25	268	25	256	25	205	25	179	25	134	25	109	25	90	25	72
26	258	26	246	26	197	26	172	26	129	26	104	26	87	26	69
27	249	27	237	27	190	27	166	27	124	27	100	27	84	27	67
28	240	28	229	28	183	28	160	28	120	28	97	28	81	28	64
29	231	29	221	29	177	29	154	29	116	29	94	29	78	29	62
30	224	30	213	30	171	30	149	30	112	30	90	30	75	30	60
31	216	31	207	31	165	31	144	31	108	31	88	31	73	31	58
32	210	32	200	32	160	32	140	32	105	32	85	32	70	32	56
33	203	33	194	33	155	33	135	33	101	33	82	33	68	33	55
34	197	34	188	34	150	34	131	34	98	34	80	34	66	34	53
35	192	35	183	35	146	35	128	35	96	35	77	35	64	35	51
36	186	36	178	36	142	36	124	36	93	36	75	36	63	36	50
37	181	37	173	37	138	37	121	37	90	37	73	37	61	37	49
38	176	38	168	38	135	38	118	38	88	38	71	38	59	38	48
39	172	39	164	39	131	39	115	39	86	39	69	39	58	39	46
40	168	40	160	40	128	40	112	40	84	40	68	40	56	40	45
41	164	41	156	41	125	41	109	41	82	41	66	41	55	41	44
42	160	42	152	42	122	42	106	42	80	42	64	42	54	42	43
43	156	43	149	43	119	43	104	43	78	43	63	43	52	43	42
44	152	44	145	44	116	44	101	44	76	44	61	44	51	44	41
45	149	45	142	45	114	45	99	45	74	45	60	45	50	45	40
46	146	46	139	46	111	46	97	46	73	46	59	46	49	46	39
47	143	47	136	47	109	47	95	47	71	47	57	47	48	47	38
48	140	48	133	48	106	48	93	48	70	48	56	48	47	48	37
49	137	49	131	49	104	49	91	49	68	49	55	49	46	49	37
50	134	50	128	50	102	50	89	50	67	50	55	50	45	50	36
51	131	51	125	51	100	51	87	51	65	51	54	51	44	51	35
52	129	52	123	52	98	52	86	52	64	52	53	52	43	52	34
53	126	53	121	53	96	53	84	53	63	53	52	53	42	53	34
54	124	54	118	54	95	54	83	54	62	54	51	54	42	54	33
55	122	55	116	55	93	55	81	55	61	55	50	55	41	55	33
56	120	56	114	56	91	56	80	56	60	56	49	56	40	56	32
57	117	57	112	57	90	57	78	57	59	57	48	57	39	57	31
58	115	58	110	58	88	58	77	58	58	58	47	58	38	58	31
59	113	59	108	59	87	59	76	59	57	59	46	59	37	59	30
60	112	60	106	60	85	60	74	60	56	60	45	60	36	60	30

The area of any slab at the thickness indicated is the product of the length times the width.
This table is used in conjunction with Table XII.
1 in. = 2.54 cm.

indicate the ordinary sizes in the gages mentioned, but the other possible variations are many indeed. The figures are applicable to ingots of any size; the size of ingot chosen will depend upon the finished dimensions of the sheets, and such ingots will be rolled as will permit of small scrap losses on shearing. Table IX shows the thicknesses to which hot-mill slabs are cold-slabbed before roughing for various gages and sizes of sheets. Table X gives the usual scrap allowances for finish shearing on aluminum sheets. Figures for shearing must be available so as to calculate the sizes of the hot-mill slabs. Table XI gives figures for the weight per sq.ft. and the thickness of various gages in aluminum sheets and in different thicknesses of slabs. Table XII is a scale for cuts on hot-mill slabs; the tabular quantities are the length which should be cut from a slab in order to roll to a definite length in the finished sheet. Table XII is to be used in conjunction with Table XIII; the latter gives the lengths and widths possible in hot-mill slabs rolled from 4 x 12 x 17 in. (13 x 30 x 43 cm.) ingots to various thicknesses. Table XIV shows the approximate number of sheets to be rolled per pack for various gages; lengths and widths do not determine the number of sheets to be rolled in pack, as will be explained at length in later paragraphs. The use of these tables will be explained at length with practical examples.

With the exceptions given below, all ingots broken down in the hot mill are subsequently cold slabbed to 0.125 in. (3.8 mm.) thick before roughing and finishing. The exceptions are these:

(1) Sheets to finish heavier than 12-gage and any length are not slabbed, but are hot rolled to thicknesses as follows:

Finished Gage	Hot Rolled to
1 to 4	0.500 inch (12.7 mm.)
5 to 7	0.300 inch (7.6 mm.)
8 to 9	0.250 inch (6.4 mm.)
10 to 11	0.200 inch (5.1 mm.)

(2) Sheets to finish 12- and 13-gage and any length are slabbed to 0.150 in. (3.8 mm.).

(3) Sheets to finish 14-gage and 50 to 124 in. (1.3 to 3.1 m.) long are slabbed to 0.150 in. (3.8 mm.).

(4) Sheets to finish 14-gage and 130 to 164 in. (3.3 to 4.2 m.) long are slabbed to 0.200 in. (5.1 mm.).

(5) Sheets to finish 16-gage and 110 to 124 in. (2.8 to 3.1 m.) long are slabbed to 0.150 in. (3.8 mm.).

(6) Sheets to finish 16-gage and 134 to 164 in. (3.4 to 4.2 m.) long are slabbed to 0.200 in. (5.1 mm.).

(7) Sheets to finish 26-gage to 40-gage, inclusive, and any length are slabbed to 0.095 in. (2.4 mm.).

Usually, all sheets to finish lighter than 11-gage are hot-rolled to twice the cold slab thickness; that is, the hot slab should be of such thickness that it may be reduced one-half on cold slabbing and still leave sufficient thickness for roughing and finishing. The figures given in the foregoing and in the tables are largely applicable in a general way, but other combinations may be as suitable. The use of the tables in connection with calculations and the actual methods of calculating orders may conveniently be explained by means of a few examples.

Example 1.—Suppose an order for 500 lb. of 20-gage, 30 x 40 in. dead soft sheet comes into the mill. On 20-gage, sheets of this size will be run two in a pack. The scrap allowances for shearing are 4 in. for side scrap and 20 in. for end scrap, from Table X. In breaking down 4 x 12 x 17 ingots for 20-gage sheet, the ingots will be hot rolled to ¼ in., and then cold slabbed to ⅛ in. (Tables VIII and XII and above explanation). The thickness of 20-gage sheet is taken as 0.031 in. The calculations are:

0.125 ÷ 0.031 = 4, a factor.
60 in. = finished length plus scrap allowance.
60 ÷ 4 = 15, the length of cuts to be made on the slab.
150 in. = length of a 4 x 12 x 17 in. ingot after breaking down to a thickness of 0.125 and a width of 34 in. (Table XIII.)
150 ÷ 15 = 10, the number of pieces which can be cut from a cold slab, rolled as indicated.
30 x 40 in. is the size of sheets wanted.
30 x 40 = 1,200 sq.in., or 12,000 sq.in. of 20-gage sheet can be obtained from one 4 x 12 x 17 in. ingot.
12,000 ÷ 144 = 83 sq.ft. of sheet.
20-gage sheet weighs 0.445 lb. per sq.ft.
0.445 × 83 = 38 lb. of finished sheet from one ingot.
Figuring 10 per cent of total order for scrap, then 500 + 50 = 550 lb.
550 ÷ 38 = 14+ ingots.
Then, 15 ingots, 4 x 12 x 17 in., should be run for this order.

Example 2.—Consider an order for 500 lb. of 20-gage, 7.5-in. diameter circles, strip-roll metal. This order will be rolled from 4 x 12 x 17 in. ingots. It would be impractical to attempt to roll a hot-mill slab to a width of about 7.5 in. from such ingots, and therefore it will be advisable to roll to about twice this width. The circle shearing allowance on a 7.5-in. circle will be 1 in. Hence,

7.5 + 1 = 8.5 in.
8.5 × 2 = 17 in.
Add 1 in. for slab shearing.
17 + 1 = 18 in., the width to which the hot-mill slabs should be rolled.
Metal for 20-gage strip rolled sheet will be hot rolled to 0.375.
0.375 ÷ 0.031 = 12, a factor.
100 in. = length obtained from a 4 x 12 x 17 in. ingot after breaking down to a thickness of 0.375 in. and a width of 18 in. (Table XIII).
The order calls for 7.5-in. diameter circles.
$\pi r^2 = \pi \times 3.75^2 = 44.18$ sq.in.
100 × 12 = 1,200.
1,200 ÷ 8.5 = 141, the number of circles in half the width of a slab.
141 × 2 = 282, the number of circles which can be obtained from one ingot.
44.18 × 282 = 12,458.8 sq.in. of circles from one ingot.
12,458.8 ÷ 144 = 86.5 sq.ft. of circles.
20-gage sheet weighs 0.445 lb. per sq.ft.
0.445 × 86.5 = 48.5 lb. of circles from one ingot.
Figuring 10 per cent of total order for scrap, then 500 + 50 = 550 lb.
550 ÷ 48.5 = 11+ ingots.
Then, 12 ingots, 4 x 12 x 17 in., should be run for this order.

Example 3—This example will explain in detail the use of Tables XII and XIII in calculations for sheets. Consider an order calling for 1,000 lb. 16-gage, 40 x 144 in., intermediate sheets, to scleroscope 13 (regular hammer). The thickness of 16-gage is 0.0508 in. Scrap allowances on sheets of the size mentioned will be 2 in. for side scrap and 16 in. for end scrap. Hot-mill slabs for these sheets will be rolled to 0.300 and cold slabbed to 0.150, and the hot slabs should measure 42 x 160 in. The calculations are:

0.150 ÷ 0.0508 = 3, a factor.
160 in. = length of the cold slab.
160 ÷ 3 = 53 in., the length of cuts to be made on the cold slab.
Referring now to Table XIII, and looking in the cold slab thickness column headed 0.150 in., run down the column to 42 (the width of the slab); the number opposite is 106.
106 in. = length obtainable from a 4 x 12 x 17 in. ingot after breaking to 0.150 x 42.
106 ÷ 53 = 2, the number of pieces which can be cut from a cold slab, rolled as indicated.
40 × 144 in. is the size of sheets wanted.
40 × 144 = 5,760 sq.in., or 11,520 sq.in. of 16-gage sheet can be obtained from one 4 x 12 x 17 in. ingot.
11,520 ÷ 144 = 80 sq.ft. of sheet.
16-gage sheet weighs 0.7078 lb. per sq.ft.
0.7078 × 80 = 56.6 lb. of finished sheet from one ingot.
Figuring 10 per cent of total order for scrap, then 1,000 + 100 = 1,100 lb.
1,100 ÷ 56 = 19+ ingots.
20 ingots, 4 x 12 x 17 in., should be run for this order.

Example 4—Later on it will be said that scrap losses may assume unreasonable proportions because of miscalculations with the size ingots to be rolled. As stated previously, the size ingots to be rolled depends upon the size of sheets to be made, and it is desirable to choose such ingots as will give small scrap losses in shearing, i.e., for example, the ingots should cut into several pieces without much scrap. A practical example will demonstrate the principles involved. Suppose an

order for 1,000 lb., 16-gage, 30 x 60 in., hard-rolled sheet is received. The question is: What size ingots shall this order be rolled from? The practical tendency in calculating would be to try a standard ingot, say 4 x 12 x 17, and see how this would work out as to scrap on shearing. The calculations for a 4 x 12 x 17 ingot would be:

0.125 ÷ 0.050 = 2.5, a factor.
The length of the sheet after scrap allowance may be taken as 75 in.
75 ÷ 2.5 = 30 in., the length of cut to be made on the cold slab after cold slabbing.
Referring to Tables XII and XIII, a cold slab run ⅛ in. thick and 32 in. wide would be 160 in. long. 160 ÷ 30 = 5 times and 10 remainder.

Shearing as indicated would allow five pieces but 10 in. scrap.

This is rather high scrap loss, so it will be advisable to try another standard ingot. Such an ingot will be one measuring 4 x 12 x 20 in. The calculations for the size will be:

0.125 ÷ 0.050 = 2.5, a factor.
75 ÷ 2.5 = 30.
The length of a cold slab run ⅛ in. thick and 32 in. wide from a 4 x 12 x 20 in. ingot will be 182 in. (a figure which can be obtained by calculations, and more readily in mill practice by drawing up a table similar to Table XII for ingots of this and other sizes).
182 ÷ 30 = 6 times and 2 remainder.

TABLE XIV. APPROXIMATE NUMBER OF SHEETS FOR VARIOUS GAGES TO BE ROLLED IN PACK

Gage*	Number of Sheets in a Pack	Gage*	Number of Sheets in a Pack
20	2	31	6
21	2	32	6
22	3	33	6
23	3	34	7
24	3	35	7
25	4	36	7
26	4	37	8
27	4	38	8
28	5	39	10
29	5	40	10
30	5		

* See Table XI.

Shearing as indicated would allow 6 pieces to be cut from each slab with only 2 in. of scrap. This is a better figure, and for the order in question, 4 x 12 x 20 in. ingots would be run.

The examples given above show in a general way what calculations arise in aluminum rolling-mill practice, and they indicate short methods for arriving at the desired results. At times, an order may be short of the required weight or number of sheets due to rejections by the inspector, because of wrong shearing, or because of scrapped slabs or sheets at the mills. No calculations can possibly remedy these difficulties. Accordingly, it is advisable to carry a fair sized stock of the sizes most often called for. Moreover, the requirements of the market, while varied, bulk very largely in certain sizes and gages, so that a stock may profitably be carried in order to fill short orders.

(Part IV, dealing with slabbing, will be published in our next issue.)

Picric Acid Plant Sold

The director of sales of the War Department announces that the Ordnance Salvage Board has sold to H. C. Couch, president of the Arkansas Light & Power Co., representing a group of business men of Little Rock, Ark., the acid-manufacturing plant near Little Rock, which was constructed by the Ordnance Department during the war for the production of picric acid. The price obtained by the Government for the property was $770,000. The purchasers were the highest of five bidders who submitted proposals for the property.

Magnesite Tariff Bill

At the hearings before the House Ways and Means Committee on July 16 and 17, 1919, of the magnesite tariff bill (H. R. 5,218), the producers of refractory magnesite were well represented, and the question of the use of magnesite in oxychloride cement received but scant attention. Calcined or caustic magnesite was included in the same classification as dead-burned and grain magnesite and the bill, as passed by the House, calls for a duty of ¾c. per lb.

However, at the hearings before the Senate Committee on Finance on Jan. 13 the composition floor manufacturers had an opportunity to present their objection to the tariff.

Calcined magnesite enters into the manufacture of Sorel cement, sanitary flooring, stucco, interior plasters and pipe insulation; a considerable business in these and other materials containing caustic burned magnesite has been built up in the past twenty years, it being estimated that in excess of 50,000 tons of crude ore was used in 1919, which is about 17 per cent of the total estimated domestic production. The producers represented that their products were in competition with other flooring materials, such as wood and ordinary cement, and that the additional cost which would be imposed should the tariff be granted would prohibit the use of their product. The present price of around $60 a ton for the caustic magnesite and $45 per ton for the chloride was compared with $25 and $16 respectively for the pre-war price and considered as sufficient to develop domestic production.

In addition the quality of the domestic caustic burned magnesite was represented as not being as uniform as that produced from Grecian ores, the principal source of foreign supply, and that because of the unreliable qualities an additional hardship was imposed upon the industry. The suggestion was made that magnesite containing an insufficient amount of iron to produce a satisfactory refractory be excluded from the provisions of the bill.

The use of magnesite in flooring for steel cars and boats, where its plasticity is an important quality, and in offices, hospitals and schools, where the sanitary and quiet features are of value, has been making particular progress during the past few years. A further important use is for exterior stucco, for which there is no practical substitute. This brings out the fact that magnesite is of wide usefulness outside the production of refractories.

German Nitrate Industry

The American Chamber of Commerce in Berlin has recently reported the results of its investigation into the present status of the industry. It appears that the entire production of nitrates in Germany is under the control of the Stickstoff Syndikat, with headquarters at Berlin. Both the Haber and cyanamide methods are used for fixation of nitrogen. The Haber plants are extensive and are located at Merseburg and Ludwigshafen. War-time developments have made Germany entirely independent of Chile, and not only will she supply her own requirements, but proposes to export fixed nitrogen as soon as her own needs are fully covered. Inland prices of nitrate and the various byproducts have been adjusted and are published in the *Reichs-Gesetzblatt*, 1919, No. 218. All questions of export and import are determined by the Stickstoff Syndikat.

Pulverized Lignite Fuel in California

By Roy N. Buell

EARLY in 1918, the hand of the Federal Government had been placed on the utilization of all fuel throughout the entire country, and in California, as elsewhere, the Fuel Administrator, in order to carry the state over a period of excessive need, had organized a corps of fuel engineers and inspectors to see that every possible source of supply was surveyed and that every pound of oil, coal or wood consumed was burned with a maximum of efficiency. The consumption of fuel oil was exceeding production by over 5,000 bbl. per day, and notwithstanding the fact that many non-essential plants had been entirely cut off, the shortage threatened to become more and more acute as time went on, unless some new source of fuel supply could be discovered.

Survey of the Lignite Field

It was decided to make a general state survey of all fuels with a view of finding some practical auxiliary for oil, and among the many possibilities to receive serious attention was California lignite. Large deposits of this material were known to exist in the Priest Valley, in which the Stone Canyon mine is situated; at Corral Hollow, where the Tesla mine is located; near Mount Diablo, at the old Black Diamond mine; in Dos Rios county, which was merely a good prospect, and in Amador county at the Ione coal mine. Experts from the United States Bureau of Mines and the technical staff of the State Fuel Administration were sent to examine these properties and report the possibility of using their output as an immediate source of domestic and commercial fuel.

The report submitted by these engineers was very thorough and complete, but hardly as reassuring in respect to the available fuel supply as had been anticipated. The Stone Canyon mine, while it contained by far the best coal in the state, could not be put in a workable condition for several months, and then at great expense. The Tesla mine, which had been worked many years before to a depth of about 900 ft. at three different levels, was found to be filled with water to within 300 ft. of the top, and aside from this a large amount of money would be required to replace tracks, elevators, tipples, etc., that had previously been either removed or destroyed. Other small deposits around Livermore, in the Mount Diablo district, were either undeveloped or completely worked out.

FIG. 1. INTERIOR OF IONE LIGNITE MINE, IONE, CAL.

In Dos Rios county several test holes were drilled and much preliminary work was accomplished, but no large veins were discovered that would warrant further continuation of the work on a large scale. It was proved, however, that this particular deposit in Dos Rios county was a high grade variety of semi-bituminous coal, equal in B.t.u. content to the Stone Canyon product. Private parties have continued to explore this field and some well-known geologists have ventured their opinion that a large coal deposit will eventually be located.

Ione Mine Chosen

One of the last mines to be explored was that at Ione, and here the engineers found that coal was actually being mined and that the plant was prepared to turn out about 500 tons per day. In the old days, before the advent of fuel oil and the discovery of better coal in Wyoming and Utah, a large portion of the fuel consumed by the locomotives of the Southern Pacific R.R. was obtained from this mine. Many an old locomotive fireman can still be found in California who can tell you many interesting incidents concerning his experience with Ione coal.

After much discussion and careful consideration of the final report submitted by the engineers, the Fuel Administration decided that the lignite from the Ione mine, although of inferior quality, offered the best possibilities for immediate service. The next step was to determine the best method to be pursued in burning the lignite. The consensus of opinion seemed to be that the best efficiency in combustion could be obtained by drying, crushing and afterward burning the lignite in a pulverized state, properly mixed with air.

Advantages of Burning Pulverized Lignite

Among the advantages of burning the lignite in pulverized form, the one that stood out above all others was the fact that no matter how much ash the fuel contained it could be burned with good efficiency. Coal and lignites, having a large ash content, are difficult to burn on grates, owing to the fact that as soon as combustion commences the ash collects all around the carbon and completely shuts off the air. Besides this, the high volatile content of the lignite does not thoroughly mix with the air, so that the combustion of the gases is not complete without admitting a large amount of excess air, and even then the efficiency is poor. When the lignite is pulverized, however, the particles are so fine that approximately the proper amount of air to insure complete combustion surrounds each little atom of fuel, which condition not only guarantees high efficiency in burning but permits of easy and accurate control.

Installation of Experimental Equipment

To carry on the necessary experimental work, preliminary to installing the process in large commercial power plants, it was decided to construct a small demonstration plant in San Francisco. Accordingly, a 50-hp. "Kewanee" return tubular boiler was equipped with the Buell-Santmyer pulverized coal system, which was considered best to burn the California lignite. Ione lignite, containing an average moisture of 40 per cent, as

mined, was allowed to air dry for seven days in shallow tipples at the top of the mine shaft, when it was shipped to San Francisco, in open cars, for treatment.

As received at the plant, the analysis was as follows:

	Per cent As received	Dry Per cent
Moisture	22.44	00.00
Volatile	43.37	54.60
Fixed Carbon	20.41	26.32
Ash	14.78	19.08
	100.00	100.00
B.t.u. per lb.	9,322	12,016

The fuel, as unloaded from the cars, was first crushed to about one-half inch. It was then dried in a semi-direct, artificially fired drier until the moisture content was reduced to approximately 6 per cent. One of the most important operations in the preparation of pulverized lignite is the drying process. At the San Francisco plant about one-sixth of the weight of the raw material was carried off as vaporized moisture, and to accomplish this, 50 lb. of pulverized lignite was consumed as drier fuel to every ton of dried product. The average temperature maintained inside the drier was 250 deg. F.. and great care had to be taken that the heat did not rise above this point, which is apt to cause spontaneous combustion or perhaps explosions.

After the lignite had been dried as described, it was pulverized to about 175 mesh, separated by air and stored in a concrete bunker, ready for use. One of the big bugaboos always brought forward in every argument against the use of pulverized lignite is that it is impossible to keep this material in storage for more than a few days without danger from spontaneous combustion. The writer's experience, however, seems to refute this claim, as he has known of one particular instance in California where several tons of powdered lignite was stored in a *metal* hopper for six months with apparently no ill effects whatsoever.

Operation of Combustion Equipment

The general layout of the combustion equipment used at the San Francisco plant is shown in Fig. 2. The pulverized lignite drops by gravity from the bunker into the feeder, where a screw conveyor, driven by a variable speed electric motor, carries the fuel to the mixer chamber. Between the feeder and mixing chamber is situated a cross, with the upper connection left open, through which induced air may be drawn, aiding materially in stabilizing the pressure. An air compressor of the rotary type furnishes the necessary energy to transport the powdered lignite from the mixer to the combustion chamber, and supplies about 40 per cent of the air required for proper combustion, the other 60 per cent being obtained by induction.

The average air pressure employed at this plant was 3 lb. at the compressor and about 12 oz. at the burner. The powdered lignite, after meeting the compressed air at the mixer, is carried along through a 3-in. pipe to the burner, the most sensitive piece of apparatus in the whole plant, although very simple in construction. The focusing sleeve, on the end of the burner, is so arranged that the flame zone can be lengthened or shortened as desired.

A secondary air line, taken off the main line near the compressor, extends completely through the burner, with orifices near the extreme end looking back toward the front of the boiler, which acts as a brake on the main body of forced air and lignite. In actual combustion, this secondary air brake causes the flame corona within the furnace to expand or contract as desired. A half-inch steam jet was used to deflect the cutting flame away from the under side of the boiler plates.

The burner was lighted instantaneously with a torch through an opening in the boiler front. These openings were also used to allow more secondary air to enter the combustion chamber if required. About 15 per cent excess air was generally employed in combustion, although when the boiler was under peak load, this amount might be slightly increased. No changes worthy of note were made in the settings of the boiler, the object being to demonstrate how readily this system could be adapted to any ordinary boiler at small expense. The grate bars were removed, and later on an inclined fill was placed in front of the bridge wall to reduce back pressure.

To remove and collect the ash a permanent soot blower was installed in the front end of the tubes and an ash trap constructed under the rear end of the boiler, near the cleanout door. A complete set of instruments was installed to record the temperatures of the feed water,

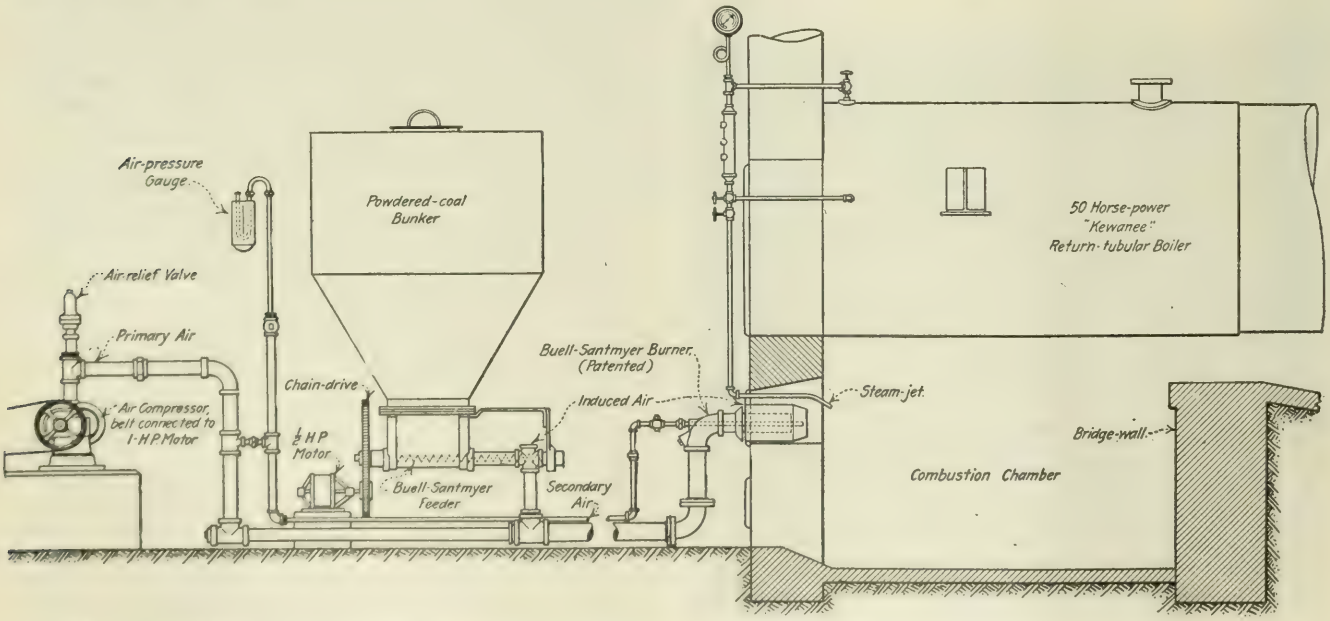


FIG. 2. GENERAL LAYOUT OF COMBUSTION EQUIPMENT, EXPERIMENTAL PLANT, SAN FRANCISCO, CAL.

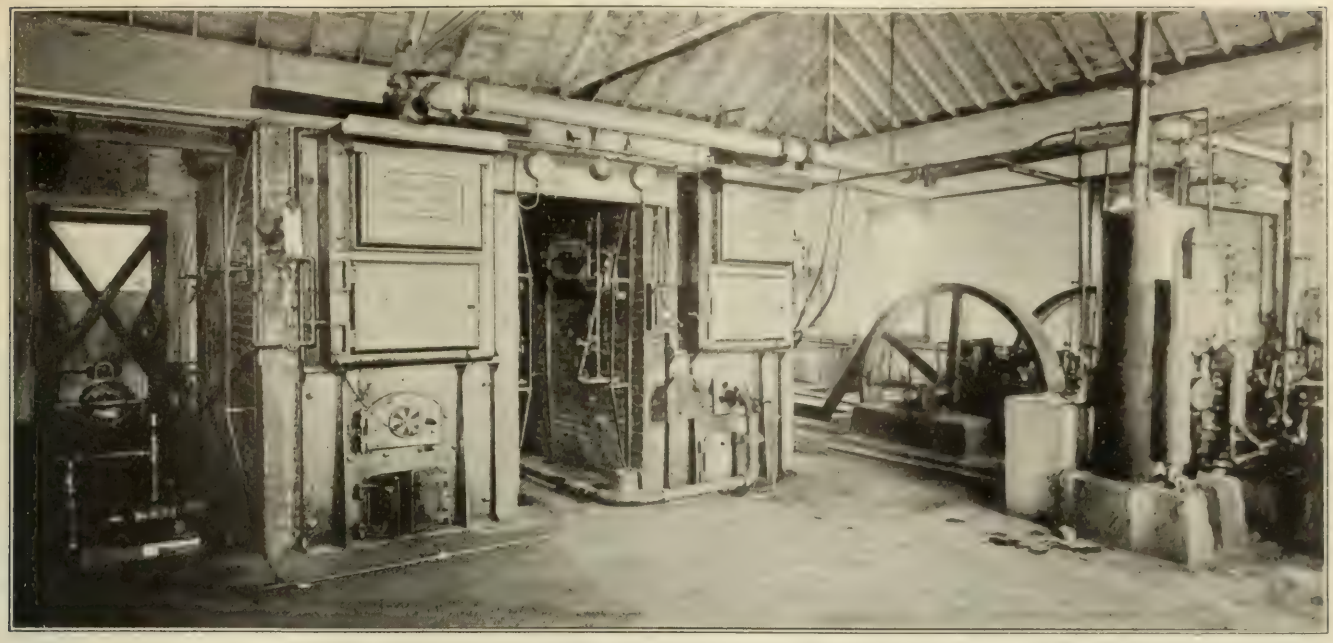


FIG. 3. POWER PLANT AT STOCKTON, CAL., USING PULVERIZED LIGNITE FUEL

the live steam, the combustion chamber and the waste gases, to determine the vacuum of the stack, draft, to weigh the feed water and to measure the steam flow.

Results Obtained

Although the conditions for efficiency at the plant were far from ideal, some very good results were obtained, both as to combustion and boiler efficiency. The average evaporation per pound of dry fuel burned was 9 lb. of water from and at 212 deg. F. The average temperature in the combustion chamber was around 2,300 deg. F. and that of the waste gases in the breeching above the boiler about 550 deg. F. The CO_2 content in the waste gases averaged 14.5 per cent. The stack dampers were so adjusted that the vacuum in the rear of the combustion chamber was 0.02 in. Fifty per cent of the ashes was carried out of the stack in suspension with the waste gases, 3 per cent lodged in the tubes and was removed by the soot blower and 47 per cent dropped either into the ash trap in the rear of the setting or onto the floor of the ash-pit in front. The latter portion of the ash proved upon analysis to be largely silica and to contain about 0.005 per cent unconsumed carbon.

Many tests were carried out at this experimental plant for the benefit of California fuel engineers, and as a result of these successful demonstrations with lignite fuel plans were drawn early in 1919 for a large steam electric generating plant at the site of the old Tesla lignite mine and three industrial power plants at Stockton to use lignite from the Ione field. A small plant has been completed at Stockton, where very gratifying results have been obtained, the powdered lignite being burned under Heine boilers, with equipment similar to that used at the initial plant at San Francisco.

When the plants now under construction in California are in actual operation and the efficiency experts have noted the great economy that will result in the generation of steam and for metallurgical purposes as well, the use of California pulverized lignite as an auxiliary to fuel oil and hydro-electric power will have received a great impetus and will without doubt soon take its proper place as a recognized and valuable California industry.

Industrial Representation in the Standard Oil Co.*

By Clarence J. Hicks†

THE labor policy of the Standard Oil Co. (New Jersey) is founded first of all on paying at least the prevailing scale of wages in the community; on the 8-hr. day, with time and one-half for overtime; one day's rest in seven; sanitary and up-to-date working conditions; just treatment assured each employee; payment of accident benefits beyond the amount prescribed by the state compensation law; health supervision by a competent medical staff; payment of sickness benefits after one year's service; co-operation with employee in promoting thrift and better social and housing conditions; and assurance for a generous annuity at the age of sixty-five, guaranteed for life after twenty years of service. Most of these features have been a part of the company's policy for many years, but it is only during the past two years that the co-operation of employees in determining these matters has been definitely assured through industrial representation.

Principle of Industrial Representation

Industrial representation, in the Standard Oil Co., is a principle rather than a procedure. It is built upon the belief that personal association of those interested in any problem leads to a mutual understanding and a fair decision as to what is right. Fully believing in this principle, representatives of employees and representatives of management evolved a simple plan, the basis of which is that it gives every individual employee representation at joint conferences on problems and fundamental principles affecting all those interested in the industry. It is based on co-operation, not antagonism; its operation makes perfectly clear both

Copyright, 1920, by the American Institute of Mining and Metallurgical Engineers, Inc.

*A paper to be presented at the Lake Superior meeting of the American Institute of Mining and Metallurgical Engineers, August, 1920.

†Executive Assistant to the President, Standard Oil Co. (N. J.).

to management and to employees that their interests are identical, that mutual understanding and co-operation insure progress and success for all. Furthermore, experience has definitely shown that representatives of the employees are not only alert for the employees' interests but are as keen as the representatives of the management in determining and insisting upon fairness to the employer.

Though the plan has been in operation nearly two years, it is an experiment, in that, being based on a principle rather than on cut-and-dried formulas of procedure, it is still subject to change and improvement. It has proved to be equally applicable in a refinery, where thousands of men are assembled, and in the sales department and producing field, where men are scattered in small groups over a wide territory. It is also in operation in several subsidiary companies. This adjustment to diverse conditions is possible because hard-and-fast rules were avoided in the belief that the human element must play an important part. Therefore the plan, to a large extent, has been permitted to build itself through experience and trial.

Co-operative Plan of Employers and Employees

The plan was brought into operation by an invitation to employees to co-operate in maintaining the company's established policy for fair treatment in matters pertaining to wages and working conditions. This invitation outlined a simple method by which the employees, by secret ballot, might elect from their own number men in whom they had confidence to represent them in conference with representatives of the management.

At the first joint conference a brief plan or agreement was evolved, which provided that adjustment of wages, including matters affecting working hours and working conditions, shall be made in joint conference between the employees' elected representatives in the division affected and the reprsentatives of the company. From the beginning, the plan stipulated that no discrimination shall be made by the company or its employees against any employee on account of membership or non-membership in any church, society, fraternity or union. Agreement was made as to offences for which employees may be dismissed without notice and also as to the offences for which an employee should be warned or suspended. Further, each employee was guaranteed recourse against unjust treatment or unfair conditions by means of a definitely prescribed method through which he, personally, or his representative may appeal his case to joint conferences of employees' and management's representatives and, if necessary, up to the highest officers of the company.

Joint Division and Joint Works Conferences

The joint works (or plant) conferences are held at regular intervals to consider all questions relating to wages, hours of employment, working conditions, and any other matters of mutual interest that have not been satisfactorily settled in the joint division conferences. These joint division conferences meet whenever needed to discuss and adjust matters within the smaller confines of a division. Many problems never go beyond the joint division conference, unless the problem develops into one that concerns other divisions. In case any matters were to come up on which the joint works conference could not agree, they would be referred to the board of directors for final decision. But as yet not one case has been referred in this manner. The decisions of the joint works conference, when they involve serious matters, such as a general increase in wages, are subject to the approval of the board of directors.

Basis of Representation for Employers and Employees

At the inception of the plan, a basis of representation was determined upon that would allow one employees' representative to be elected by approximately 150 employees, with provision for a minimum of two employees' representatives from each division. In extending the plan to other departments of the company, such as the producing field and a refinery where fewer employees are required, this basis was amended to meet conditions obtaining in that field. On this point two essentials must be kept in mind: First, that an elected representative must not have more constituents than he can easily keep in touch with; second, that the joint conferences must not be so large as to be unwieldy at times when important discussion and decisions must be had. Experience has shown that there are many advantages to be gained by personal contact of employees' representatives and management's representatives, and therefore full joint conferences are preferable to numerous smaller subcommittees.

Other Protective Methods for Employees Maintained Solely by the Employer's Funds

Entirely apart from the industrial representation plan, but equally established as a policy in the Standard Oil Co., is a method of protection for employees and their families. This is attained in several ways: Group life insurance covering, at the company's expense, every employee after one year's service, affords some financial resources to dependents in case of death of an employee—a provision that was greatly appreciated during the influenza epidemic of 1918-19. There is a fully equipped and competently manned medical department to look after the health of all employees; and there is provision for half pay during a period of sickness. An annuity plan provides for employees who retire after twenty years of service or who are incapacitated after even shorter service. These forms of financial security are considered by the company as being good business and therefore are maintained solely by the company's funds, not by either voluntary or involuntary assessments on the employees.

Training Employees to Assure Opportunity for Advancement

The company is committed to a policy of training for employees as a means of assuring, to each one who desires, an opportunity for fair advancement to greater responsibilities. The administration of training is co-ordinated with other personnel functions, such as selection of new employees, transfers and promotions. Thus each employee not only has the feeling of security in his position and his earnings but also knows that the company is ready to help fit him for advancement to any position within his capacity.

Contemporary Foreign Opinion on Sulphur and Phosphorus in Steels

During a Trip to English and French Metallurgical Centers, Opinions Were Canvassed as to How Moderate Increases in Sulphur and Phosphorus Would Influence Laboratory Tests and Service Performance of Such Steels

By HENRY S. RAWDON
Physicist, Bureau of Standards

In connection with the joint investigation now under way in America on the limits of sulphur and phosphorus in steel, a trip was made to England and France to consult the opinion of metallurgists, and of users of steels. An examination of available specifications, especially for railway steels, was made, and inquiry as to results of metal made and put into use under rather lax war-time specifications.

French Specifications

Inasmuch as French specifications for steels and similar metals are based on the foundation principle of mechanical properties, it is extremely difficult to obtain data and opinions offhand strictly applicable to problems arising in the consideration of specifications in accordance with American metallurgical practice. In specifying steels the criteria for acceptance or rejection are the mechanical properties. Chemical composition is regarded only as an index of the probable mechanical properties rather than as a characteristic of the material itself, and for this reason composition does not appear in French metallurgical specifications.

Consequently it was impossible to collect any experimental data from French metallurgical practice bearing directly upon the question of suitable limits for sulphur and phosphorus in steel. The discussion of the question was avoided, the reason given being that mechanical tests if properly conducted and interpreted will tell everything which is needed to be known, e.g., the results of shock tests will give good indications as to the phosphorus content, while the effects of sulphur may be gaged by "hot" and "cold" bends.

An official commission under the leadership of Le Chatelier and Guillet is now studying and codifying specifications for all materials of construction, but their work doubtless will not introduce a rigid adherence to chemical analysis. It is believed, however, that when the work of testing the various types of steel which are to be made has been carried far enough to warrant some conclusion being drawn, the information contained in the French specifications will be of value in showing to what extent the composition of the steels may be varied with respect to its sulphur and phosphorus content and still meet them satisfactorily. They may also offer some suggestions as to suitable tests to be made upon certain special products.

French Metallurgical Opinion

The following was formulated as the general opinion concerning the Bureau's program in the sulphur-phosphorus investigation after consultation with prominent French metallurgists:

Tension tests will tell but little concerning the effect of sulphur and phosphorus in the small amounts allowed, particularly if all the specimens are to be cut longitudinally from the steel. Sulphur as manganese sulphide in particular has its greatest effect in reducing the *transverse* strength of steel. Dynamic tests should also be made; in particular, impact or shock tests. It is in this respect that phosphorus has its pronounced effect.

All agreed that a preliminary examination should be made to determine to what extent segregation had taken place; this examination was ranked as of prime importance and a steel, e.g., of 0.07 per cent sulphur, if unsegregated, was mentioned as being preferable to one of 0.04 per cent S if pronouncedly segregated.

Regarding rivets of high sulphur content, the opinion was held that if the material can be worked to the shape of rivets satisfactorily, no trouble will be experienced in the later processes of riveting nor could any reason be given why material as high as 0.07 per cent sulphur should not behave as satisfactorily in service as steel of 0.05 per cent sulphur.

French Railway Material

Great emphasis was placed by railroad engineers upon the preliminary metallographic examination for the purpose of revealing unsoundness and segregation. Although the material which has been put into service on the railways of France during the past few years has in many cases been far below the former standards, still no reliable data are available regarding its behavior. The conditions of service have been so severe and unprecedented that every bit of metal has been worked to the limit and removed either because of failure or wearing out. It is therefore not possible to express any reliable opinion as to its suitability for the service it was intended to stand.

In general, the French were of the opinion that American specifications for sulphur and phosphorus are too stringent and if care was taken to have uniform distribution of these elements in the material, it would be found that a steel of 0.07 per cent sulphur as compared with 0.05 per cent sulphur would meet all the required specifications as to mechanical properties and be suitable for use.

Ideas of English Metallurgists

In England, as in France, but little experimental data bearing on the subject of the influence of sulphur and phosphorus were available and it was necessary to depend upon the opinions of those consulted. A research of value and interest in this connection is one that is being undertaken by the aëronautic section of the British Engineering Standards Association. In order to determine the effects of sulphur and phosphorus up to the prescribed war-time specification limits on cold-drawn carbon-steel tubing such as is used in airplane

construction, a series of ingots of steel of special phosphorus and sulphur content are to be obtained and then worked down into the form of tube and sheet and the product thoroughly tested. It is planned to collect ingots made under war-time conditions, of three sulphur contents up as high as 0.07 per cent (viz., 0.03, 0.05 and 0.07 per cent), with a high and low phosphorus content in each case. Later it is hoped that other types of steel entering into airplane construction will be investigated in a similar way. The fact that this research is being carried out along exactly the same lines as the one planned in the United States is evidence of the lack of available experimental data in English metallurgical practice from which a solution of the problem might be made.

On account of the larger number of metallurgists consulted in England a greater difference of opinion concerning the effects of sulphur and phosphorus upon steel was expressed than was the case with the French metallurgists. The following opinions concerning the program of the research outlined by the Bureau of Standards and its associates were expressed by nearly all consulted:

Opinions Concerning the Research Program

The tests to be made should be of two general types, first, upon the behavior of the material during fabrication and second, mechanical tests upon the fabricated material. Tension tests should not be depended upon to differentiate the effects of sulphur in varying amounts no higher than those laid down in the program. The transverse tension test will be found much more useful. The opinion was held by some, however, that the difference between longitudinal and transverse tensile strength which exists in steel of normal sulphur content is often of sufficient magnitude to mask entirely any additional effect due to a higher content of sulphur. The importance of dynamic tests, particularly some form of impact test, was emphasized as well as the simple bend test.

The opinion was expressed by nearly all that if it were possible to form rivets satisfactorily from steel of rather high sulphur content they would behave satisfactorily during the riveting. A test suggested by several as useful in this case was a cold-heading process to determine the effect of the sulphur.

The importance of the examination to determine how uniformly the sulphur and other metalloids are distributed throughout the steel was emphasized strongly by all and the statement made that it would probably be found that in order to be absolutely safe it will be necessary to penalize a considerable amount of good material on account of occasional bad specimens due to segregation.

In regard to the general subject of necessary tests, one very eminent metallurgist said that no matter how many laboratory tests were made and how carefully they were carried out there is no way of translating the results obtained into service. The suggestion was made that in each case a comprehensive series of service tests should be made and that until the results of such service tests were available it would be unwise to change specifications which were known to be safe. In other words the wide margin of safety obtained with rather rigid specifications is a much wiser policy than an uncertainty due to new specifications which had not been fully and thoroughly tried out in practice.

Regarding the method of adding sulphur in making up the heats of special composition, all consulted were of the opinion that the sulphur should be added during the melting (preferably as iron sulphide) rather than at the end of the process. Phosphorus may be easily obtained from high-phosphorus pig iron; the use of screw stock high in sulphur and phosphorus is admirable for addition purposes in those heats in which a considerable amount of both sulphur and phosphorus is desired. It is essential, however, that the effect of each element be investigated alone before the more complicated case of the two combined be taken up.

It was thought that this difference existed between "residual" and added impurities: Residual impurities are more uniformly distributed throughout the finished steel, while added sulphur, for instance, may exist in considerable amount as ferrous sulphide and hence is apt to be more detrimental in its effects upon the properties of hot metal.

None of the men consulted would agree to the contention that within certain limits sulphur and phosphorus are not decidedly detrimental in themselves but are only indicators of some other undesirable condition. All were of the opinion that both sulphur and phosphorus had a characteristic effect upon the mechanical properties of the steel in which they occur, although such effects may be augmented by other undesirable conditions which may accompany amounts somewhat above the usual percentage. Such undesirable conditions may possibly consist, for example, in incomplete deoxidation or in the nature and distribution of the slag, more of it being retained by the metal. In general, however, most of the men consulted stated that they could not readily visualize and describe these concomitant conditions and were inclined to consider the matter worthy of very little consideration.

One important point brought out by a keen student of the question was that the simultaneous effect of carbon and phosphorus should be taken into account in the case of high-phosphorus steels. The hardening effect of phosphorus is much augmented by that of carbon, both elements affect the material in the same direction. In a low-carbon steel a rather high-phosphorus content can be used with safety, while the same amount in a high-carbon steel such as spring steel would be viewed with suspicion and alarm.

Among special tests mentioned as probably necessary for some products was a determination of the effect of high sulphur (and phosphorus) upon the corrodibility of the metal. This was mentioned as being of grave importance in the case of boiler tubes and other materials subjected to similar conditions.

Divergent Views of English Manufacturers

Opinions held by representatives of different steel manufacturers on the subject of the effect of sulphur and phosphorus differed radically. The extreme view taken by one Sheffield firm was that they were convinced as a result of their war experience that a sulphur content as high as 0.07 per cent was entirely safe provided the steel was "properly controlled in the melting and pouring." Thousands of airplane crank shafts were made by this company during the progress of the war with a sulphur content as high as 0.07 per cent. It was claimed that there was no evidence that any of these had ever failed in service because of the higher sulphur content, although it is undoubtedly true that such ma-

terial is as severely stressed in service as anything in the entire engineering field. The stand is taken that sulphide of manganese is no more detrimental in its effects upon steel than are other inclusions and should be regarded in the same light.

The other extreme was held by another company in the same region, that anything that breaks up the continuity of the metal is to be regarded as detrimental to the steel and that the effort should be to produce steel which is as pure as possible in this respect. Hence sulphur should be maintained as low as possible in amount. The representatives of this company were quite frank in saying that they expected very little from the research that the Bureau has under way.

Most of the manufacturers, however, take an intermediate stand. Provided there is but little segregation and the metal is uniform in composition (special ingot types were recommended by some as being a desirable feature of the research on sulphur and phosphorus for this reason), the sulphur and phosphorus can be safely raised to a percentage of 0.07. By some this figure was placed still higher, 0.08 to 0.09, "depending upon the manufacturer who made the steel."

The suggestion has been offered by a few that the manganese content should be taken into account, particularly in those steels of high sulphur content. Most of the steel men, however, thought that for the range of sulphur content under investigation this was a refinement that would be beyond the control of the furnace man in making up his charge.

Sulphur and Phosphorus in Railway Materials

Although a considerable difference of opinion exists among users of this type of steel, it may be stated that the general tendency of the railways is to get back to the pre-war specifications as quickly as possible. Although it was necessary to relax the specification limits considerably during war time, the step was taken by the railway officials only with the understanding that the responsibility for anything arising from the use of such untried material should be assumed by the government.

It is felt that since the war-time experience with the newer material has been made under such unusual conditions of service, together with the fact that complete records of such materials were not made, there is no warrant for the continued use of this type of material. They are interested in obtaining material which they have found by experience to be entirely safe and claim to be finding no difficulty in obtaining it. It may be noted that in some cases the material used is not as closely specified in respect to sulphur as the present British Engineering Standards specifications call for. Locomotive crank axles, for example, are allowed 0.04 per cent sulphur by the specifications of the Midland Ry., while 0.035 is the amount allowed by the B. E. S. specifications. In general, the stand taken by the users of railway materials in England appears to be that the upheaval which occurred has not shaken their faith in their old specifications.

Summary and Conclusions

1. But very little data strictly applicable to the present research on sulphur and phosphorus in steel were obtainable in either England or France. This is partly accounted for by the different basis used abroad in drawing up specifications for metals.

2. A research conducted along exactly the same lines is now being carried out by the British Engineering Standards Association to determine the effect of sulphur upon a certain type of steel product. The inference to be drawn is very evident—there are no data available for settling the question, but direct experimental evidence must be resorted to.

3. The much-used tension test is to be regarded as only a start in the mechanical testing necessary for determining the effects of varying amounts of sulphur and phosphorus upon steels. Dynamic tests should be given full consideration as well as tests which will show the properties of the metal in a transverse as well as in the longitudinal direction. The behavior of the material during fabrication should be regarded as one line of testing of equal importance with mechanical tests on the finished metal.

4. The necessity of extensive service tests was emphasized, since no matter how many laboratory tests are carried out there is no way of interpreting such tests in terms of ordinary service.

5. The opinions expressed by manufacturing metallurgists differ very widely as to permissible limits for sulphur, diametrically opposing views being taken.

6. Regarding the method for obtaining suitable sulphur and phosphorus contents in experimental heats to be made, the general opinion appeared to be that the additions should be made during the heat and not at its close. Regarding the subject of "residual" vs. "added" sulphur, the general opinion was held that the difference consisted largely in the physical condition of the two and no *clear, definite* expression of opinion could be obtained as to the possible detrimental effect of some obscure condition accompanying high percentages of sulphur and phosphorus.

7. The general tendency of the English railways is to revert to the pre-war specifications for ordering materials. No such generalization can be made regarding the French practice, on account of the greater effect that the war had upon the systems as well as the fact that at the present time all specifications are being reviewed and unified by a national commission appointed for this purpose.

Meeting of Electric Furnace Association

Definite plans have now been made for the meeting of the Electric Furnace Association in Boston. The business meeting and election of officers will be held at the Copley-Plaza Hotel at 1 p.m. on Thursday, April 8, and will be combined with a luncheon. At 2 p.m. there will be a general meeting, also at the Copley-Plaza, which will be open to all who are interested in the electric furnace industry. The subject of the discussion will be "Adequately Trained Men an Urgent Need of the Electric Furnace Industry." This subject has been chosen at the instance of a number of electric furnace operators. Papers have been prepared by makers of furnaces and equipment and by electric steel manufacturers. A number of engineering institutions will also discuss what they are doing to train men for metallurgical work.

On Friday, April 9, the Association will join with the American Institute of Electrical Engineers and the American Electrochemical Society in their discussions on "Electrically Produced Alloys" and "Power for Electrochemical Purposes." During the afternoon all three organizations will probably make a trip to the plant of the General Electric Co. at Lynn.

The Physical Condition of Workmen

By Chesla C. Sherlock

COMPENSATION is ordinarily payable to workmen who have been injured through accidents which arise in the course of the employment, as well as out of it. If the workman dies as a result of his injury, the compensation is payable to his dependents.

All workmen, unfortunately, are not of the same physical condition at the time of their injury. A slight strain that would not affect a normally healthy man in the slightest may cause the death of a workman suffering from heart trouble.

The question naturally comes to every employer, at some time or other, whether the law intends to hold him liable for the physical condition of his workmen in a compensation way. Is the employer entitled to charge off the pre-existing condition of the workman?

Here we have a workman who has served his employer through long years at heavy labor. In the course of time, he is unable to continue at work; he is like an old broken down horse; he has suffered a cardiac breakdown which absolutely prevents him "carrying on." Is he entitled to compensation?

Instances Cited

In another instance, a workman may be suffering from heart trouble. He has been warned by his physician not to do any lifting and to be very careful as to the sort of work he does. But in the struggle for a livelihood he takes a job at lifting and conceals from his employer the facts in his case. To the employer he is apparently able-bodied and capable of carrying on the work. A few days after he goes to work, the strain is too much for his weakened heart, and he dies. Is he entitled to compensation?

In another case, a workman may apparently be in fine health and spirits. He has been concealing a hernia from his fellows, fearing that if it were known he would be discharged. In the course of his work, he is called upon to do some lifting which would not in any way affect a normally healthy man, but in his case it strangulates his hernia and he dies before relief can be secured. Is he entitled to compensation?

Or, and this case is not so visionary as it might seem, suppose that a workman is unable to get up on "high places." He is required to wash windows or repair roofs and, finding himself on the high spot, suffers a faint spell, falls and injures himself, or because of his weakened heart has an attack of heart failure and dies. Is he entitled to compensation?

I might enumerate many other instances such as these, but that is unnecessary. What the employers want to know is the law and the basis upon which the courts and commissions arrive at their decisions.

The General Established Rule

The question of pre-existing condition is one of the hardest that ever confronted the courts under the compensation system. A general rule has finally been established which is, I think, generally accepted as being a happy solution of the problem.

The underlying principle of the compensation acts, it will be recalled, is that since the workman has, during his productive years, added something to the wealth of society, society should compensate him (share his loss) when industry robs him of his earning capacity. This is a great, humane principle, and as near a socialistic principle as you will find supported anywhere by the law.

If the physical condition of a workman was to be taken into consideration, it would be possible for the employer to defeat the very purpose of this principle, in many cases, by using the workman up to the point where he develops, or is about to develop, incapacity or predisposition to injury or disease, then discharge him and prevent him obtaining compensation. It would further operate to close the doors of industry to this man so that he could not obtain employment elsewhere, for no employer would be willing to run the risk of employing the fellow, under the circumstances, and having him "die on his hands."

It would mean that employers would have to take physical examinations of their workmen at regular intervals, especially in first employing them, in order to protect their own interests. This would not only add a burden to the cost of labor turnover and management but it would operate to destroy the effectiveness of the compensation acts, except in clear-cut cases of injury by accident.

Attitude of the Courts

The courts were fortunate in early seeing the matter in this light. They said that it is unfortunate if an employer employs a man who is predisposed to injury or disease, because of impaired physical vigor, but the law cannot take any affirmative action in the matter. If the man employed is sufficiently able-bodied to be hired by the employer, then the employer cannot be heard to come into court when subsequent events disclose that the workman suffered from pre-disposition to injury or disease and whine about his tough luck. To permit this would be to destroy the very underlying principle upon which the compensation system rests.

And so we find the courts saying that compensation is not necessarily barred because a claimant suffered from an impaired physical condition which rendered him more susceptible to injury than a normally healthy man.

It must be remembered, however, that the right to compensation is based upon an injury by accident arising out of and in the course of the employment. If the workman is doing something which produces an accidental happening injuring or incapacitating him, however slight it may be, he is entitled to compensation regardless of his pre-existing physical condition.

But as an English court has said: "No compensation is recoverable for incapacity caused by cardiac breakdown which was not due to any sudden strain, but was the natural result of the workman continuing to do work which was too heavy for him."

The rule is stated in this country that if the workman was doing his ordinary work in the ordinary way and something happened causing him to die or become incapacitated, he cannot receive compensation, as the injury clearly arose out of his impaired physical condition, there being no fortuitous event at the time indicating that it arose by accident out of and in the course of the employment.

It is a general rule that if, at the time of the accidental injury, the workman was capable of performing the work of an able-bodied man *in that employment*, pre-existing conditions cannot be successfully pleaded in bar of compensation.

Legal Notes

By Wellington Gustin

Duties and Liabilities Where Wrong Products Are Delivered—Express and Implied Warranties

Some very workable points in law are involved in the case of Samuel and others against the Delaware River Steel Co., recently decided in the Supreme Court of Pennsylvania. (107 A., 700.)

It appears that the steel company purchased two carloads of "roll scale" from plaintiffs, who are brokers in steel and iron products at Philadelphia, to be delivered to defendant at Chester, Pa. Plaintiffs purchased the roll scale from the Lebanon Valley Iron & Steel Co. and ordered shipment made directly to defendant's mill. The defendant claimed that upon unloading the material it was found one of the cars contained largely "mill cinder," a product of less value than roll scale. However, the entire shipment was used within the day following delivery. A week later a formal written complaint was made by defendant saying that the material in one of the two cars consisted approximately of 75 per cent cinder and 25 per cent roll scale, and that it would expect the bill to be rendered on that basis. Later defendant proposed to pay the market price of cinder, and this offer was refused by plaintiffs, who contended that the product delivered was roll cinder, and further that even if it were not such product, by accepting and using the car before making complaint defendant waived the right to object that it was not the article ordered.

This became the issue in the case. The trial judge submitted to the jury the question whether the material delivered was roll scale or mill cinder, with the further instruction that if it found it was mill cinder, to determine whether it was practicable for the defendant to have offered to return the product, and that if mill cinder was delivered, if defendant discovered the fact before it was used, there should have been an offer to return, and in absence of such offer defendant would be liable for the contract price. On this the plaintiff was given a verdict by the jury for the difference between the amount paid by defendant and the price of roll scale. Now, this trial court held that it was the duty of the defendant to notify the plaintiff, upon discovery that the product received was not "roll scale," and before using same.

On appeal to the Superior Court the judgment was reversed, because it held that the proposition of law laid down above was error. However, in reversing this, the court directed the entry of judgment for defendant, and from this judgment an appeal was made to the Supreme Court.

Implied Warranty, Like the Express Warranty, Survives Acceptance

This last court said it was well established that, in the sale of a chattel by sample or description, an implied warranty attaches that the article shall be of the kind ordered.

Now, where there is an express warranty the general rule is that it survives acceptance of the goods, and the purchaser may thereafter sue for the breach of said warranty, or may set off damages for such breach in an action brought by plaintiff for the purchase price of the goods.

And now the question is whether the implied warranty, that the material was of the kind ordered, was also one which survived the acceptance and use of the material without previous notice to the plaintiffs. Said the court, there was considerable conflict of opinion in the authorities, but the greater weight in courts of other states was that the implied warranty, like the express warranty, survives acceptance, even though the defects were known at the time the commodity was accepted and used. And so the court held. Notice to plaintiff before use was unnecessary.

However, it found that the Superior Court also fell into error in directing judgment for defendant in that plaintiff's evidence that the material furnished was roll scale, though contradicted by defendant's evidence that it was mill cinder, made a question for the jury to decide.

Hence it was ordered that a new trial be had to determine that question.

International Forge Co. Judgment Affirmed by Pennsylvania Supreme Court

In the case of the International Forge Co., Inc., against Paul S. Reeves & Co., Inc., to recover the value of certain lost metal, the judgment for plaintiff for $2,146.35 has been affirmed in the Supreme Court of Pennsylvania. (107 Atl., 837.)

The Reeves company had entered into a written contract with the plaintiff, the International Forge Co., to manufacture castings out of materials to be furnished by it. This contract provided that the Reeves company should "stand all metal losses," and this action was brought to recover the value of lost metals furnished to it.

There were originally two assignments of error given as reasons for asking a reversal of the judgment. The first was withdrawn and the second was not supported by proper complaint. Hence the judgment was affirmed.

Liability for Guaranteed Analyses

The constitutionality of the Florida laws regulating the sale of fertilizer was recently presented to the Supreme Court of Florida in the case of Adams against the American Agricultural Chemical Co. The plaintiff had entered suit against the defendant company, alleging that the defendant, being engaged in the business of handling and selling commercial fertilizers, sold to him fertilizers bearing a stated guaranteed analysis, and that upon an analysis made by the state chemist, it was discovered that plaintiff had been defrauded by reason of deficiencies of constituent elements in the fertilizer, and the plaintiff claimed double the price of the fertilizer as his damages, as provided by statute. Among other grounds, the chemical company defended on the contention that the sections of the statutes as named above were unconstitutional, for the reason that their effect is to deprive fertilizer manufacturers and dealers of their property without due process of law.

Provisions of the Statute

The first section of the statute referred to provides for an analysis of the fertilizer purchased, by the Commissioner of Agriculture, and the second permits a recovery of twice the amount paid for the fertilizer. The last-named section contains this provision: "In case any purchase be made of any manufacturer or agent of any person or persons residing out of the State of Florida, manufacturing, compounding or furnishing

for sale any such commercial manure or manufactured fertilizer, cottonseed meal, castor pomace, tobacco stems, tobacco dust or tobacco meal, the purchaser thereof may, at his option, proceed by attachment, as now provided by law in case of non-resident and absconding debtors, against any such property, rights or credits of any person or persons selling, manufacturing, compounding or furnishing said manures or fertilizers when such property, rights or credits can be found within the limits of the state."

DICTUM OF THE COURT

Passing upon the question involved, the Supreme Court said in effect (82 So., 850): "Section 1,272, General Statutes of Florida, gives 'to any person purchasing any fertilizer or fertilizing materials from any manufacturer or vendor who shall . . . discover that he had been defrauded by reason of adulteration or deficiencies of constituent elements, . . . in the fertilizing material so purchased,' a right of action against the manufacturer or vendor, and the right thereby given is not limited to those who discover such fraud 'upon an analysis by the state chemist.'

"Section 1,271 . . . provides a method by which the user of fertilizer, if he be a citizen of this state, may determine whether his fertilizer measures up to the guaranteed analysis, and allows him to use the certificate of the state chemist as prima facie evidence in any suit brought under section 1,272; but such certificate, while competent, is by no means exclusive evidence as to the real analysis, the state chemist being subject to the ordinary rules of cross-examination and contradiction.

"The cause of action given by section 1,272 lies in fraud, and the declaration should be based upon the fact of the fraud, and not upon the analysis by the state chemist; such analysis being evidence only of the real cause of action, to wit, fraud.

"The primary purpose of section 1,272 is to afford compensation to the purchaser and user of fertilizer for his probable, though uncertain, loss resulting from the use of inferior fertilizer. The measure of recovery is in the nature of liquidated damages.

"Sections 1,271 and 1,272, General Statutes of Florida, do not appear, from the facts presented, to deprive the defendant of property without due process of law, nor to deny to it (a corporation) the equal protection of the law, contrary to the state or Federal Constitution.

"The requirements of due process of law and of equal protection of the laws are satisfied if there is no unauthorized and merely arbitrary exercise of the powers of government, to the detriment of the people, or some of them; and inasmuch as the statutory damages of double the price paid for the fertilizer are not shown to be unjust, unreasonable, nor arbitrary in this case, and inasmuch as the statute applies alike to 'any manufacturer or vendor' of fertilizer, the constitutional rights of the defendant do not appear to have been violated.

"A corporation is not a 'citizen,' within the 'privileges and immunities' provisions of the Federal Constitution.

"One who is not himself denied some constitutional right or privilege cannot be heard to raise constitutional questions on behalf of some other person, who may at some future time be affected."

Therefore the judgment of the trial court in favor of the chemical company, which had contended the statutes were unconstitutional and void, was reversed.

Air Conditioning Prevents Explosions Ignited by Static Electricity

ONE of the three principal dangers of factories where quantities of chemicals are being handled is that of explosion due to chance sparks from static discharges, and this is one of the most subtle (because frequently untraceable) causes of such accidents. Oftentimes such explosions result disastrously, and case after case remains, in its origin, a mystery, the safety engineers of the factory not being able to determine beyond doubt the direct cause, because of some hidden and unusual static cause, a "freak"—and freaks are something to which static discharges are very liable.

Of serious consequence is the low relative humidity in the winter, when the possibility of static discharge is greatly increased.

The safest way to prevent such explosions, due to the ignition of mixtures of combustible vapors and air, is in the use of all reasonable precautions, and then an air-conditioning system which eliminates dangerous atmospheric conditions. Properly-conditioned air is "climate made to order." It means air that is sufficiently moist to cause the air to become a good conductor and carry away the charge as formed, and prevent it building up a sufficient potential to form a spark. Dust particles, being moistened in this way, tend to fall to the floor, rather than float in air currents. But the air must be sufficiently dry so that chemical work may be carried on entirely free of all risk that hydroscopic materials will absorb moisture.

According to the B. F. Sturtevant Co., of Boston, specialist in air conditioning, the field of chemistry and metallurgy has furnished one of the most severe tests of the application of air conditioning which could be imagined. That it has emerged from this test with ample proof of its value and advantages not possible in any other way has been established in all cases and under a great variety of conditions. To quote the Sturtevant company:

"The exact nature of the work done in the chemical laboratory, manufactory, dye house and mixing room calls for minute care in temperature and humidity, if ideal results are to be realized. This is more or less of a truism, but even now all concerns do not fully recognize the important part that atmospheric conditions play in the rate of production.

"When important work is in process, calling for the combination of chemicals under certain definite conditions, a degree one way or the other may mean all the difference between success and failure. Or it may possibly be the means of a disastrous explosion, as was the case some time ago with a large plant which was completely destroyed, due to a chance frictional spark caused, possibly, by a too-high static condition in the atmosphere. With proper air conditioning, chemical processes and combinations involving the handling sometimes of highly hydroscopic materials are performed under ideal conditions, assuring maximum success in results. Where moderate temperature is required, where humidity must be accurately regulated and maintained, where weather conditions cannot be allowed to interfere with difficult and costly work, there air conditioning has proved its vital usefulness in plants of every kind, all over the country."

Synopsis of Recent Chemical and Metallurgical Literature

Colloidal Clay Soap.—What is described as a revolution in soap making is the subject of a lengthy and analytical article in *Chemical Age* (London) of Jan. 17, 1920, in which the use of colloidal clay as an addition to or as an alternative for some of the customary constituents of soap is shown to possess properties of great value.

F. E. WESTON, the writer of the article, is stated to have been associated in a consultative capacity with an important industrial undertaking in connection with the utilization of colloidal clay. This clay, he states, "belongs to the general class of 'suspenoids' and is a reversible colloid, since it is possible to disperse it in water or throw it out of colloidal solution at will.

"True colloidal clay is prepared from china clay. One of the many and varied applications of colloidal clay is that of its use as an adjunct in the manufacture of soap, not as a 'filling' material or as an adulterant, but as an actual substitute for soap material."

After describing the usual constituents of soap, Mr. Weston refers to the conclusion arrived at by Spring that the concentration of soap on the surfaces of the adsorbing bodies is the chief factor in the detergent action of soap. According to Michaelis, adsorption is the greatest for those substances which produce the greatest lowering of the surface tension of a liquid when in solution in that liquid. He points out that soap dissolved in water considerably lowers the surface tension of water against air; that clay can be brought to such a highly colloidal state that it closely resembles soap in its physical behavior; and that when properly incorporated with soap it actually increases the lathering and detergent properties of the latter. "Chemically, soap and clay belong to two distinct types of compounds. Physically, however, the solutions of these bodies resemble each other closely; they both possess emulsifying power, both have the power of 'adsorbing' dirt, grease, etc., and both have detergent properties."

Incorporated with soap, the clay tends to lower the surface tension of water to a greater extent than soap itself. Experiments with high-class toilet soap and a soap made up of 80 per cent soap plus 20 per cent colloidal clay showed that the soap containing the colloidal clay lowered the surface tension 9.1 per cent and 6.9 per cent more than the pure soap, at 20 and 45 deg. C., respectively. Lathering experiments were also carried out, and the lather obtained by adding collodial clay to the soap was found to be much greater than that obtained by the soap itself; moreover, in all cases the lather was of a firmer nature and was more persistent.

Other experiments are described by Mr. Weston, and objections against the use of alkalis to increase lathering and detergent properties of soap are given, and he proceeds to state that the custom of taking, as a criterion of a soap, the percentage of fatty acids present therein will no longer hold good, "since colloidal clay contains no fatty acids," whereas the experiments show that such clay increases the lathering and detergent properties of soap. It is not asserted at present, however, that fatty acids can be entirely dispensed with, but that their present proportion can be halved. It is pointed out that colloidal chemistry "in its application to industrial problems is only just beginning to be realized"; it is a "branch of chemistry still in its infancy."

In conclusion, it should be noted that *Chemical Age* remarks: "According to Mr. Weston, the colloidal clay, which forms the subject matter of his article, is prepared by a patented colloidal process, and it would appear that many varieties of clay, both in Great Britain and in other countries, may be found amenable to the process."

Old Rails With High Internal Strains Contained No Fissures.—Significant studies of old rails were carried out recently to test the theory that transverse fissures in rails are produced by permanent strains set up by the distortion of the metal in service under rolling loads. As detailed by W. C. CUSHING, chief engineer of maintenance, Pennsylvania Lines West of Pittsburgh, in a report (No. 84) to the rail committee of the American Railway Engineering Association, a number of old rails were taken out of the track and examined for structure, internal strains, segregation, and existence of transverse fissures.

Rails that had been in service from ten to forty-five years were examined; some of the oldest were of wrought iron, others rolled from iron and steel pile, while those ten to twenty-five years old were of bessemer steel. All of them "were carefully examined for transverse fissure defects, but none were found." Nevertheless their internal strains were very high according to 10-in. strain-gage measurements which were made on various strips $\frac{1}{2}$ x $\frac{1}{8}$ in. cut from different parts of the rails.

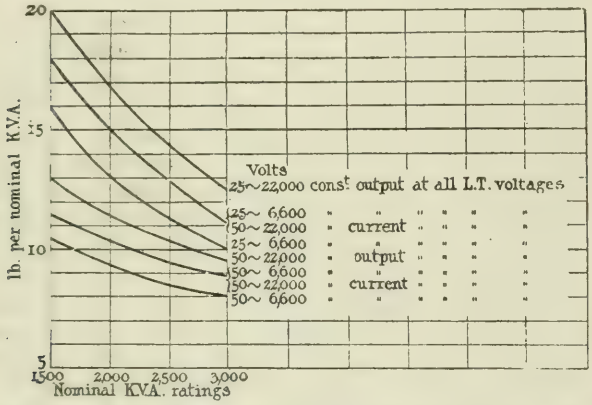
In the old wrought-iron rails, head strains corresponding to 24,000 to 27,000 lb. per sq.in. in compression were found, which appeared the more serious because the material had a low elastic limit, 26,670 to 48,760 lb. per sq.in. The piled rails showed maximum head strains of 24,000 lb. per sq.in., and the elastic limit of the material ranged from 33,700 to 53,830 lb. per sq.in. Still higher internal strains, however, were found in steel rails that had been in service twenty to twenty-five years, several measurements of 36,000 and 33,000 lb. per sq.in. being made, as against elastic limits of 46,500 to 58,450 lb. per sq.in. These high values of permanent strain were measured at the surface of the head and on the side opposite the gage side, in nearly every case. One abnormal result was a reading of 57,000 lb. per sq.in., tensile stress, in the flange of an 85-lb. rail that had been in service from 1898 to 1917; Mr. Cushing calls this "extraordinary and inexplicable."

Segregation was rather high, particularly in the rails exhibiting the highest internal strains, and at the same time these rails showed low elastic-limit load in the quick-bend test (though not in tests in direct tension). Mr. Cushing concludes:

"If severity of service, especially by exceedingly heavy wheel loads, be the sole cause of the defect known as transverse fissure, these rails, after their unusually long service, and in some of the cases under the heaviest wheel loads in use, would be sure to be filled with transverse fissures. That such was proved by careful examination not to be the fact, that rails adjacent to and undergoing precisely the same conditions of serv-

ice as those in which transverse fissures have been found do not have any, and that rails never put into service as well as those which have been in service have been shown by Waring and Wickhorst to contain microscopical cracks, seems to prove beyond a doubt that the cause, the real cause, of transverse fissures must be sought in the process of manufacture. The wheel loads are the instruments of development from the initial defect, and it is true that the service has become uncommonly severe."

Transformers for Electric Furnaces.—J. L. THOMSON gives in the London *Electrician* of Jan. 30 and Feb. 6 a comprehensive discussion of the present and future status of transformers for electric furnace work. The author states that at the present time electric steel furnaces have been designed for capacities of fifteen tons and that the future will demand larger sizes up to thirty or forty tons. Assuming that 200 kva. is required per ton, transformer groups of 6,000 to 8,000 kva. will be required. While transformers of larger capacities have been designed, this particular problem is complicated by the low voltage and heavy currents required. The writer then deals with the design of the furnace with special regard to the heavy magnetic fields involved, the


20
15
10
5
lb. per nominal KVA.
Volts
25~22,000 const. output at all L.T. voltages
25~ 6,600 " " " " " "
50~22,000 " current " " " "
25~ 6,600 " " " " " "
50~22,000 " output " " " "
50~ 6,600 " " " " " "
50~22,000 " current " " " "
50~ 6,600 " " " " " "
1500 2,000 2,500 3,000
Nominal KVA. ratings

APPROXIMATE WEIGHT OF FURNACE TRANSFORMERS

mechanical stresses and furnace layout. He states that in order to reduce the possibility of a heavy choking effect and unbalanced voltages, the following suggestions may be useful: (1) Transformers should be placed as near to the furnace as possible, so that heavy low-voltage leads may be of minimum length. (2) Low-voltage leads of the various phases should be symmetrically placed with respect to transformers and furnace. (3) The area between positive and negative low-voltage leads should be as small as possible and also that between phases so that inductance may be a minimum. (4) Low-voltage leads for heavy currents (above 5,000 amp.) should be in multiple and interleaved from the transformer to a point as near the furnace as possible. This will keep the inductance low and make that of each lead approximately the same, thus insuring that each parallel lead takes its proper share of the load. (5) Heavy current leads should not be run near any heavy magnetic structure such as girders or supporting columns unless both the positive and the negative leads are run together and interleaved. (6) No magnetic material should form a closed circuit around any positive or negative conductor, or heavy currents will be induced in that circuit. The positive and negative conductors interleaved may be run through a magnetic circuit. Clamps for heavy-current leads should be of non-magnetic material.

Recent Chemical and Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Camphor From Isoborneol.—Nitric acid, 600 lb., sp.gr. 1.4, is placed in a stoneware kettle provided with a stirrer, and heated to 40 deg. C. Two platinum electrodes in the form of plates (1 in. wide x 6 in. long) separated by insulating blocks are suspended in the acid. While the stirrer is at rest about 0.5 lb. of isoborneol is dropped upon the top of the immersed electrodes and a current of 1.6 volts and 30 amp. passed until the reaction has started, as shown by the evolution of red fumes. The electrodes are now removed and isoborneol added in small quantities with constant stirring until 150 lb. has been added. The temperature is held at 40 deg. C. by means of cooling coils. The camphor nitrate which floats as an oil on the surface of the weak acid is decanted and drowned in an excess of water, whereupon it breaks up to form camphor, which is washed, dried and purified by sublimation. (1,324,140; ROLAND L. ANDREAU, of Wilmington, Del., assignor to E. I. du Pont de Nemours & Co.; Dec. 9, 1919.)

Toluene From Xylene or Solvent Naphtha.—BENJAMIN T. BROOKS, of Pittsburgh, Pa., has found that the xylenes, which are of little commercial value, can be converted into toluene by a "cracking" process. Crude solvent naphtha containing 70 to 80 per cent of the three xylenes is heated with dry aluminum chloride under a reflux condenser so regulated that the toluene vapors can escape as formed, at a temperature between 105 and 115 deg. C., while the xylene vapors are returned to the still. The condensate will generally run about two-thirds toluene, one-sixth benzene and one-sixth heavy oils (xylene, etc.), and may be fractionated in a suitable still. (1,324,143; assigned, by mesne assignments, to E. I. du Pont de Nemours & Co.; Dec. 9, 1919.)

Strontium Peroxide.—When strontium oxide is heated to about 400 to 500 deg. C. with oxygen at a pressure of 1,500 to 1,800 lb. per sq.in. strontium peroxide of high test (over 85 per cent SrO_2) is formed. (1,325,043; JAMES B. PIERCE, JR., of Charleston, W. Va.; Dec. 16, 1919.)

Pyrocatechin Aldehyde.—If piperonal is treated with thonylchloride at the temperature of the water bath, a reaction takes place according to the equation:

$$R.CHO + SOCl_2 = R.CHCl_2 + SO_2 \quad (1)$$

By treating the piperonaldichloride (piperonylchloride) thus obtained with four molecules of chlorine, dichlorpiperonylchloride is formed. This compound when hydrolyzed yields pyrocatechin aldehyde, carbonic and hydrochloric acids being split off. Reaction (1) is excellently suited for the protection of the aldehyde group, so that a good yield of pyrocatechin aldehyde is obtained. (1,326,793; LUDWIG SCHMIDT, of Munich, Germany; Jan. 6, 1920.)

Hexanitrodiphenylamine.—It has previously been considered impossible to use mixed acid in the preparation of symmetrical 2.4.6.2'.4'.6'-hexanitrodiphenylamine from 2.4-dinitrodiphenylamine. The usual procedure has been to nitrate the latter compound

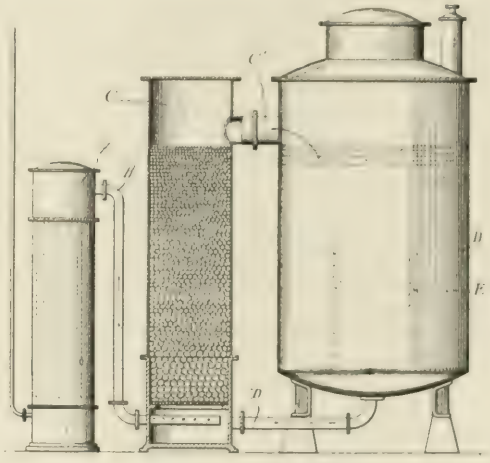
with 50 per cent nitric acid to form 2.4.2'.4'-tetranitrodiphenylamine, and to complete the nitration with 90 per cent acid. In working with such concentrations of nitric acid, the use of lead lined or enameled vessels is imperative. JOHN MARSHALL, of Swarthmore, Pa., has devised the following procedure, in which mixed nitric and sulphuric acids are used as the nitrating agent: Into an iron water-jacketed vessel provided with a stirrer is introduced one part by weight of 2.4-dinitrodiphenylamine at a temperature of about 70 deg. C., together with five parts by weight of mixed acid containing approximately 30 per cent nitric acid, 55 per cent sulphuric acid, and 15 per cent water. Thereafter the temperature is raised to from 80 to 90 deg. C., in any suitable manner, and the agitation is continued at this temperature for approximately one hour. Thereupon the mixture is cooled to 30 deg. C., and the solid 2.4.2'.4'-tetranitrodiphenylamine is separated from the spent acid by filtration. The material thus obtained, in an acid condition, is added, at 70 deg. C., to five parts by weight of mixed acids containing 20 per cent nitric acid, 75 to 80 per cent sulphuric acid and 5 to 0 per cent water in the vessel previously referred to. The mixture is then raised to 80 to 90 deg. C., and kept at this temperature for from 1 to 2 hr. The solid 2.4.6.2'.4'.6'-hexanitrodiphenylamine is separated from the spent acid by filtration, is drowned in water, and washed with hot water until freed from acid. Afterward it is centrifuged from the wash water and dried. (1,326,947; assigned to E. I. du Pont de Nemours & Co.; Jan. 6, 1920.)

Recovery of Molybdenum From Its Ores.—HENRY ALFRED DOERNER of Meriden, Conn., has developed a process whereby molybdenum may be recovered from its ores by heating to about 500 deg. C. in a stream of chlorine gas. The molybdenum is volatilized as chlorides or oxychlorides, and these may be condensed, or may be decomposed by steam or water into oxides and hydrochloric acid. By maintaining the condenser at a temperature of 200 deg. C., the hydrochloric acid may be separated from the oxides and recovered in a separate condenser. (1,329,380; Feb. 3, 1920.)

Purification of Zinc Solution. — The successful deposition of zinc by electrolysis from the sulphate solution obtained by leaching roasted zinc-bearing material with solutions containing sulphuric acid is dependent upon the production of a solution of a high order of purity and entails the elimination of such impurities as copper, cadmium, iron, arsenic, antimony, nickel and cobalt. SAMUEL FIELD of London, England, proposes to lixiviate roasted zinc ores in the presence of ozone for the purpose of preventing the formation of iron salts. This is carried on in the presence of a catalyst, for example a manganese compound, and in a warm solution (80 to 100 deg. C.). Materials suitable for treating the solution in conjunction with ozone are manganese dioxide and hydrate; lead oxide and carbonate; zinc oxide, hydrate and carbonate. The result of this treatment is that any iron present is completely precipitated as ferric hydroxide, cobalt is thrown down as a higher insoluble oxide, and with these metals any arsenic and antimony present are also thrown down. Copper, nickel and cadmium are not, however, completely removed, but traces of these metals remaining may be removed by treatment with zinc fume. (1,331,334; Feb. 17, 1920.)

Process for Producing Refractory Compounds.—As is well known, domestic magnesite does not produce a satisfactory refractory, either in the grain form or when made into brick, without the addition of a bonding material. The process of producing a refractory, similar to Austrian magnesite, which consists in pulverizing and mixing calcined magnesite with a definite amount of an iron compound (sulphate, etc.) and silica to produce a material of approximately the following composition: magnesia, 86 per cent; iron oxide, 8 per cent, and silica, 6 per cent, after the mixture has been burned at a temperature of between 1,540 and 1,750 deg. C. has been patented by WILFRED M. HANDY of Spokane, Wash. (1,330,268; Feb. 10, 1920.)

Continuous Production of Ether.—Two forms of apparatus for the continuous production of ether are described by EMILE A. BARBET of Paris, France. The accompanying figure represents one type and will serve to demonstrate the principle, which is the same in each case. Alcohol is heated in *A*, the vapors passing through *B* to the bottom of the tower *C*, which is filled with acid-proof packing material. Sulphuric acid regenerated in the second step of the process also enters



APPARATUS FOR CONTINUOUS PRODUCTION OF ETHER

the bottom of tower *C* through *D*. The alcohol vapor and sulphuric acid pass concurrently upward through tower *C*, reacting to form ethyl sulphuric acid, which overflows through *C* into the still *D*. This still is heated by the steam coil *E* and the ethyl sulphuric acid is decomposed with the production of ether and the regeneration of the sulphuric acid which passes out through *D*, thus completing the cycle. (1,328,258; assigned to E. Barbet & Fils & Cie., of Paris, France; Jan. 20, 1920.)

Synthetic Production of Cyanides and Nitrides.—Instead of forcing air through a heated mixture of carbon and alkali, AXEL R. LINDBLAD of Stockholm, Sweden, uses an electric furnace in which the air or nitrogen is sucked through the mass, thereby avoiding the necessity of heating to the reaction temperature large volumes of air which, in the former method, escape through the walls of the furnace. The cyanide volatilizes as formed and is drawn off with the exit gases. In the production of nitrides, the finished product is raked out through a discharge opening in the lower part of the furnace. (1,328,575; Jan. 20, 1920.)

Personal

M. LOUIS BOYER, representative of the firm of Gaillard, of Bezieres, France, recently visited the Burgess Laboratories, Madison, Wis.

J. A. BRETZ, chief chemist for the Bettendorf Co., Bettendorf, Pa., and president of the Chemists' Club of the Tri-Cities, is now chief chemist for the Southern Manganese Corporation at Anniston, Ala.

BRUCE K. BROWN has joined the staff of the Burgess Laboratories, Madison, Wis.

J. M. CLARK, formerly chief chemist for the Sherwin-Williams Chicago plant, is now superintendent for the Delora Smelting & Refining Co. at Delora, Ont., Canada.

LEVERETT DAVIS, consulting engineer, of Denver, Col., has been in New York on professional business.

W. M. DREW has been made manager of the Cleveland branch of Marden, Orth & Hastings Corporation, succeeding H. W. Galley.

Dr. FEDERICO GIOLITTI has sailed for Italy after a stay of several months in the United States, in the interests of his clients, G. Ansaldo Co., Stein & Co., and the Fiat Automobile Co.

Dr. JOHN CHARLES HESSLER has been appointed assistant director of the Mellon Institute of Industrial Research of the University of Pittsburgh, by Director Raymond F. Bacon. Dr. Hessler, who is now serving as president of the James Milliken University, Decatur, Ill., will enter upon his new duties at the close of the present academic year. As a member of the administrative staff of the Mellon Institute, Dr. Hessler will be in supervisory charge of certain of the researches in organic chemistry, a field in which he has specialized during the past twenty years.

G. M. HUNT, of the wood preservation section of the Forest Products Laboratory, recently gave a lecture before the Western Society of Engineers, Chicago, on the relation of the Forest Products Laboratory to the engineering profession.

Dr. DAVID KLEIN has resigned his commission as Major in the Sanitary Corps, U. S. Army, and accepted a position with Wilson & Co., Chicago, Ill.

DONALD M. LIDDELL, who has been on a professional trip in the West, has returned to New York.

JOHN L. MALM, metallurgical engineer, of Denver, Col., has been in New York on professional business.

ROBERT B. MILLER has entered upon his duties as state forester at the University of Illinois, Urbana, Ill.

R. B. RUDY, formerly consulting engineer with the Nitrate Division, Ordnance Department, has accepted a position with the Air Reduction Co., Inc., 120 Broadway, New York City.

FRANK L. SILSBEE, secretary of the National Association for the Protection of American Rights in Mexico, with headquarters in New York City, has been elected vice-president of the Federal Petroleum Co., with headquarters at Shreveport, La. He will have charge of the operations of that company in the Louisiana territory.

H. G. THIELE, formerly with the Oliver Continuous Filter Co., has accepted the position of superintendent in charge of the Boro Solvay potash plant of the Solvay Process Co., at Searles Lake, Cal.

FRED H. WAGNER has just returned from an extended trip in Europe, where he has been in the service of the Bartlett-Hayward Co., Baltimore, Md.

A. E. WHEELER has arrived in New York City after about a year's absence in England and the Belgian Congo, on work in connection with the new concentrating plant for Union Miniere du Haut Katanga.

B. B. THAYER, WILLIAM WRAITH and W. C. CAPRON expect to return early in April from Chile, where they have been inspecting the developments at the Andes mine and leaching plant.

Dr. WILLIS R. WHITNEY is to be the recipient of the Chandler medal as a recognition of his achievements in science. Dr. Whitney's subject will be "The Littlest Things of Chemistry." His lecture will be in Havemeyer Hall, Columbia University, New York City, the evening of April 27, 1920.

Obituary

ZEAR J. CHAMBERLAIN, of the Ludlow-Saylor Wire Co., St. Louis, Mo., died suddenly on March 20, in his forty-fifth year. He had been with this company since he was seventeen years old.

DIRK GEIJSBEEK MOLENAAR, of the Geijsbeek Engineering Co., Portland, Ore., died on March 11.

MELVIN B. NEWCOMB, aged thirty-one years, chief engineer of the rubber machinery department of the Wellman-Seaver-Morgan Co., died on Sunday, March 13, after a short illness, at his home, 742 West Ave., Akron, Ohio.

Current Market Reports

The Non-Ferrous Metal Market

New York, March 29, 1920.—The market remains quiet, with quotations as follows:

	Cents per Lb.
Copper, electrolytic	18.75
Aluminum, 98 to 99 per cent	31@32
Antimony, wholesale lots	11.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	61.50
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	8.75
Zinc, spot, New York	8.75
Zinc, spot, E. St. Louis	8.50

OTHER METALS

Silver	oz.	$1.23½
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f.o.b.) Niagara Falls)	lb.	1.60
Platinum	oz.	150.00
Iridium	oz.	250.00
Palladium	oz.	150.00
Mercury	75 lb.	95.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	22½@23½
Aluminum, sheet scrap	22 @22¾
Aluminum clippings	25½@26½
Copper, heavy machinery comp	15 @15½
Copper, heavy and wire	13½@14¼
Copper, light and bottoms	12 @12½
Copper, heavy cut and crucible	15 @15½
Brass, heavy	7 @7¾
Brass, casting	10 @10½
Brass, light	5⅞@6¾
No. 1 clean brass turnings	7⅜@7¾
No. 1 comp. turnings	11¼@11½
Lead, tea	5½@5¾
Lead, heavy	7 @7½
Zinc, scrap	4¼@4½

The Iron and Steel Market

Pittsburgh, Pa., March 26, 1920.

The iron and steel markets in the past week have been rather bare of the new developments that have been making the weeks interesting for a long time past. Without there being clear-cut developments, however, there have been distinctly marked trends of importance. One of these is the great dwindling in the volume of prompt business, together with a tendency of delivery premiums to decrease. Another is the growing indisposition of buyers

to commit themselves for forward deliveries. In pig iron there has been a very quiet market, but that is not a particularly fresh item. In spots a little softening in pig-iron prices is noticed, but on the other hand prices seem to hold up moderately well for such a quiet market.

Delivery Premiums

With a calm view of the whole market situation, one can hardly avoid the conclusion that the basis of the market is the Industrial Board prices which became effective March 21, 1919, and to which the United States Steel Corporation shows fully as strong adherence as at any time. A corollary is that all other and higher prices are premium prices, the premium being paid by reason of the earlier delivery involved as compared with the delivery the Steel Corporation could make, or by reason of the buyer not having an allotment by the Steel Corporation sufficient to cover his needs fully. For quite a while there was ground for a view that possibly there were two markets, Steel Corporation and independent, so that eventually one would have to meet the other. Such a view is certainly not tenable now. At any price above the Steel Corporation price one cannot sell far ahead.

The maximum range of delivery premiums has moved downward. The highest mill price obtained in the past few days for sheets has hardly been above 7c., when 10c. was done in a few instances late in February. The maximum on plates is now 4c., when 4.50c. was being obtained in not a few instances two or three weeks ago. The decline is not due to heavier offerings but rather to lighter market demand, this being due in turn to heavier receipts by consumers against purchases previously made.

As to prices of large independent producers who regularly sell some distance ahead, several of these producers are now committed to a definite policy of selling quarter by quarter, having a formal opening of books and naming prices just after the opening of one quarter for delivery in the succeeding quarter. Some sales are made in advance, however, perhaps at special prices, while next week or shortly thereafter there may be formal opening of books to all regular customers. Prices will not be above 3c. for bars, 3.10c. for shapes and 3.25c. for plates, and they may be lower, so that the market as to business of this description cannot be said to be advancing.

As to Steel Corporation prices, the only item this week is that sales of nails are again being made at the flat base price of $3.25. For a short time the corporation had been booking nails with the price item left open, the price to be the corporation price at time of shipment. This had led to an expectation that the corporation might make an exception of nails and announce a definite advance. There is a loss in nails, i.e., the profit is less in selling nails at $3.25 than in selling the plain wire at 3c., the corporation price.

Production

Production of pig iron and steel has increased slightly, but is still under restriction by car shortage, limiting the movement of Connellsville coke and of coal to byproduct ovens, as well as of fuel coal to steel plants. By announcement of the President, price restrictions on coal and coke are lifted, effective April 1. Then there will be an open market, with higher prices than the Government limits. This will not of itself increase the total supplies of coal, but it will enable the steel industry to bid for coal, and as its ability and willingness to pay higher prices, for the purpose of securing full production, are virtually unlimited the supplies will be obtained, probably insuring a large increase in byproduct coke production and a full operation of steel mills in the near future.

Pig Iron Dull

There are fewer offerings of small prompt lots of pig iron in the local market, but there are still sufficient offerings to meet the limited demand. Consumers are but little interested in early deliveries, and in second half deliveries they are not interested at all. Consumers of pig iron are evidently covered ahead to the extent that they have sold their finished products, whether iron castings, steel castings or rolled steel; and as their finished products are not selling with much freedom at present, there is no occasion for extensive purchases of pig iron to be made. As to steel-making pig iron, it is quite plain that there is no promise now of steel mills being able to sell finished steel products for second half delivery that would justify the payment of prices now asked for basic or bessemer iron. Pig iron, in its spectacular advance, was unable to force the steel market up sufficiently to make a harmonious relation. The market is quotable, largely nominal, at about $42 for bessemer, $41.50 for basic and $42 for foundry, f.o.b. valley furnaces, freight to Pittsburgh being $1.40.

Ferro-Alloys

Spiegeleisen is quiet at $57@$60. Ferromanganese is firm at the recently advanced price, $180, delivered, being minimum for second half, with some producers talking of $200. Prompt has sold at well above $200, but only in small lots. Ferrosilicon is quotable at $80@$81, delivered, for 50 per cent and $140 for 75 per cent. Bessemer ferrosilicon is $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. furnaces at Jackson and New Straitsville, Ohio.

Chemical and Allied Industrial Markets

New York, March 27, 1920.

The overtaxed chemical market has been firmer, if anything, during the past week than it was in the previous report. Supplies are not being replenished by producers at a rate sufficient to meet the demand and spot material on practically all items is nominal. Price advances during the week have been brought about mainly by the decreasing amount of supplies being received from producers, who are sold up from two to four months ahead on the main items on the list. The shortage of steel drums and containers has further hindered shipment from the producer to the consumer.

General Chemicals

Under the pressure of heavy foreign demand *aluminum sulphate,* commercial, advanced to 2½@3½c. per lb. with supplies on hand very light. Iron free has remained firm at 2¾@3¾c. per lb. Supplies on both grades of *sal ammoniac* are very scarce and the spot market is practically nominal, with white quoted at 15@18c. per lb., while gray is listed from 13@14½c. per lb. The stocks of English material in this market are now practically exhausted and a still further advance by domestic manufacturers is looked for. *Barium chloride* is firmer than at the time of the last report. Sales have been reported as high as $155@$160 per ton, but this is not to be taken as market price, as consumers under pressure of necessity will pay most any price. Manufacturers are sold ahead so far that relief is not expected before the end of the summer. *Calcium hypochlorite* remains steady, ranging from $3.50@$4.50 per cwt., according to the amount. A rise on this item is looked for in some quarters, owing to shortening of supplies being received from producers. Prices on *carbon bisulphide* have been advanced from 6c. as low mark on car lots to 7@8c. per lb. Quotations on *nickel salt* are practically nominal, as there is very little material to be had, 16@17½c. for the single and 14@15c. per lb. for the double.

Caustic potash is very scarce and at present the spot market is exhausted of supplies. Prices range from 25@28c. on car lots, according to quality, while dealers are asking from 30@35c. per lb. for spot with very little material to be found. *Soda ash* is in the control of the dealers, as they are the only ones who have any material to offer. Sales on the light have been reported as high as $3.50 per cwt. *Sodium nitrite* is somewhat easier than it was last week, spot material being offered at 35@45c. per lb., but the acute shortage of two weeks ago is not relieved and it will be some time before this item is back to normal.

Coal-Tar Products

General conditions remain unchanged, with the spot market tighter in supplies and firmer in price. Producers are not able to cope with the demand. Many of the items on

the list are nominal, as there is no material to be had at the prices quoted. One large factor in *naphthalene* has withdrawn from this market, as he is sold ahead into midsummer. The price has advanced from 6@8c. to 8@9c. per lb., while flake is firmer at 7½@8½c. per lb. *Solvent naphtha*, pure water white, jumped to 25@31c. from 27c. per gal. of last week. *H acid* is being sold by dealers at $1.75@$1.90 per lb., with very little material available at these prices. The demand on *cresol* has been steady during the week and the price held firm at 16@18c. per lb.

Waxes

There has been the usual amount of business in this market during the week. The only fact worthy of comment is continued shortage of the *paraffine* grades. Foreign buyers are still active inquirers on these items.

Naval Stores

There has been no activity in this market during the past week. Prices on *turpentine* have gone up, but there is no material available at any price. Current quotations range from $2.35@$2.40 per gal. with a steady increase looked for until relief can be received from Savannah.

Rosins are in the same condition, all prices being nominal. It is reported that there are several ships on the way from the South, but it may be impossible to unload them because of the longshoremen's strike.

Crude Rubber

This market during the past week has remained unchanged. The rate of exchange is the controlling factor at present. If the rate goes up sellers withdraw their low offerings; if the rate goes down buyers refuse to take any active part. Outside of the bare necessities, consumers are not in the market to any extent.

Oils

The increasing shortage of *linseed oil* has caused a strengthening in this market and no immediate relief is in sight from the Argentine crop, as it is the opinion of many that the new seed will not be able to meet the demand. Current quotations are: $1.84 raw car lots and $1.87 for boiled, tank cars. *Cottonseed* is firm at former prices, crude being quoted at 18@19c. per lb., while winter yellow is listed at 22@24½c. per lb.

Miscellaneous Materials

This branch of the market has held firm throughout during the past week, *barytes* being the most active item on the list. A rise in price is looked for shortly. Current quotations: Domestic white floated, $35@$40, and off color, $25@$30 per ton.

Chicago, March 24, 1920.

Comparatively quiet markets with prices unchanged and firm rule in all branches of the local chemical trade with the exception of alkalis, vegetable oils and naval stores. *Alkalis* continue under heavy demand from exporters and every day sees a slight boost in prices. The same is true of *naval stores*, but *vegetable oils* continue to be very weak. Business of the past two weeks has been marked by no spectacular feature.

Conditions brought about by the shortage in *turpentine* are forcing many industries which formerly used pure gum spirits to use wood turpentine. This product, although not equal in purity to the pure gum grade, is being substituted and can be produced in unlimited quantity and is quoted at a cheaper price. The principal disadvantage of this substitution is the offensive smell of wood turpentine. If present conditions remain unchanged, it is possible that the industrial arts will, in time, all come to the use of wood turpentine, leaving the gum spirits for use in paints.

Heavy Chemicals

As has been the case for several weeks, the demand for alkali products has greatly exceeded supply. Spot stocks are close to the vanishing point. On what is purely a sellers' market, *solid caustic* is now bringing $6.25 per cwt. f.o.b. works in cars, with a half cent higher on small spot transactions. The *granulated* commands 6c. at the works. *Soda ash*, in sympathy with the other items of this classification, is quoted at $3 per cwt., f.o.b. works. *Bleaching powder*, quoted two weeks ago at $3.50, now brings 4@5c. per lb., depending on how badly it is needed. *Sal soda*, in cars, is quoted at $1.50 per cwt., while jobbers are asking as high as $2.25 in small lots.

On the strength of anticipated receipts from abroad, recent panicky conditions in *sodium nitrite* have partially subsided. Current transactions are at 35c. per lb. While this seems high, it will take a considerable increase in supply over that now available to reduce it materially. Only nominal quotations are available on all grades of *alcohol*. A few small actual transactions have occurred in denatured, 180 proof, at $1 a gal. *Formaldehyde* continues to bring whatever the buyer can offerd, actual quotation being around $1 per lb. *Sodium bichromate* shows further reduction, now going for 35c. per lb., spot, in small quantity.

White sal ammoniac, the shortage of which is said to be due to transportation troubles, remains high, current price being 19@20c. per lb. for immediate delivery. Strong lead market has developed high prices in lead products, *acetate* being firm at 14½c. per lb. and *arsenate*, powdered, at 30@31½c. per lb.

The most important factor in connection with *acids* is the difficulty in securing containers, both drums and tanks, in which to make shipment. Firmness in price is noted, with *boric* at 16c. in cars and *oxalic* at 44@47c. in cars. Stocks of *hydrofluoric* seem to be seriously depleted, current quotation being 8@8½c. per lb.

Coal-Tar Products

Conditions are practically unchanged since last reported. The steady improvement in supply continues and a slight reaction in price has resulted. *Benzol* and *tuluol* are firm at 28c. in carloads. *Anilines* are some easier, the *oil* going at 32@35c. per lb. and the *salts* at 42@50c. per lb., with the latter figure prevailing in most cases. *Dimethylaniline* is being quoted at $1.60 per lb., but this quotation is purely nominal, no stocks being on hand. *Salicylic acid* is slightly under previous quotation. Present figures for technical grade, 47c.; for U. S. P., 57@58c. per lb. While no change has recently been noted in *naphthalene*, a decided firmness is noted due to dwindling stock. The ruling price for *flake* from stock is 8c. per lb., and 10c. for balls.

Vegetable Oils

This market continues weak. With buyers controlling the market, prices remain at a low level. *Cocoanut oil* in sellers' tanks, f.o.b. coast, is still quoted at 17c., and *soya bean oil* at 16@16½c. The *linseed oil* market remains very strong; transportation troubles, lack of imports of South American seed and uncertainty as to the extent of the new crop tend to a bull market. Present quotation in tank cars f.o.b. Chicago is $1.66@$1.71 per gal. In barrels, in quantity up to five, jobbers are getting $2.05.

Flotation Oils—Naval Stores

Turpentine continues to soar. Actual stocks on hand are known to aggregate only about 20 per cent of the normal for this time of year and the coming crop is an unknown factor. Those claiming to be in a position to know foretell a very scant crop, which means that present scarcity may even be made worse. Every few days sees a fresh advance and only a fraction of the demand is being supplied. Price in cars f.o.b. Chicago is $2.38@$2.40, and in barrels $2.52 per gal. No price change is noted on *pine oil*, but existing quotations of $1.60 for 0.933 pure steam distilled and $1.55 for destructively distilled are nominal, as demand so greatly exceeds supply. *Rosin* and *pine tar oil* show no material change in price, but demand is less.

Fertilizers

The expected slump has occurred. Stocks are now plentiful and calls from all sources are becoming few. Most seasonal demands are supplied and manufacturers are running to store stocks for future requirements. Ruling prices on *high-grade blood* are: For ground, $8.25@$8.40 per cwt.; on *tankage*, for high-grade ground, $7.65@$7.90 per cwt., and for low-grade ground, $7@$7.25 per cwt.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.00 – 3.75
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent., carboy	cwt.	12.00 – 14.00	15.00 – 15.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech.	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.05 – .06	.05½ – .07
Molybdic, C. P.	lb.		4.25 – 5.00
Nitric, 40 deg.	lb.	.06 – .06½	.07½ – .08½
Nitric, 42 deg.	lb.	.07½ – .08	.08 – .09¼
Oxalic, crystals	lb.	.35 – .42	.43 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 – 22.00	
Sulphuric, 60 deg., drums	ton		
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	
Sulphuric, 66 deg., drums	ton		
Sulphuric, 66 deg., carboys	ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –	40.00 –
Tannic, U. S. P.	lb.		1.35 – 1.45
Tannic (tech.)	lb.		.60 – .80
Tartaric, crystals	lb.		.69 – .74
Tungstic, per lb. of WO	lb.		1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.35 – 2.75	
Alcohol, denatured, 188 proof (nominal)	gal.		1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.		.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	† lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	† lb.	.02½ – .03	.03½ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	† lb.	.15 – .15½	.16 – .18
Ammonium chloride, granular (gray salammoniac)	† lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	
Ammonium sulphate	lb.	.05 –	.06 –
Amylacetate	gal.		3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.		.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	
Barium chloride (nominal)	† ton	125.00–135.00	140.00 –150.00
Barium dioxide (peroxide)	lb.	.23 – .27	.28 – .30
Barium nitrate	lb.	.18 – .19	.20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)			
Blue vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.85 – .95	
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.		.04¾ – .05
Calcium chloride, fused, lump	ton	20.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	† cwt.	3.50 – 3.75	4.00 – 4.50
Calcium peroxide	lb.		1.50 – 1.70
Calcium phosphate, monobasic	lb.		.75 – .80
Calcium sulphate, pure	lb.		.25 – .30
Carbon bisulphide	† lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½ – .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.		.80 – 1.05
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.28 – .29	.30 – .31
Cobalt oxide	lb.		2.00 – 2.05
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.		.65 – .70
Copper sulphate, crystals	lb.	.08½ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)			
Glycerine	lb.		.24½ – .26
Iodine, resublimed	lb.		4.10 – 4.30
Iron oxide, red	cwt.	1.20 –	.03 – .20
Iron sulphate (copperas)	lb.	.12 – .13	1.25 – 1.75
Lead acetate, normal	lb.		.14 – .23
Lead arsenate (paste)	lb.		.13 – .17
Lead nitrate, crystals	lb.	.14 – .15	.70 – .80
Litharge	lb.		15½ – .16
Lithium carbonate	lb.		1.50 –
Magnesium carbonate, technical	100 lb.	3.40 – 3.55	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	3.00 – 3.10	3.60 – 3.75
Magnesium sulphate, commercial	† lb.	.14 –	3.10 – 3.25
Nickel salt, double	† lb.	.16 – .17	.15 –
Nickel salt, single			.17½ –
Phosgene (see carbonyl chloride)	lb.		
Phosphorus, red	lb.		.60 – .65
Phosphorus, yellow	lb.	.32 – .33	.35 – .37
Potassium bichromate	lb.		.34 – .37
Potassium bitartrate (cream of Tartar)	lb.		.56 – .60
Potassium bromide, granular	lb.	.60 –	.50 – .65
Potassium carbonate, U. S. P.	lb.	.26 – .27	.65 – .70
Potassium carbonate, crude	lb.	.16 – .20	.28 – .30
Potassium chlorate, crystals	lb.	.25 – .28	.21 –
Potassium hydroxide (caustic potash)	† lb.		.30 – .35
Potassium iodide	lb.	.19 –	3.35 – 3.60
Potassium nitrate	lb.		.21 –
Potassium permanganate	lb.		$0.65 – $0.95

†(See New York market letter).

		Carlots	Less Carlots
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	.34 – .36	.40 – .70
Potassium iodide	ton	$225.00	
Rochelle salts (see potassium sodium tartrate)			
Salammoniac (see ammonium chloride)			
Saltpeter (see potassium nitrate)			
Salt cake (see sodium sulphate)			
Salt cake	ton	21.00 – 22.00	
Silver cyanide (fresh made)	oz.		1.25 –
Silver nitrate (fresh made)	oz.		.77 – .82½
Silver nitrate (recrystallized)	oz.		– 3.50
Soda ash, light	100 lb.	2.50 – 2.60	– 3.55
Soda ash, dense	100 lb.	2.70 – 2.75	
Sodium acetate	lb.	.06½ – .07	.07 – .08
Sodium arsenate	100 lb.	2.40 –	2.75 – 3.00
Sodium bicarbonate	lb.	.03 – .04	.05 – .06
Sodium bichromate	lb.	.13 – .14	.15 – .16
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.05½ – .06½	.07 – .07½
Sodium borate (borax)	lb.	.08½ – .08¾	.09 – .09½
Sodium carbonate (sal soda)	100 lb.	1.25 – 1.35	1.40 – 1.50
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	5.00 – 6.00	6.10 – 6.25
Sodium hyposulphite	lb.		.03 – .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	† lb.		.35 – .45
Sodium peroxide, powdered	lb.		.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.40 – .42	.43 – .45½
Sodium prussiate, yellow	lb.	.23 – .29	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.50	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent conc.	lb.		.05 – .06
Sodium sulphide, fused, 60–62 per cent conc.	lb.	.03½ –	.04 – .06
Sodium sulphite, crystals	lb.	.25 –	.28 –
Strontium nitrate, crystals	lb.	.05½ –	.06 –
Sulphur chloride	ton	22.00 –	
Sulphur, crude	lb.	.09 –	.10 – .12
Sulphur dioxide, liquid, cylinders	100 lb.	3.35 –	3.40 – 3.65
Sulphur (sublimed), flour	100 lb.	3.20 –	3.30 – 3.40
Sulphur, roll (brimstone)	lb.	.42½ –	.46 – .50
Tin bichloride (stannous)	lb.	.50 – .60	.65 –
Tin oxide	lb.		.20 –
Zinc carbonate, precipitate	lb.	.13 –	.13½ – .15
Zinc chloride, gran.	lb.	.49 –	.50 – .60
Zinc cyanide	lb.	.11½ – .12½	.13 – .15
Zinc dust	lb.		.19 – .21
Zinc oxide, U. S. P.	lb.	.03½ – .03¾	.04 – .04½
Zinc sulphate			

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00	$1.10
Alpha naphthol, refined	lb.	1.40	1.60
Alpha naphthylamine	lb.	.40	.50
Aniline oil, drums extra	lb.	.34	.45
Aniline salts	lb.	.42	.48
Anthracene, 80% in drums (100 lb.)	lb.	.75	1.00
Benzaldehyde (f. f. c.)	lb.	2.00	2.10
Benzidine, base	lb.	1.25	1.35
Benzidine, sulphate	lb.	1.00	1.15
Benzoic acid, U.S.P.	lb.	.90	1.10
Benzoate of soda, U.S.P.	lb.	.80	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25	.31
Benzyl chloride, 95-97%, refined	lb.	.35	.40
Benzyl chloride, tech.	lb.	.25	.35
Beta naphthol benzoate	lb.	.50	.65
Beta naphthol, sublimed	lb.	.70	.90
Beta naphthol, tech	lb.	.45	.55
Beta naphthylamine, sublimed	lb.	2.25	2.35
Cresol, U. S. P., in drums (100 lb.)	† lb.	.16	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85	1.00
Cresylic acid, 50%, first quality, drums	gal.	.60	.70
Dichlorbenzol	lb.	.07	.10
Diethylaniline	lb.	1.40	1.50
Dimethylaniline (nominal)	lb.	.95	1.50
Dinitrobenzol	lb.	.26	.37
Dinitrochlorbenzol	lb.	.25	.30
Dinitronaphthaline	lb.	.45	.55
Dinitrophenol	lb.	.32	.36
Dinitrotoluol	lb.	.38	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38	.40
Diphenylamine (nominal)	lb.	.55	.65
H-acid (nominal)	† lb.	1.75	1.90
Metaphenylenediamine	lb.	1.15	1.80
Monochlorbenzol	lb.	.12	.15
Monoethylaniline	lb.	1.50	1.75
Naphthaline crushed, in bbls. (250 lb.)	† lb.	.08	.09
Naphthaline, flake	lb.	.07	.08
Naphthaline, balls	lb.	.08½	.10
Naphthionic acid, crude	lb.	.70	.85
Nitrobenzol	lb.	.14	.19
Nitro-naphthaline	lb.	.30	.35
Nitro-toluol	lb.	.20	.30
Ortho-amidophenol	lb.	3.75	4.25
Ortho-dichlorbenzol	lb.	.15	.20
Ortho-nitrophenol	lb.	.80	1.25
Ortho-nitro-toluol	lb.	.25	.40
Ortho-toluidine	lb.	.25	.45
Para-amidophenol, base	lb.	2.50	3.50
Para-amidophenol, HCl	lb.	2.50	3.25
Para-dichlorbenzol	lb.	.12	.18
Paranitraniline	lb.	1.00	1.35
Para-nitro-toluol	lb.	1.35	1.50
Paraphenylenediamine	lb.	2.15	3.00
Paratoluidine	lb.	1.75	2.50
Phthalic anhydride	lb.	.65	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12	.25
Pyridin	gal.	2.00	2.50
Resorcin, technical	lb.	4.25	4.50
Resorcin, pure	lb.	6.25	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45	.50
Salicylic acid, U. S. P.	lb.	.55	.60
Salol	lb.	.90	1.00

Solvent naphtha, water-white, in drums, 100 gal. †	gal.	$0.25 —	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal. †	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark †	lb.	$0.38 —	$0.40
Beeswax, refined, light †	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal) †	lb.	.43 —	.45
Japan	lb.	.17 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.08
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11¼
Paraffine waxes, refined, 133-135 m.p.	lb.	..... —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	..... —	.14
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.47
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	†280 lb.	$17.95 —	$18.25
Rosin E-I	280 lb.	18.75 —	19.00
Rosin K-N	280 lb.	19.45 —	21.00
Rosin W. G.-W. W.	280 lb.	22.00 —	22.50
Wood rosin, bbl.	280 lb.	15.50 —	17.50
Spirits of turpentine	gal.	..... —	2.35
Wood turpentine, steam dist.	gal.	..... —	2.25
Wood turpentine, dest. dist.	gal.	..... —	2.10
Pine tar pitch, bbl.	200 lb.	8.40 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl.	500 lb.	15.00 —	15.50
Rosin oil, first run	gal.	.92 —	.95
Rosin oil, second run	gal.	.94 —	.97
Rosin oil, third run	gal.	1.10 —	1.15
Rosin oil, fourth run	gal.	1.17 —	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.32½ —	.33
Plantation—First latex crepe	lb.	.47½ —	.50
Ribbed smoked sheets	lb.	.47½ —	.48¾
Brown crepe, thin, clean	lb.	.45 —	....
Amber crepe No. 1	lb.	.46 —	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.24½ —	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18 —	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½ —	.23
Corn oil, crude, in bbls.	lb.	.18 —	.19
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.18
Cottonseed oil, summer yellow	lb.	.19½ —	.20½
Cottonseed oil, winter yellow	lb.	.22 —	.24½
Linseed oil, raw, car lots	gal.	1.84 —	.....
Linseed oil, raw, tank cars	gal.	1.77 —	.....
Linseed oil, boiled, car lots	gal	1.87 —	.....
Olive oil, commercial	gal.	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15¾ —	.17¾
Palm, Niger	lb.	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½ —	.22
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined in bbls	gal.	1.70 —	1.78
Rapeseed oil, blown, in bbls.	gal.	1.80 —	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.18½ —	.23
Soya bean oil, tank cars, f.o.b. Pacific coast	lb.	.15¾ —	.20

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal.	1.30 —	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	..... —	.....
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal)	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	52.00 —	57.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.07
Graphite, crucible, 88% carbon content	lb.	..... —	.08
Graphite, crucible, 89% carbon content	lb.	..... —	.08½
Graphite, crucible, 90% carbon content	lb.	..... —	.09¼
Graphite, crucible, 91% carbon content	lb.	..... —	.08
Graphite, crucible, 92% carbon content	lb.	..... —	.09¾
Graphite, crucible, plus 92%	lb.	..... —	.12½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine nominal	lb.	1 45 —	.....
Shellac, orange, superfine	lb.	1.50 —	1.55
Shellac, A. C. garnet	lb.	1.25 —	1.30
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick net ton	75-80 at Chester, Penn.
Chrome cement net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay 1,000	38-45 at Clearfield, Penn.
Clay brick, 2nd quality 1,000	33-35 at Clearfield, Penn.
Magnesite, dead burned net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in. net ton	80-85 at Chester, Penn.
Silica brick 1,000	45-50 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn	gross ton	180.00 —	225.00
Spiegeleisen, 16-20% Mn	gross ton	50.00 —	70.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	70.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	..... —	25.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.25 —	6.75
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

PASADENA — Samuel Storrow has awarded the contract for the construction of a 2-story, 85x140-ft. factory for the manufacture of bricks, on Raymond Ave., near Dayton St., to L. P. Pomeroy, 751 North Catalina St., at $38,615.

Connecticut

MERIDEN—The International Silver Co., 48 State St., has awarded the contract for the construction of two 1-story additions to present manufacturing plant on George St., to the Immick Co., State St. Estimated cost, $40,000.

Illinois

CHICAGO—The Advance Spring & Wire Co., 1749 Carroll Ave., plans to construct a 2-story annex to the present plant on the southwest corner of Carroll Ave. and North Wood St. Estimated cost, $125,000.

CHICAGO—The American Glue Co., 123 West Kinzie St., plans to construct a factory at 3640 Iron St. Estimated cost, $160,000. S. Scott Joy, archt.

CHICAGO—The Boyle Ice Co., 136 West Lake St., is building an artificial ice plant on Larrabee St. near Chicago Ave. Estimated cost, $200,000.

CHICAGO—The Troco Nut Butter Co., 30 North Michigan St., is constructing a building for the manufacture of food products, on the southwest corner of 37th and Iron Sts. Caleb E. Johnson, pres.

CHICAGO—The Western Campbell Ice Machine Co. plans to build a plant for the manufacture of ice machinery on Cornelia St. near the Chicago, Milwaukee & St. Paul Ry. Estimated cost, $150,000.

Iowa

DEXTER—The city has awarded the contract for the construction of a sewage disposal plant, to F. H. Christenson, Guthrie Center, at $12,465. Noted Feb. 18.

STANTON—The city has awarded the contract for the construction of a sewage disposal plant, to Harness Bros., Ottumwa, at $12,600. Noted Feb. 25.

TABOR—The city has awarded the contract for the construction of a sewage disposal plant to Ward & Weighton, Davidson Bldg., Sioux City, at $17,560.

Maryland

BALTIMORE—The Autogenous Welding & Machine Co., 1213-1223 Maryland Ave., has awarded the contract for the construction of a 1-story, 25x150-ft. addition to welding plant at 1223 Maryland Ave., to F. A. Condon, 1520 West Baltimore St. Estimated cost, $12,000.

BALTIMORE—The Emery Steel Castings Co., 210 Garrison Lane, has purchased the Pabst Brewery property on South Charles St. at the intersection of Hanover St. and the Baltimore & Ohio R.R. and plans to move its plant and equipment there. Alterations are being made to turn brewery buildings into a modern steel foundry. An electrical steel furnace will be installed in same.

ELKTON—The Bd. of Comrs. is having plans prepared for the construction of a filtration plant, etc. Estimated cost, $40,000. W. H. Mackall, pres. L. J. Houston, Fredericksburg, engr.

Massachusetts

NATICK—The New England Pressed Steel Co. plans to construct a 1-story, 55x85-ft. manufacturing plant addition. Estimated cost, $25,000.

Minnesota

MINNEAPOLIS—The Henepin Atomixed Fuel Co., 520 Security Bldg., is having plans prepared for the construction of a 1- and 2-story, 100x150-ft. fuel-crushing plant on B'way and Johnson St., N. E. Estimated cost, $150,000.

MINNEAPOLIS—W. T. Rawleigh Co., Freeport, Ill., has awarded the contract for the construction of a 2-story, 50x160-ft medicine factory on 10th Ave. N., and 3rd St., to the C. W. Lundquist Co., 1621 East Hennepin Ave. Estimated cost, $60,000.

Missouri

ST. JOSEPH—The St. Joseph Oil Co., southwest corner 4th and Duncan Sts., is having plans prepared for the construction of a 2-story fuel oil plant. Estimated cost, $200,000.

New Jersey

TRENTON—The Lenox Inc., Mead St., has awarded the contract for the construction of a 1-story, 100x394-ft., 2-story, 20x400-ft., and 3-story, 41x75-ft. buildings for the manufacture of ceramic ware, to Karno-Smith Co., Broad St. Bank Bldg., Estimated cost, $200,000.

TRENTON—The Pocono Rubber Cloth Co., East State St., plans to construct a 1-story factory. Estimated cost, $50,000. Karno-Smith Co., Broad St. Bank Bldg., engrs.

New York

BUFFALO—The Stron Steel Fdry. Co., Norris St., plans to build two 1-story additions to present factory at 33 Norris St. Estimated cost, $20,000.

ITHACA—The Cornell University Bldg. Committee had plans prepared for the construction of a 5-story chemical laboratory on the site of the home of President Jacob Gould Schurman on East Ave. Chemical equipment will be installed in same. Estimated cost, $1,500,000. Gibb & Waltz, Trust Co. Bldg., archts.

Ohio

CLEVELAND—Allen Osborn Co., archt. and engr., Rose Bldg., will soon award the contract for the construction of a 1-story, 100x200-ft. foundry on Dunham Rd., for the Minerva Engine Co., East 66th St. and Euclid Ave. Estimated cost, $60,000. C. S. Goby, pres. and treas.

ASHLAND—The city received bids for furnishing and installing filter equipment from the Amer. Water Softener Co., 1011 Chestnut St., Philadelphia, Pa., $34,000. Noted March 10.

CLEVELAND—The Collinwood Fdry. Co., 17004 Waterloo Rd., has awarded the contract for rebuilding the 1-story, 60x200-ft. foundry which was recently destroyed by fire, to A. A. Lane Constr. Co., Union Bldg. Estimated cost, $50,000.

Oklahoma

PAWHUSKA—The city had plans prepared for the construction of a filtration plant near the present water plant. The plant will have a capacity of 2,000,000 gal. per day. Estimated cost, $65,000. State Water Engr., Oklahoma City, engr.

Oregon

BEND—The Bend Water, Light & Power Co. plans to install an auxiliary pumping and sterilization plant including one 1,500-gal. per minute pump and construct a 30,000-gal. reservoir. Estimated cost, $12,000.

Pennsylvania

PHILADELPHIA—The Brown Instrument Co., Wayne and Windrim Sts., is constructing two buildings, one for the manufacture of recording thermometers and the other for a research department. Estimated cost, $100,000. R. P. Brown, pres.

PHILADELPHIA—The Dept. of Pub. Wks., City Hall, will soon award the contract for the construction of an intake house and for furnishing, delivering and installing various safety devices, including screens, etc., for the Bureau of Water Supply, 788 City Hall, at the Queens Lane Filters and at six other pumping stations.

Tennessee

MEMPHIS—The Fischer Lime & Cement Co., 269 Walnut St., is building a 2-story, 84x300-ft. warehouse on Walnut St. and Linden Ave. W. W. Fischer, pres.

MEMPHIS—The Southern Art Corp. has purchased a 6-acre site at the corner of Nelson St. and East Parkway and plans to construct a plant for the manufacture of art novelties on same. Estimated cost, $220,000. A. C. Jahl, vice-pres.

MEMPHIS—Swift & Co., 35 Union Ave., plans to construct an oil refinery and lard compound plant to have a capacity of 1,000,000 lb. per week. S. L. Kopald, mgr.

Texas

RANGER—The Thurber Earthen Products Co. is building a large rock crushing plant just east of here on the Hagerman land along the Texas & Pacific R.R.

DALLAS—The Fleischman Co., manufacturer of yeast, 711-13 North Ervay St., has purchased a site here and is having plans prepared for the construction of the first unit of a factory on same. Estimated cost, $1,000,000, ultimate cost, $1,500,000. Address G. W. Neary, 4630 Munger Ave.

Washington

SPOKANE—John G. F. Hieber, 2011 1st Ave., is having plans prepared for the construction of a 3-story, 73x160-ft. fruit juice plant. Sterilization coils, cooling coils, etc., will be installed in same. Estimated cost, $100,000. H. E. Smith, 1211 Old Natl. Bank Bldg., engr.

Wisconsin

CUDAHY—The Federal Rubber Co. will build a 6-story, 160x220-ft. factory on Packard Ave. Work will be done by day labor.

MARKESAN—E. W. Laper, village clk., will soon award the contract for the construction of sewage disposal plants, etc. Address G. C. Hank, 465 Sidney St., Madison.

British Columbia

NEW WESTMINISTER—The Imperial Oil Co., Cambie and Smith Sts., Vancouver, has awarded the contract for the construction of a distributing plant, etc., to the Dominion Constr. Co., 509 Richards St., Vancouver, at $24,500.

Ontario

DES QUINZE—M. J. O'Brien, Renfrew, plans to construct a pulp and paper plant, etc., here. Estimated cost, $4,000,000.

LONDON—The Bd. Educ., City Hall, is having plans prepared for the construction of a collegiate building on Ridout St. Chemical and physical laboratory equipment will be installed in same. Estimated cost, $215,000. L. V. Carrothers, Hydro Offices, archt.

TULBURY—The Tullsary Brick & Tile Co., Ltd., manufacturer of all sizes of drain tile and red wire cut face brick, is in the market for Bensing automatic brick cutters, 9-in. capacity and drain tile cutters, 13½-in. capacity, etc.,

Quebec

IBERVILLE — The town has been ordered by the Provincial Bd. of Health to construct a filtration plant and improve waterworks system. Estimated cost, $25,000.

LEVIS—The town has been ordered by the Provincial Bd. of Health to construct a filtration plant and improve waterworks system. Estimated cost, $25,000.

SOREL—The town has been ordered by the Provincial Bd. of Health to construct a filtration plant and improve waterworks system. Estimated cost, $25,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive at St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 2. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meet-

ing in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Romance of Leather Making," Tuesday, April 13, at 4 P.M., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 P.M., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 P.M., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 P.M., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 P.M., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE ELECTRIC FURNACE ASSOCIATION will hold a meeting in Boston, April 8 to 10, together with the American Institute of Electrical Engineers and the American Electrochemical Society. The subject is "Electrically Produced Alloys and Power for Electrochemical Purposes." Headquarters will be at the Copley-Plaza Hotel.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INTERNATIONAL MINING CONVENTION will be held in Seattle April 7 to 10.

THE [illegible] STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

THE EAGLE-PICHER LEAD CO., Chicago, Ill., at the annual meeting held in Cincinnati on Feb. 17, elected Dr. John A. Schaeffer vice-president of the company in conjunction with his former position as chief chemist and chief metallurgist. His headquarters will be in the Railway Exchange Bldg., St. Louis. R. E. McCormack, formerly of Joplin, Mo., will be his assistant.

TECHNICAL ADVERTISING SERVICE, INC., 1132 Broadway, New York City, has recently enlarged its technical staff and opened an export service division under the management of J. S. Beckett, a chemical engineer of wide experience in laboratory, plant and construction work. This service offers to exporters answers to such inquiries as "Please send me a complete equipment for a metallurgical laboratory 12 x 17 ft. sq." or "a plant to make rubber heels," and is equipped to take care of any inquiry in the technical field, covering mechanical, chemical, civil, mining and metallurgical engineering. This department draws up complete and detailed specifications for all equipment covered by the inquiry, obtains quotations from the manufacturers, places the order and follows it through until the material is delivered as specified and on time at the dock or alongside the steamer.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa., announces the appointment of Arthur Elliott Allen as district manager at New York, to succeed Edward D. Kilburn, who has been elected vice-president and general manager of the Westinghouse Electric International Co.

H. DEVERELL announces that he has sold his interest in and severed his connection with Deverell, Spencer & Co. He will be engaged hereafter in the elevating, conveying and transmission machinery business, with offices at 1401 Lexington Bldg., Baltimore, Md.

THE CHEMICAL EQUIPMENT CO., Chicago, is moving to a new and larger plant at 2457-59 South Western Ave. The general officers will remain at 910 Monadnock Bldg.

THE BUFFALO FORGE CO., Buffalo, N. Y., at a recent meeting elected the following new officers: Henry W. Wendt, president; Edgar F. Wendt, vice-president and treasurer; Henry W. Wendt, Jr., vice-president and secretary; C. A. Booth, vice-president and sales manager. The new directors include the above-named officers, and in addition H. W. Whiting.

GLANDER & CO., formerly at 115 Broadway, New York City, are now located at 568 Broad St., Newark, N. J.

DEVERELL, SPENCER & CO., Baltimore, Md., announce that John C. Carter has purchased H. Deverell's interest in the company, and will be actively associated with J. H. Spencer. The name of the company will shortly be changed to the Spencer Construction Co.

THE GENERAL NAVAL STORES CO., with general offices at 90 West St., New York, has recently made a material expansion of the facilities in Chicago, to handle the pressure of business at that point. Enlargements trebling the office space in the McCormick Bldg. and increasing the warehouse and yardage space at 37th Street and Normal Ave. from 10,000 to 25,000 sq.ft. and installing storage tanks are now in process. Yardage expansion will give railroad trackage, which the company has not previously enjoyed. This company is the exclusive agent for the output of the Newport Co., a large producer of pine tar products, with works at Bay Minette, Ala., and Pensacola, Fla. It also has an office in St. Louis, Mo., and maintains stocks in Cincinnati, Detroit, Philadelphia, Norfolk and Denver.

THE ELECTRIC FURNACE CO., Alliance, Ohio, has opened a Middle Western office at 301 Frisco Bldg., St. Louis, Mo., in charge of W. E. Prosser.

THE TULSA LABORATORIES, formerly owned by James H. Holden, have been taken over by H. R. Rowe, W. A. Goldstrap and Roy L. Ginter. The new owners are putting in new supplies and equipment and are prepared to make oil field tests on casinghead and natural gas, also efficiency tests on gasoline plants where boiler trouble is experienced. In the laboratory they will handle oil and general analytical work, including complete gas analysis and drug assays.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, announces that arrangements have been made with the Wellman Bibby Co., Ltd., 38 Kingsway, London, W. C., 2, England, to act as its representative in Great Britain and Ireland for the sale of the American steam ash conveyor. It is the intention of the Wellman Bibby Co. to manufacture the American steam ash conveyor in England.

THE JEFFREY MFG. CO., Columbus, Ohio, has opened a new branch office in Los Angeles, Cal., in charge of F. R. Field, formerly manager of the Denver office. This addition to branch offices has been made necessary to give adequate service to clients in California, Arizona, Nevada and the State of Sonora, Mexico.

THE ROME WIRE CO., Rome, N. Y., has recently authorized an increase in the capital stock to $4,000,000 of 7 per cent first preferred and $5,650,000 common. The shares in each issue are $100 par value. The company's main plant is located at Rome, N. Y., on the New York Central R.R., and on the New York State Barge Canal. The land comprises twenty-two acres with 348,000 sq.ft. of modern factory buildings, fully protected by sprinkler equipment. All of the buildings have been constructed since 1905 and the larger part of them since 1914. The equipment is all modern and first class in every particular. The Buffalo plant consists of eleven acres of land in the northeastern part of the city, on the D., L. & W. R.R., with excellent trackage facilities and well-constructed buildings adapted to the manufacture of electrical wires and cables. A large addition is under construction at this branch.

THE AMERICAN ASSOCIATION OF COMMERCE AND TRADE IN BERLIN (American Chamber of Commerce) has just begun the monthly publication of the *Transatlantic Trade* in the interests of the American manufacturer, exporter and importer. The first issue is a 32-page magazine containing reports of commercial and industrial conditions in Germany, and opportunities for American goods in that country. Names of firms open for commercial connection with American manufacturers and other items of commercial interest are given. The subscription price in the United States is $2 per year.

THE WESTINGHOUSE ELECTRIC & MFG. CO., Pittsburgh, Pa., has given an insurance policy for $500 without cost to each employee who has been in the company service for six months or more. After April 1 employees may increase the value of their policies to amounts varying from $1,000 to $2,000 depending upon their length of service and continuity of saving. All employees who have been in the company's service for six months or longer and who deposit a sum each payday in the employees' savings fund equal to 2 per cent or more of their earnings will not only receive 4½ per cent interest compounded semi-annually on such deposits but in addition will automatically have their insurance increased to amounts up to $2,000, depending on the length of time they have been with the company. This insurance is to be made effective at all of the various offices and plants of the Westinghouse Electric Co. and will affect approximately 50,000 persons.

THE MOTOR TRUCK OWNERS OF NORTH AMERICA is a new organization of motor truck users and operators formed at the recent automobile shows in New York, Chicago and other cities. It is an outgrowth of the tri-state association which included Indiana, Ohio and Pennsylvania. Indianapolis, Ind., is the new headquarters.

THE GLIDDEN STORES of Cleveland, Ohio, will open a branch at 157 Madison Ave., Memphis, Tenn., for the sale of varnishes, insecticides and sundry products. B. F. Hammond has been appointed district manager.

THE TOLEDO SCALE CO. has established a branch sales office at 11 South Third St., Memphis, Tenn., under the direction of W. D. Weidlein.

Manufacturers' Catalogs

THE QUIGLEY FURNACE SPECIALTIES CO., New York, has issued a folder on low-cost per heat-hour of pots (cyanide chloride, lead) and boxes (carbonizing annealing).

THE JOSEPH DIXON CRUCIBLE CO., Jersey City, is distributing, to any foundryman requesting it, a copy of booklet No. 190-A, entitled "Crucibles—Their Care and Use." This company has found that many foundrymen do not fully appreciate the importance of keeping and handling their crucibles in a manner which will insure the greatest number of heats with the least danger of accidents, and this booklet is being distributed to emphasize this point.

THE DENVER FIRE CLAY CO., Denver, Col., announces a new catalog on D.F.C. Clay Products. This attractive booklet gives in 20 pages descriptions and illustrations of such products as annealing cups, assay crucibles, annealing cup trays, tall form crucibles, crucible covers, melting crucibles, special crucibles, crucibles for melting platinum, etc., together with prices.

THE HIRES TURNER GLASS CO., Philadelphia, Pa.: Bulletin No. 11-A, entitled "Corrugated Wire Glass for Industrial Buildings," illustrates and describes the different types of corrugated wire glass and the purposes to which they can be put. Photographs of actual installations are shown.

THE GRISCOM-RUSSELL CO., New York City, is issuing Bull. 311, on the Reilly Evaporator, submerged type. Illustrations are given of the evaporator closed and open, with a steel shell, single manifold, and also with a cast-iron shell, double manifold, together with a description; together with instructions for marine installation of a multicoil evaporator and distiller plant.

THE VINELAND SCIENTIFIC GLASS CO., Vineland, N. J., is issuing a "loose-leaf" compilation of illustrated price lists of items of chemical, medical, pharmaceutical, and surgical glassware.

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G WIKOFF
Assistant Editors

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 — New York, April 7, 1920 — *Number* 14

Spring Conventions Of Chemical Societies

THE month of April brings the customary spring meetings of the American Electrochemical Society and the American Chemical Society—two of the principal events of the year in chemical circles. The electrochemists, who meet at Boston this week, are provided with an unusually good program, with three symposia —on colloid chemistry, electrically-produced alloys and power for electrochemical purposes. The first of these will be led by the Society's president, W. D. BANCROFT, himself a leading authority on the subject. The second has been contributed by a large number of manufacturers. The third, being the joint product of the Society and the American Institute of Electrical Engineers, will serve an excellent purpose in bringing together the producer and consumer of electric power. It is seldom that the programs of the American Electrochemical Society have excelled that of the Boston meeting.

Less is known at this writing about the general plan or the details of the meeting of the American Chemical Society in St. Louis next week, although we may assume from past experience that it will prove to be a successful meeting. We believe it is unfortunate that the American Chemical Society has never seen fit to follow the customary practice of the electrochemists, mining engineers, and other associations of technical men in publishing papers in advance of the meeting so that those who attend may know what to expect and be prepared with discussion on subjects with which they are familiar. In our judgment the meetings of the American Chemical Society will never hold for its members the attraction and interest which other professional societies secure until there is a change in policy in this respect. Some difficulty may be encountered in adopting this plan, because the inertia of authors must be overcome; but the principal requisite is decision upon the part of the Society's officers. Once this is reached, authors will realize they must conform thereto if they are to find a place on the program. If the change is too drastic to be applied throughout, a beginning could be made by applying it to the larger and better established sections and divisions. It is largely a question of official attitude.

Chemistry and the Interstate Commerce Commission

IN HANDING down a recent decision on the transportation of sodium nitrate the Interstate Commerce Commission made some startling observations on the properties of that well-known substance. After announcing the rates from the seaboard to inland points, the Commission proceeded to dilate upon the chemistry of sodium nitrate and stated that it oxidizes rapidly when exposed to the atmosphere and reacts violently in combination with water. These are indeed shocking details to reveal to chemists who thought they were quite familiar with the characteristics of sodium nitrate.

It may be that this salt is particularly unfortunate in regard to its reputation, for an honorable Senator recently insisted at a committee hearing that Chilean saltpeter is highly explosive and can be ignited by a match.

The facts would not be worth recording merely for the purpose of provoking a smile, but they are significant of the increasing complexity of our daily business life and the necessity for technical knowledge in the transaction of the Government's business. The Interstate Commerce Commission undoubtedly knows much about railroad rates, but is badly in need of a technical adviser when it comes to chemistry.

In Support of the Chemical Warfare Service

WHEN the House of Representatives passed its Army reorganization bill and made the Chemical Warfare Service a separate organization, the outlook for that branch of the service was distinctly improved. It now remains for the Senate to display equally good judgment and assure the country of an Army unit skilled in the means of offensive and defensive gas warfare and able to train the remainder of the troops.

If the Chemical Warfare Service finally becomes established as a separate branch of the Army, it will not be due to the efforts of the Secretary of War or the Chief of Staff, but rather in spite of their opposition. To no one more than to Colonel A. A. FRIES will the retention of the Service be due, if the Senate follows the example of the House. He it was who had charge of chemical warfare on the other side and observed its effects and value. Returning to this country, he first preached the doctrine of the humanity of gas warfare and showed by actual figures the low percentage of death among gas casualties as compared with the results of artillery and infantry fire. His convictions led him to work for the retention of the Service even when its demobilization had been ordered, and his zeal and enthusiasm converted others to his viewpoint. In fact, the revulsion of feeling against gas warfare gradually dissipated to such an extent that no Congressman raised his voice against it when the House bill was passed.

It required no gift of prophecy to foresee the immediate and insistent demand that will arise for chemical warfare if this country again becomes involved in war. That and the air service will be the two new means of offense and defense that will be most urgently needed. Civilian chemists will again be called to the

colors in their professional capacity. In the meantime the least that the Army can do is to retain the skeleton of an organization for the prosecution of research and the training of troops. The latter is in itself a huge problem when it is considered that the National Guard as well as the Regular Army must be trained. Add to this the responsibility of the Chemical Warfare Service for the production of chemical supplies for the entire Army, and we have a task requiring a larger organization than the minimum which has been suggested. The Senate has here an opportunity to urge an increase in the peace-time minimum so that the duties can be performed by Chemical Warfare officers and men, without resorting to special details from other branches of the service which probably would be returned to their original branches in case of hostilities, thus crippling the Chemical Warfare Service when most urgently needed.

An official estimate of the minimum peace-time strength of the Chemical Warfare Service is 171 officers and 2,057 enlisted men, and the Senate will do well to accept the suggestion. It should also see that a clause is introduced defining the duties of the Service, as otherwise a loophole will be left through which opponents of the Service may undermine its independent status and even dismember it on the score that it has no excuse for existence. The duties can well be defined to include the production of gases and smokes for offense, appliances for gas defense, research and investigation in chemical warfare, and the training of the Army in offensive and defensive methods of gas warfare. Until this is done, and the Chemical Warfare Service is firmly established in the Army, the country cannot feel that Army reorganization has been accomplished in the most intelligent and effective manner.

A Balance Nicely Struck

WE ALWAYS object to the charge, sometimes made by narrow-minded scientists, that the engineer is only a craftsman who commercializes science and who sees in a truth only the prospect of monetary gain. On the other hand, we equally regret to hear the "practical" man give vent to unsympathetic criticism of the scientific investigator.

In his address before the American Association of Petroleum Geologists on March 18, GEORGE OTIS SMITH, director of the United States Geological Survey, has struck a splendid balance between the call of pure scientific research and the problems of industry and the arts. He refers to applying the known truths of science for human benefit as "the hallmark of true value"; but he hastens to add the comment: "In a way I suppose we may regard science as an expendible resource; those who apply science to the needs of man seem to require fresh supplies from which to draw for their use. At least it is true that each new advance in the engineering arts calls for a corresponding reinforcement by scientific truth."

It is always a difficult matter to tell when the results of technical investigation will be of value in their application. It is a long step from the test-tube to a satisfactory balance-sheet on a year's plant operations. But the test-tube stage is important, none the less. The executive who plans for an extensive chemical industry (and which of our industries is not in some measure chemical?) without including in his calculations an appropriate allowance for research is likely to find himself left far behind in the industrial race. It is proper that the executive expect this research department to show convincingly that it pays good dividends; but in this department there will always be some problems under study that "we know will never pay," as one director of research put it.

It is fortunate that we have those who love the labors of pure research and who stick to their work despite the charge that they are "impractical acedemic theorists." By their explorations they constantly push back the boundaries of technical ignorance and thus leave more territory for settlement and cultivation by those who follow. Such pioneers perhaps never grow rich; but what pioneer ever does? However, they derive a wonderful store of new experiences which in themselves are a real reward; and they also deserve our cordial support and respect.

There is no ground for contest between the investigator and the one who will apply his discoveries in the useful arts. There is room and need for both. And above all there is need for mutual respect and co-operation.

Conserving Radium As a National Asset

WHEN the Bureau of Mines investigated the radium-bearing ores of Colorado and Utah in 1912 it disclosed a national asset unknown prior to that time, and one that has not been fully appreciated since then. Prior to 1913 the world's production of radium came from Austria, but since then the United States has produced and is producing more of it than all other countries combined. Of the known total world's production of from 100 to 110 grams of radium element it seems likely that domestic ores have yielded 75 to 80 grams, of which say 70 grams has been extracted in this country and the balance abroad.

Early in the development of the radium industry in the West, officials of the Bureau of Mines sounded a warning against the dissipation of our supply of radium, either through non-essential uses in the arts or by unrestricted export to foreign countries. The supply of ore was even then known to be limited, and the life of the mines could be predicted with sufficient accuracy to foresee their exhaustion in a few years. Today the supply of ore seems sufficient to last not more than ten years if the present rate of production and price of radium are maintained.

It seems evident, therefore, that if a conservative note of warning was warranted eight years ago it should now be amplified into a blast of trumpets. Not all of the radium hitherto produced, say 100 grams, is today available for its principal use, viz., the treatment of cancer. Some of it has gone into the production of luminous paint and more of it was consumed during the war in making luminous dials on airplanes, luminous gunsights, etc. All of this is lost to science and medicine. Nor have we in this country in medical use today much more than 20 to 25 grams out of the 70 that our own ores are known to have produced.

If the United States is to accumulate any considerable supply of radium, it would seem high time to make a beginning. Through inquiry we learn that the treatment of cancer with radium is proving more and more successful every day, and that it is practically the only method of treatment in vogue in certain hospitals. But

even here there is danger of scattering the supply too widely, so that sufficient quantities are not available in one place to accomplish the best results. The crux of the matter seems to be that radium is so expensive that private interests cannot afford to purchase it in sufficiently large quantities for its most effective use. The solution of the problem would seem to lie in the private endowment of hospital funds for the purchase of radium or an appropriation by the Government for the same purpose. If the public interest is to be served we must depend on private philanthropy or Government support.

Railroad Efficiency And Steel Requirements

IT IS quite certain that two or three months ago a great many buyers of steel products were misjudging the volume of railroad demand for steel during the remainder of the year. Buyers were highly excited, estimating steel-producing prospects by the light production of the closing months of 1919, and fearing that railroad buying would cut off even a portion of the supplies they had been receiving. The buyers made the steel market, bidding higher and higher prices for steel, and there were evidences of a runaway market. Indeed, a runaway actually began, but it did not continue, rather merging into a condition in which fancy prices obtained for early deliveries, against relatively moderate prices for later deliveries. The result was a high premium market rather than a general runaway.

A clearer perception of the condition and prospects is now being reached, with the result that a more safe and sane market for steel is to be expected. The steel industry is beginning to function well again, the American Iron and Steel Institute's report indicating that steel ingots were produced during February at the rate of 44,200,000 gross tons a year, or 46 per cent better than the average rate during 1912 and 1913, by far the two best tonnage years before the war, and years of approximately equal tonnage. The increase in the rate from January to February was between 8 and 9 per cent, prospects being that March will show a further decided improvement, whereby the quarter's production will represent about 90 per cent of capacity, instead of the 75 per cent mentioned in some of the gloomy forebodings.

Reverting to the fears that the railroads would corral the steel market as soon as the lines were returned to their owners, it is high time that the public, not merely the general run of steel consumers, take a more rational and intelligent view of the work that lies before the railroads. It may be thought natural that when a shipper does not receive enough cars for loading from the railroad, or does not receive raw material because those from whom he buys do not get cars, the shipper should jump to the conclusion that the railroads should buy more cars, and keep on buying until they have enough. But if the shipper has two office boys and both are habitually very late to work he is hardly likely to solve the "problem" by continuing to put additional office boys on his payroll until he finds a good supply every morning at 9 o'clock or whatever his hour may be. He is more likely to look into the habits of the boys he is already paying.

Roughly speaking, there are about 2,500,000 freight cars in the country, a few less than that owned by the railroads, and a few more counting the private cars. The report for last December, by the way, showed 6.2 per cent of the cars "unserviceable," against 5.8 per cent the previous December, just after the Armistice. To add 10 per cent to the number would mean 250,000 cars, costing the better part of a billion dollars. When the roads have functioned well cars have moved, loaded, an average of nineteen miles a day, while when there is "car shortage" the movement is slower. Which would you rather do, spend the major part of a billion dollars or move cars 1.9 miles more per day? A fact that seems pertinent is that there are about 500 freight cars per freight locomotive. This looks hard for the locomotive but seems to give the freight car an easy time. Another noticeable fact is that when there are serious car shortages some of the yards and terminals are badly congested.

Undoubtedly the railroads need more cars, and they are buying some of those additional cars now. They need also to replace old cars, so productive of wrecks, by new cars. Beyond this they need much more motive power, much improvement of terminals and yards, and a great deal of block signaling of track that does not now render the service required of it. Simply to clutter up tracks with more cars will not make the railroads fully serviceable.

The railroad managers are, as a matter of fact, confronted with a very big problem, to put the lines in condition to render much more service and much steadier service. The problem is big financially and big from the engineering side. It is not one that can be solved by instructing the purchasing agent to rush into the market and buy everything at once that is to be had. During the remainder of this year the railroads will make only a beginning. Much more actual work will be done in 1921, and if things go right still more will be done in 1922. Railroad demand will engage relatively little of the steel-making capacity this year, but a great deal more in succeeding years if the railroad companies are able and willing to do their duty to the public.

Artistic Imagination For Engineering Workers

Art is always and everywhere the best way of doing a thing.

THIS definition by one of the *literati* is relevant to the engineering business in that it involves action. Art is concerned not only with museums of junk, philharmonic gatherings or brochures of purple paragraphs, as we are wont to connect it through long association, but applies to the creation or production of anything that is beautiful in its service to the industries and mankind.

An artistic conception of the vocation is essential to the engineer, for, genius or otherwise, he is a worker; and to work successfully he must be led by inspiration, not driven by necessity.

Burning Clay In Sanskrit

WITH the aid of skilled etymologists a committee of the American Ceramic Society has discovered that from the Indo-European base word "car" comes our modern derivation "ceramics." The Greek term "keramos" and Latin "cremo" were intermediate steps. The word means "to burn" earthy materials. The engineer may now add to polite conversation on the arts when the subject of Ming dynasty pottery is broached in the drawing room.

British Chemical Industry

(From our London Correspondent)

London, March 8, 1920.

INTEREST in the United Kingdom has centered upon the continued appearance of new capital issues and the adjustments and changes in policy which are occasioned by them. As was to be expected in view of the acquisition of the Castner-Kellner interests, Brunner Mond & Co. are now to purchase the business of Electro Bleach & By-Products, Ltd., of Middlewich, the latter firm being the only serious competitor in regard to electrolytic caustic soda. In addition it is rumored that as a logical consequence of Brunner-Mond's purchase of the government Haber plant at Billingham, it is intended to consolidate the firm's position in the nitrogen industry as far as possible. The dispute between Brunner-Mond and Lever Bros. in regard to the hydrogenation of fats and the manufacture of alkali was settled some time ago, and the transfer to Lever Bros. of Crosfield & Gossage's soap works is evidently intended to leave the soap industry in the hands of the one combination and the alkali industry in that of the other, probably with a mutual understanding in regard to the use of processes germane to both industries.

The alkali position will probably be affected in the future by the large quantities of sodium carbonate which will be available in British East Africa from the Magadi Soda Co. Operations on the branch railway to the deposits were suspended during the war, all such facilities being required for military operations. The railway has now been restored to the company, and it is stated that the first shipments of soda will be forthcoming in the summer of this year.

British Cellulose Co.

The British Cellulose Co., it will be remembered, erected large works at Spondon, near Derby, to manufacture cellulose acetate for airplane manufacture. The British Government provided about $9,000,000, secured upon the property, and after many vicissitudes, production commenced on a large scale some months before the end of the war. The company was adversely criticized, but largely exonerated by the special committee appointed to investigate its activities. Further capital being now required, the government was induced to exchange its debentures for profit-sharing preference shares, being part of the new issue. We thus have the curious situation of the government becoming a speculative shareholder in a chemical manufacturing company whose objects, as explained in the prospectus, go far beyond that of dope manufacture. One of the probable sources of profit indicated is that of artificial silk manufacture, and it is not surprising that much objection should have been taken to the government's course, not only by the artificial silk manufacturers, but also by the general public, which does not appreciate government competition with private enterprise.

British Manufacturers' Report

The report of the Association of British Chemical Manufacturers previously referred to[1] has been issued in abstract to the press, but it is still not available in full to the general public or to chemical manufacturers abroad, although it is hardly possible to prevent its indirect transmission. Missions such as that which issued the above report seem to give rise to some misunderstanding and suspicion. Thus, in the above case, a creditable report was evolved in the short space of three weeks' stay in Germany, yet adverse criticisms in regard to its contents have been made by those who did not take part and it has even been hinted that much additional useful information might have been included, which was either overlooked or withheld on account of uncertainty or self-interest. Again, in the case of the Color Users' Purchasing Commission, which visited Germany at the end of January, the principle of collective buying which its name indicates is not generally accepted (by the smaller users, at any rate) as the most advantageous one, and this in spite of the obvious lessons that could be drawn from such methods of co-operation in Germany before the war.

The Spirit of Co-operation

These internal dissensions are almost entirely due to the lack of co-operation in the British chemical industry as a whole and the ingrained distrust, jealousy and suspicions of the smaller manufacturers and, in some degree, of the various learned societies, which time and experience alone can eradicate. The fine chemical industry is a distinct sinner in this respect, and the leading firms in that industry show no signs of taking a lead in regard to co-operation, but maintain complete silence as to their future program. Signs are, however, not wanting that the smaller fine chemical manufacturers are discontented with the lack of capital of the industry as a whole and the aloofness of the larger manufacturers.

An attempt will probably be made to prevent the closing down of some of the smaller works, which will be inevitable if the industry as a whole is not placed on a secure foundation comparable with the American and continental organizations. As regards the various technical societies, it is understood that the scheme by which they will nearly all be accommodated in a central building on the lines of the Engineering Societies in the United States will shortly be formulated and that it will involve the raising of a very large fund. The matter is in the hands of the Federal Council of Learned and Scientific Societies under the guidance of Sir William Pope.

A more favorable moment could hardly have been chosen than the present in appealing for funds, when the value of science and chemistry in particular is at last being appreciated in some measure by the general public. The dinner of the Chemical Trade Association did not justify the hopes of its organizers, but when the older and more influential manufacturers proceed with their new and more comprehensive association, the position will become more stable. The functions and uses of a chemical merchant are not properly appreciated either by the general public or by the manufacturers, and in fact, the latter have lately been making strenuous efforts by direct and indirect propaganda to eliminate the merchant and middleman as far as possible. In doing so and in setting up their own special sales organizations, they overlook the fact that a merchant can dispose of the output of several factories more easily and at a lower cost than a single manufacturer can deal with his own output. While this policy may be satisfactory for the largest firms or for co-operative sales organizations in special lines such as sulphate of ammonia, the policy is unsound and may lead to retaliation from the merchants should they themselves decide to manufacture.

[1] Chem. & Met. Eng., vol. 22, No. 9, March 3, 1920, p. 389.

Ethylene and Propylene Chlorhydrins and Glycols From Oil Gas

Description of the Synthesis of Glycols From Ethylene and Propylene by Clorhydrating and Hydrolyzing—Content of Ethylene and Propylene in Oil Gas — Details Regarding Methods, Distilling and Hydrolyzing

By BENJAMIN T. BROOKS

THE chemical utilization of petroleum, that is, in ways other than direct combustion as fuel, readily suggests a series of latent or undeveloped possibilities. The present work is an effort to develop one phase of this problem.

Interest in the simpler chlorhydrins and glycols has been recently revived in connection with the substitution of glycols for glycerine in explosives and also in connection with the manufacture of ββ dichlorethyl sulphide, or the now well-known mustard gas. The Germans made their mustard gas from ethylene chlorhydrin, but in the Allied countries this method was superseded by the direct or sulphur chloride method.[1]

The simpler glycols have frequently been proposed as substitutes for glycerine but until quite recently a satisfactory method for their commercial manufacture has been lacking. In normal times the supply of glycerine available in the sweet lye from soap manufacture more than meets the demand for such material and the larger soap manufacturers are able to recover glycerine of good quality at a very low cost. However, it is possible that uses for the glycols may be found in which the glycols may possess certain advantages over glycerine. Ethylene and propylene glycols are much less viscous than glycerine and may therefore have a certain advantage over the latter in refrigeration systems, low freezing solutions and the like.

Several years ago A. M. Hough[2] showed that glycols can be smoothly nitrated to the corresponding dinitrates and that these glycol dinitrates may be mixed with nitroglycerine to form very low freezing mixtures. Hough seems to have been the pioneer of practical work in this field, although the glycol nitrates were made and described many years ago by Henry,[3] Champion,[4] Demjanow,[5] Nef[6] and others. Mathews, Strange and Bliss[7] have patented explosives containing nitrated 1,2 glycols compounded with nitrocellulose, infusorial earth, etc., and under the Jolicard patent[8] explosives containing nitroglycerine, together with nitrocellulose, nitroglycerine and nitrate salts, are said to have been manufactured industrially in Europe.

Other substances capable of lowering the freezing point of nitroglycerine and possessing explosive values of their own have been tried, for example glyceryl monochlorhydrin dinitrate[9] and glyceryl methyl ether dinitrate.[10] One objection which explosive manufacturers have repeatedly raised against the nitroglycols is their high volatility as compared with nitroglycerine, and their toxicity. Several patents on explosives containing nitroglycols have recently been granted to J. Barab.[11]

Ethylene and propylene glycols, as described in the earlier literature, are very hygroscopic liquids, considerably more volatile than glycerine. This tendency to evaporate causes flexible glue compositions containing glycol to become brittle. On the other hand, when added to tobacco, the natural resins present appear to retard the evaporation of the glycol.

Trimethylene glycol, or 1.3 dihydroxypropane, has also long been known and is obtained in commercial quantities as a minor byproduct in the manufacture of glycerine and is apparently formed from glycerine itself by fermentation. The total available supply of this material is, however, quite small.

The cheapness of chlorine under present conditions brings the manufacture of these glycols and chlorhydrins within the bounds of economic production. The following résumé indicates the methods thus far found successful and indicates also other possible methods.

Dihalides

In the older published work the dibromides were employed almost exclusively, on account of the ease of preparing them in the laboratory and the facility with which they are hydrolyzed or converted into esters. The chlorination of oil gas with the formation of Dutch liquid was first carried out by Faraday in 1825.[12] As pointed out by Armstrong and Miller,[13] "oil gas" has the same general composition, whether made from fatty or mineral oils. But the chlorination of ethylene to the dichloride, which is the kernel of the matter, was first carried out in 1795 by the four Dutch chemists from whom the dichloride gets its name of "Dutch liquid." Several recent patents on the subject refer to special methods of chlorination.[14]

[1] The preparation of mustard gas, or *ββ* dichlorethyl sulphide, from ethylene chlorhydrin was plainly indicated by the work of Victor Meyer and Clark, and involves treatment of aqueous ethylene chlorhydrin with sodium sulphide, concentrating or dehydrating the dioxysulphide thus formed and warming the latter with concentrated hydrochloric acid. It was perhaps fortunate that the manufacture of ethylene chlorhydrin, on a commercial scale, had not been perfected in any of the Allied countries, since by the development of the direct sulphur chloride process the Allies were able to reach a production capacity for mustard gas approximately thirty times that of the Central Empires. (Pope, *J. Chem. Soc.*, vol. 115, p. 402, 1919.)

[2] U. S. Pat. 1,206,233.

[3] *Ann. d. Chim.* (4), vol. 27, p. 253 (1872), vol. 28, p. 425 (1873).

[4] *Compt. rend.* vol. 73, p. 571 (1871).

[5] *Chem. Zentr.*, 1899, vol. 1, p. 1,064.

[6] *Liebig's Ann.*, vol. 335, p. 279 (1904); cf. also Mixter, *Am. Chem. J.*, vol. 13, p. 507 (1891); Carlson, *Ber.*, vol. 40, p. 4,192 (1907).

[7] Fr. Pat. 458,309 (1913).

[8] Fr. Pat. 456,456 (1912). One composition reported is as follows: nitroglycerine 66.4 per cent, glycol dinitrate 16.6 per cent, collodion 5.0 per cent, KNO_3 10.0 per cent, cellulose 2.0 per cent (cf. *Z. Schiess u. Spr.*, 1913, p. 234.

[9] Sprengstoffwerke R. Nahnsen & Co., D. R. Pat. 37,854

[10] Jones, *J. Chem. Soc.*, vol. 115, p. 76 (1919).

[11] U. S. Pats. 1,307,032, 1,307,033, 1,307,034.

[12] *Philos. Trans.*, 1825, p. 440.

[13] *J. Chem. Soc.*, 1886, p. 74.

[14] Brooks & Smith, U. S. Pats. 1,231,123, 1,235,283; Smyth, *J. Soc. Chem. Ind.*, vol. 35, p. 1,130 (1916); Tinker, Br. Pat. 108,602; Meigetsu, U. S. Pat. 1,224,485; Harding, Br. Pat. 126,511 (1918).

The author, with I. W. Humphrey,[15] has shown that the conversion of ethylene chloride to glycol proceeds readily when heated under pressure with methyl alcohol and an alkali formate, ethylene diformate being formed as an intermediate product. Aqueous carbonate or bicarbonate solutions at somewhat higher temperatures and pressures also give good yields, which process has been patented by Matter.[16]

Chlorhydrins

The conversion of ethylene and propylene chlorhydrins to the corresponding glycols may be effected by heating with aqueous bicarbonate or carbonate solutions. The best yields, about 85 per cent of the theory, are obtained by heating chlorhydrin solutions containing not over 20 per cent chlorhydrin with a slight excess of sodium bicarbonate in an autoclave to 110 deg. for about two hours. Hydrolysis of the chlorhydrin with evolution of carbon dioxide is quite appreciable at 70 deg. but by simply refluxing the chlorhydrin with bicarbonate solution the yield of glycol is about 50 per cent of the theory. This method, which has also been patented,[17] gives very much better yields than the older methods described in the literature by Henry and others. Typical results of this method are described below.

Oxidation of olefines to glycols by cold dilute permanganate solution is frequently given in text books as a general method, but as the yields are seldom more than 5 per cent of the theory and the materials costly, this is clearly out of the question as a commercial method. However, catalytic oxidation by oxygen or air through an intermediate oxygen carrier, as is suggested by the work of Hofmann and Schneider[18] on oxidation in the presence of a very small quantity of osmic acid, would be economically sound should suitable catalysts be discovered.

Raw Materials

Oil gas, containing 35 to 45 per cent olefines, still gases from petroleum cracking stills and containing 10 to 12 per cent olefines, and ethylene made by the decomposition of alcohol are the only sources of ethylene and propylene of practical importance. The hydrogenation of acetylene to ethylene has never been carried out on a large scale, nor by any method having great promise of industrial success. One possible source of these simpler olefines is suggested by the large quantities of ethane and propane which are available in natural gas, or more specifically, in the very light fractions ordinarily permitted to escape from casing head gasoline which has been condensed under considerable pressure.

Ethane and propane are partially converted into ethylene and propylene by heat and the monochlorides are almost quantitatively decomposed to the corresponding olefines by passing the vaporized chlorides over pumice impregnated with barium chloride and heated to 400 to 450 deg. C.[19]

The manufacture of very pure ethylene by the catalytic decomposition of alcohol, together with a little steam, in contact with kaolin at 400 to 500 deg. has been carried out on a large scale with excellent yields and low cost by the U. S. Chemical Warfare Service.[20]

[15] *J. Ind. Eng. Chem.*, vol. 9, p. 750 (1917).

[16] U. S. Pat. 1,237,076.

[17] Soc. An. d'Explosifs et de Prod. Chim., Fr. Pat. 458,733 (1912).

[18] *Ber.*, vol. 46, p. 1,657 (1913); vol. 48, p. 1,585 (1915).

[19] This has not been carried out on a large scale.

[20] Dorsey, *J. Ind. Eng. Chem.*, vol. 11, p. 288 (1919); Engelder, *J. Phys. Chem.*, vol. 21, p. 676 (1917); Hough, U. S. Pat. 1,206,222, employs $Al_2(SO_4)_3$ on an inert material at 350-400 deg. Of. also Norris, *J. Ind. Eng. Chem.*, vol. 11, p. 821 (1919).

Although oil gas has been manufactured for a great many years and under widely varying conditions, little or no attention has been given to its composition with respect to the different olefines which it contains, as these are commonly determined together as "illuminants."

The data given in Table I indicate approximately the composition of oil gas, with respect to ethylene and propylene, as made in commercial practice in a gasifying apparatus of the Pintsch type. The temperatures given are those at the beginning and end of the gas-making periods. From the work of Whitaker, Rittman and Alexander, it is certain that the percentages noted are not the equilibrium values for these temperatures. Also from the work of Hall it is recognized that comparatively slight variations in temperature produce large changes in the composition of the resulting gas. The data given are merely those obtained from gas made by commercial practice.

TABLE I. PER CENT ETHYLENE AND PROPYLENE IN OIL GAS[21]

Temp. Deg. C.	Higher Olefines, Per Cent	C_3H_6 Per Cent	C_2H_4 Per Cent	Total Olefines Per Cent
805—650	1.4	18.6	16.3	36.3
660—535	1.6	19.0	18.3	38.9
635—535	2.4	22.4	12.5	37.3
625—535	2.6	22.6	13.7	38.5
615—425	3.8	25.7	12.0	41.5

The data in Table II show the composition of the oil gas obtained by rapidly passing the oil vapors, under pressure, through tubes heated to certain definite temperatures in an apparatus of the Hall type.

TABLE II. COMPOSITION OF OIL GAS MADE IN TUBES MAINTAINED AT DEFINITE TEMPERATURES

Temperature, deg. C	600	650	700	730
Pressure, lb	57	72	83	95
Ethylene, per cent	19.3	19.0	17.7	17.5
Propylene, per cent	28.0	28.4	23.9	20.0
Higher olefines, per cent	3.2	4.2	3.5	3.1
Total olefines, per cent	50.5	51.6	45.1	40.6

Although the per cent of total olefines is somewhat less at the higher temperature, the net yield is considerably greater on account of the larger volume of gas produced, as is indicated by the figures given in Table III.

TABLE III. PER CENT OIL GASIFIED IN HALL TYPE APPARATUS AT DIFFERENT TEMPERATURES

Temperature, Deg. C.	Per Cent Gas	Per Cent Ethylene and Propylene
605	17.7	47.9
625	26.6	46.1
645	37.6	44.9
665	40.0	43.7
685	40.8 (?)	42.6
705	48.7	39.5
725	66.6	38.5

It will be noted in the analysis quoted that the higher olefines commonly represent about 4 per cent by volume of ordinary oil gas and may be present to the extent of 10 per cent in a gas made at low cracking temperature and containing about 52 per cent total olefines. In order to limit the chlorhydrins and glycols to ethylene and propylene (incidentally removing[22] also benzine and

[21] The above values were obtained by absorbing the higher olefines in 70 per cent sulphuric acid (Hempel pipette), the propylene in concentrated sulphuric acid sp.gr. 1.84 at room temperature, and the ethylene in bromine water. According to Nef (*Liebig's Ann.*, vol. 318, p. 1901) these olefines may be quantitatively separated and determined in this manner. In the author's opinion, this method is much more accurate than that of fractionating the mixture of olefine dibromides, and is very much more rapid.

[22] The resulting liquid is practically identical with the light "drips" which it is customary to separate in the manufacture of Pintsch gas.

gasoline vapors), it is necessary to remove the higher olefines, which in this work was done by cooling and compressing to 175 to 200 lb. pressure.

Ethylene and Propylene Chlorhydrins

The problem of manufacturing these chlorhydrins proved not to be particularly difficult, once the discovery was made that the addition of hypochlorous acid to ethylene and propylene takes place at ordinary temperatures in very dilute aqueous solution with extreme rapidity.

Some of the older work, for example that of Wurtz and Carius, was misleading in this respect. They permitted ethylene to be slowly absorbed by a fairly strong solution of hypochlorous acid during long standing in the dark at room temperature and atmospheric pressure. The chief factor retarding the actual preparation of the chlorhydrins appears to be the solution of the gas in the aqueous solution. Thus we have found that it is not necessary to employ solutions more concentrated than 0.10 per cent total hypochlorites. Conditions which promote the solution of the gas in the aqueous solution, as for example agitation or moderate pressures, and which should not appreciably affect the rate of the reaction with HOCl, very greatly accelerate the formation of chlorhydrin.

The Preparation of Hypochlorous Acid

In the earlier work on chlorhydrins the method of preparing hypochlorous acid usually was the well-known reaction between mercuric oxide and chlorine water.[23] The method of adding a weak acid, such as boric acid, to a hypochlorite in dilute aqueous solution was carried out by Lauch,[24] Bamberger,[25] Baeyer and others. A more satisfactory method is that of Wohl and Schweitzer,[26] which consists in passing chlorine into a cooled solution of sodium carbonate or bicarbonate. Weyl also recommends this method.[27] H. V. Walker has patented a variation of this method, which consists in adding an excess of sodium bicarbonate to an alkaline solution of sodium hypochlorite.[28]

Although quite concentrated solutions of sodium hypochlorite are quite stable when sodium hydroxide is in excess, as shown by Muspratt and Smith,[29] the decomposition of such concentrated hypochlorite solutions is so rapid the instant free hypochlorous acid is present that good yields of chlorhydrin are not obtainable from them. The gradual liberation of free HOCl, in the presence of ethylene and propylene, by weak acids such as CO_2 and boric acid, were tried but the yields of chlorhydrin based on the original quantity of hypochlorite were only 25 to 30 per cent of the theory. Somewhat better results were obtained by liberating HOCl from bleaching powder by CO_2 in the presence of ethylene and according to Norris[30] the Germans made ethylene chlorhydrin, for mustard gas manufacture, in this manner.

The continuous process described below gave much better results, however, and work with concentrated hypochlorite solutions was abandoned.

McElroy[31] has patented a novel and ingenious method of manufacturing chlorhydrins from ethylene or oil gas, which consists in passing the olefines into a mixture of steam and chlorine. According to the author's experience, on a large experimental scale, large proportions of highly chlorinated oily products result under these conditions. The apparatus required is large and comparatively costly. Typical results are as given in Table IV.

TABLE IV. TREATMENT OF OIL GAS WITH STEAM AND CHLORINE

	I	II	III
Total gas used, cu.ft.	1,920.00	1,730.00	2,010.00
Gas rate, cu.ft. per hr.	240.00	216.00	251.00
Total chlorine, lb.	53.40	51.60	52.20
Pounds chlorine to 1 lb. chlorhydrin.	2.27	2.40	1.86
Dilute chlorhydrin distillate, lb.	582.00	312.00	545.00
Steam, total lb.	1,460.00	1,364.00	1,477.00
Per cent chlorhydrin in distillate.	4.05	6.91	5.15
Steam, lb. to 1 lb. chlorhydrin.	62.00	63.00	52.80
Total lb. chlorhydrin.	23.50	21.50	28.00

From what is known of the properties of hypochlorous acid it seemed probable that better yields would be obtained by working with cold aqueous solutions. Considerable careful work on the system

$$Cl_2 + H_2O \leftrightharpoons HOCl + HCl$$

has shown that the relative amount of hypochlorous acid which is present at any one moment is quite small. But, as shown by Gomberg,[32] the velocity of the combination of HOCl and ethylene is so much greater than that of the formation of ethylene chloride that very excellent yields of ethylene chlorhydrin may be obtained by passing chlorine and ethylene into cold water, with vigorous agitation to promote the solution of the two gases.

This operation is readily carried out with oil gas in a suitable apparatus, i.e., one in which the cold reaction solution does not have to be pumped or circulated. The apparatus developed by the author for making chlorhydrin was of the liquid circulating type, and in order to minimize the corrosion difficulties the free HCl in the solution was neutralized by soda ash, sodium bicarbonate or borax, although, as shown by Gomberg, the salt which thus accumulates in the solution retards the production of chlorhydrin. The general plan of the apparatus employed is shown in Fig. 1. In a small apparatus of this type, in which the reaction tower measured 12 ft. x 12 in., it was shown that the production of chlorhydrin was fairly rapid until the solution contained about 5.0 per cent chlorhydrins. Thus in one experi-

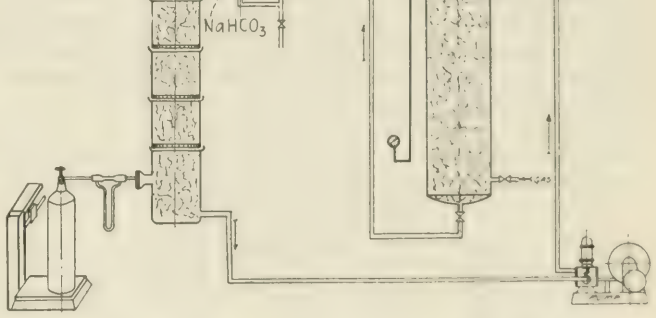


FIG. 1. SKETCH SHOWING MANNER OF TREATING OIL GAS WITH HYPOCHLOROUS ACID SOLUTION

[23] Reformatsky, *J. prakt. Chem.*, N. F., vol. 40, p. 396 (1889).
[24] *Ber.*, vol. 18, p. 2,287 (1885).
[25] *Liebig's Ann.*, vol. 288, p. 81 (1895).
[26] *Ber.*, vol. 40, p. 94 (1907).
[27] "Die Methoden d. Org. Chem." Leipsig, 1911, vol. 2, p. 794.
[28] U. S. Pats. 972,952, 972,954.
[29] *J. Soc. Chem. Ind.*, vol. 17, p. 1,096 (1898); vol. 18, pp. 210,-232 (1899).
[30] *J. Ind. Eng. Chem.* vol. 11, p. 817 (1919).
[31] U. S. Pats. 1,253,616; 1,295,339.
[32] *J. Am. Chem. Soc.*, vol. 41, p. 1,414 (1919).

ment lasting 14 hr. the concentration of chlorhydrin in the solution at the end of 7.5 hr. was 5.0 per cent, but in the next 6.5 hr. only increased to 6.65 per cent, although chlorine and oil gas were supplied at the same rate and all other conditions, pressure and temperature, remained the same. Also it was noted that propylene reacted more readily than ethylene, as was indicated by the fact that the proportion of ethylene to propylene was much greater in the exit gases than in the gas supplied to the hypochlorous acid solution; for example, a gas contain-

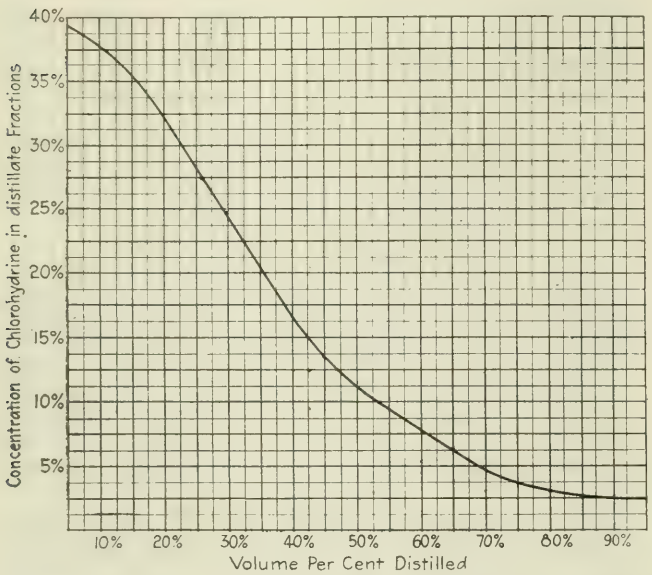


FIG. 2. DISTILLATION BEHAVIOR OF ETHYLENE CHLORHYDRIN ABOUT 24 PER CENT BY WEIGHT SOLUTION

ing 15.7 per cent ethylene and 10.2 per cent propylene after passing through the apparatus showed 3.4 per cent propylene and 3.6 per cent ethylene.

After a large number of experimental runs, the data of which it is not necessary to include here, a larger cement lined apparatus was erected, of dimensions permitting the employment of about 600 lb. of chlorine and 1,000 gal. of solution per batch. The circulating solution was cooled to keep the temperature practically constant at 15 deg. C. The following results, obtained in the larger apparatus, under 75-lb. gas pressure and using oil gas containing 34 to 36 per cent total ethylene and propylene, are representative:

TABLE V. ETHYLENE AND PROPYLENE CHLORHYDRINS FROM OIL GAS AND COLD AQUEOUS HOCl

Exp. No.	Chlorine, Lb.	Gas, Cu.Ft.	Sodium Bicarbonate, Lb.	Olefines Used, per 100 Cu.Ft. Gas	Chlorhydrin Per Cent	Chlorhydrin Lb.
I	415	3,470	607	32.6	4.55	407
II	424	4,290	600	28.8	4.70	425
III	531	5,060	650	29.4	5.30	488
IV	540	4,530	700	26.5	4.65	430
V	681	6,040	750	28.4	7.75	561

Sodium bicarbonate may be replaced by soda ash with equally good results, but the solution must be cooled more strongly to maintain the temperature at 15 deg. on account of the heat of solution of soda ash and the larger amount of heat developed by neutralization.

Aqueous ethylene chlorhydrin is not affected by free chlorine at 0 deg. Propylene chlorhydrin is only very slowly acted upon by free chlorine at this temperature. At about 95 to 100 deg. and in the presence of steam small quantities of very acrid irritating substances are produced, probably chloracetaldehyde and chloracetone.[33] Gomberg[34] has noted the distillation behavior of dilute ethylene chlorhydrin solutions. Fig. 2 indicates the distillation behavior of an ethylene chlorhydrin solution, 24 per cent by weight, the first fractions consisting of the constant boiling mixture containing 37.5 per cent chlorhydrin. Fig. 3 gives the distillation behavior of the oil gas chlorhydrins, ethylene and propylene chlorhydrins being present in about equal amount, the aqueous solution taken for distillation containing 24 per cent by weight of the chlorhydrins. The same figure also shows (curve I) the effect of saturating a solution of the same concentration with common salt. On saturating with salt two layers are formed, the upper layer containing most of the chlorhydrin, and it will be noted that the distillation of the saline chlorhydrin solution more nearly approaches that of a pair of two mutually insoluble liquids. When the initial solution contains more chlorhydrin than corresponds to the constant boiling mixture, the latter will of course distill first and finally anhydrous chlorhydrin will distill, as indicated in Fig. 4.

As the work described in the present paper was carried out under industrial conditions and primarily for the purpose of making the mixed glycols, no attempt was made to distinguish between the two isomeric propylene chlorhydrins. Michael,[35] Henry,[36] Smith[37] and others have shown that on the addition of HOCl to propylene the resulting chlorhydrin mixture contains mostly chlor-β-hydroxypropane.

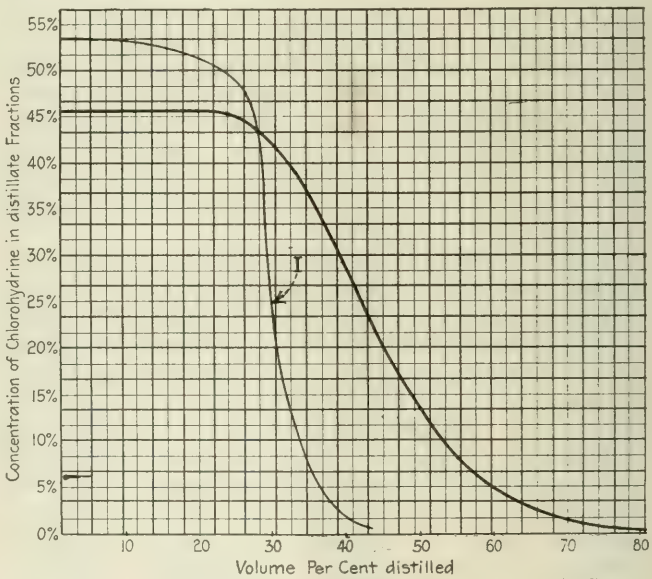


FIG. 3. DISTILLATION BEHAVIOR OF OIL GAS CHLORHYDRINS

That anhydrous chlorhydrins possess valuable solvent properties is well known, but the ease with which they hydrolyze, with the formation of hydrochloric acid, greatly restricts their field of usefulness. The hydrolysis of an 8 per cent solution of ethylene chlorhydrin at 95

[33]The relative stability of ethylene chlorhydrin to chlorine is of interest as indicating the influence on the $-CH_2OH$ group of a chlorine atom attached to the adjacent carbon atom. It tends to confirm also the generally accepted view that when ethyl alcohol is chlorinated the $-CH_2OH$ group is first attacked to form CH_3CHO, which then immediately is chlorinated in the methyl group, finally to chloral.

[34]*J. Am. Chem. Soc.*, vol. 41, p. 1,414 (1919).

[35]*Ber.*, vol. 39, p. 2,785 (1906).

[36]*Bull.*, Acad, royal Belgique 1906, p. 523: *Comp. rend.*, vol. 134, p. 1,070 (1902).

[37]*J. Chem. Soc. Abs.* (1913), p. 35; cf. Krassusky Jahresber, d. Chem. (1901), p. 581.

deg. (maintained at 95 deg. in a Freas oven) is graphically indicated in Fig. 5. The hydrolysis of propylene chlorhydrin, 9.4 per cent, or equivalent to the concentration of the ethylene chlorhydrin solution, is also shown in Fig. 5.

The use of chlorhydrins as solvents for cellulose acetate has been patented by Lindsay and by the von Hayden Chemical Co.[38] Glycol mono-acetate is said to affect favorably the physical properties of cellulose acetate films and also increases the ability to dye.[39]

Although the simpler chlorhydrins have frequently been salted out with potassium carbonate, it was apparently not observed until comparatively recently that by merely warming the aqueous solutions with alkali carbonates or bicarbonates, glycols are produced. Evans[40] stated that the alkali carbonates converted these chlorhydrins into the corresponding alkylene oxides, but did not actually isolate or identify them. On heating aqueous solutions of ethylene or propylene chlorhydrins and sodium bicarbonate to 65 deg., marked evolution of carbon dioxide takes place. By refluxing with sodium carbonate or bicarbonate and carefully working up the aqueous solution for glycol, yields of 44 to 48 per cent of the theoretical are obtained. The remainder is converted into ethylene and propylene oxides which pass off with the carbon dioxide. The older statements are therefore partly correct. By carrying out the reaction in an autoclave and heating to 105 to 110 deg. C. for 2 hr., yields of glycol equivalent to about 90 per cent of the theory are obtained. The remainder is a tarry material which cannot be distilled at 10 mm. without decomposition and is probably identical with the non-distillable

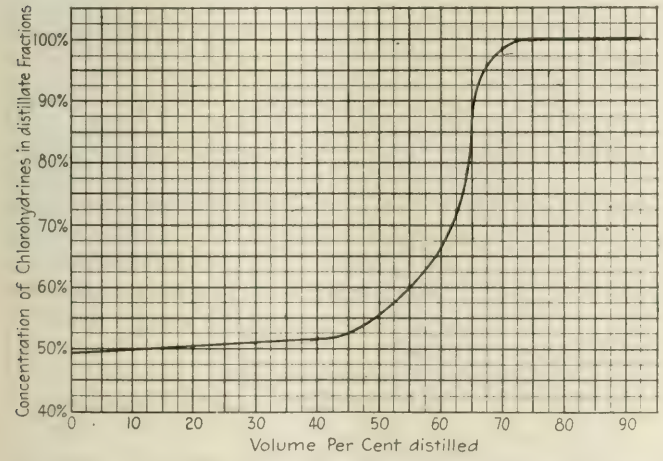


FIG. 4. DISTILLATION BEHAVIOR OF 70 PER CENT ETHYLENE AND PROPYLENE CHLORHYDRIN MIXTURE: 30 PER CENT WATER

amorphous substance obtained by Wurtz by treating ethylene oxide in aqueous solution with alkali.[41]

It might conveniently be noted here that the yields of alkylene oxides obtainable from the simpler chlorhydrins depend upon the concentration of caustic alkali and the removal of the volatile oxides from the reaction mixture as rapidly as possible. Thus by dropping concentrated, nearly anhydrous (90 per cent) ethylene chlorhydrin upon solid caustic soda and stirring slowly to break up the crusts of sodium chloride, a yield of 80 per cent of the theory of ethylene chlorhydrin is obtained. When an equivalent quantity of 10 per cent caustic soda is employed no ethylene oxide can be obtained and evaporation of the solution yields an amorphous material probably identical with Wurtz's product.

Ethylene chlorhydrin gives nearly theoretical yields of the glycol. A typical result is the following: Twelve kilos of a solution containing 6.22 per cent ethylene chlorhydrin was treated with 835 g. sodium bicarbonate and heated for 1 hr. at 105-110 deg. C. in an autoclave. From the resulting solution 536 g. anhydrous ethylene glycol was obtained, which is equivalent to 93.5 per cent of the theoretical yield.

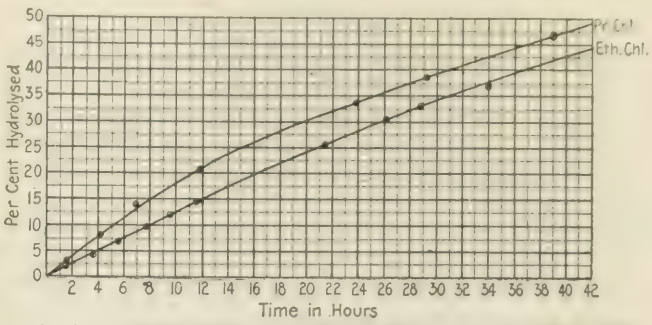


FIG. 5. HYDROLYSIS OF ETHYLENE AND PROPYLENE CHLORHYDRIN SOLUTIONS AT 97 DEG. C.

An aqueous solution containing 20.8 per cent ethylene and propylene chlorhydrins, from oil gas, the two chlorhydrins being present in nearly equal amounts, gave a slightly lower yield. Three kilos of the chlorhydrin solution, equivalent to 625 g. anhydrous chlorhydrins, and 570 g. sodium bircarbonate, yielded 403 g. glycol, or about 81.5 per cent of the theoretical. Slightly lower yields of glycol were obtained when sodium carbonate was substituted for sodium bicarbonate. To 300 g. anhydrous chlorhydrin mixture 5.5 liters of water and 180 g. sodium carbonate were added and the mixture heated for 1 hr. at 105 deg. From the solution 176 g. glycol was recovered, equivalent to 74.2 per cent.

The above processes have been carried out on a semi-industrial scale. The autoclave pressures, due chiefly to the carbon dioxide liberated, are not excessive, ranging from about 100 to 150 lb., depending upon the concentration of the solutions employed and the relative volumes of liquid and air space in the autoclave. The recovery of glycol from the saline aqueous solutions is very much the same as in the case of glycerine, except that the two glycols are much more volatile than glycerine, ethylene glycol boiling at 197.5 deg. C. and propylene glycol boiling at 188 deg. The separation between water and the glycols on distilling is therefore not so sharp as in the case of glycerine. In order to obtain water-white anhydrous glycol free from decomposition products it is necessary to distill *in vacuo*, and on a large scale the same type of still as is employed for glycerine serves admirably for the glycols. On account of the large quantities of salt in the glycol reaction mixture it is preferable to concentrate to a glycol-water ratio of about 70 : 30, when nearly all the salt is deposited. The filtered glycol may then be distilled *in vacuo* without difficulty, which practice of course is not novel, closely following the procedure common with glycerine liquors.

The author desires to express his indebtedness to Dr. J. B. Conant and Dr. James R. Norris of the U. S. Chemical Warfare Service for their many suggestions and advice.

[38]German Pat. 288,267 (1914).
[39]Henckel-Donnersmarck-Werke. German Pat. 228,867 (1907).
[40]*Z. physik. Chem.*, vol. 7, p. 337 (1891).
[41]*Ber.*, vol. 10, p. 90 (1886).

Balanced Reactions in Steel Manufacture*

An Argument That the Oxidation of Iron During Melting Is by Steam, That Iron Oxide Is Soluble in Molten Iron, and That Silicon Is Reduced From an Acid Slag by Carbon—Observations on the Composition of Gas in Blow-holes and in Solution in Solid Steel

BY ANDREW McCANCE

THERE is no satisfactory theory of the reactions which take place in the open-hearth furnace during the manufacture of steel. A general view presents several separate groups of facts with independent explanations which have not yet been connected, one with the other, in logical sequence. In this paper a rough outline is put forward of these facts considered from the standpoint of physical chemistry and of well-established theoretical principles, and the connection which exists between the final quality of the solid steel and the antecedent conditions during manufacture is traced with special reference to the contained gases. Though the author deals mainly with the open-hearth process, much of course is applicable to the other processes of steel manufacture, where the general conditions are similar in principle though different in detail.

MELTING

During the melting period in the furnace the metal is in contact with a variety of gases, such as CO_2, water vapor, nitrogen, as well as unburned oxygen and CO, with which it can react under appropriate conditions. There is one fact which guides us, however, in determining the dominant reaction from among the many complex reactions possible, and that is, that as the average temperature of melting gets lower there is greater oxidation of the scrap and consequently more FeO in the slag. Every steel-smelter knows that with a cold heat there is a more open slag and a greater tendency to go on the boil without ore than when the charge is melted hot. In terms of slag analyses, the following are two typical cases:

	FeO	SiO_2
Cold heat	36.3	36.4
Hot heat	20.8	45.0

The higher the temperature is, the rate of oxidation of the iron gets less, and possible reactions may be considered in the light of this fact.

1. The direct oxidation of the iron by the air is ruled out of account at once, since it is known that the rate at which scale forms on an iron surface increases greatly with temperature. Direct oxidation does, of course, take place, but it is not the main cause of oxide formation, but only a secondary one.

2. Oxidation by CO_2 is possible in two ways

$$Fe + CO_2 = FeO + CO - 2.3 \text{ cal.}^1 \quad (1)$$

$$3Fe + 4CO_2 = Fe_3O_4 + 4CO - 1.4 \text{ cal.} \quad (2)$$

These are balanced reactions, of which the first has been worked out fairly fully, and the composition of the gases which are in equilibrium with iron and ferrous oxide at different temperatures is as follows:

Temp., Deg. C.	CO Per Cent	CO_2	Ratio CO:CO_2
550	54	46	1.16
650	58	42	1.38
750	61	39	1.56
850	68	32	2.12
900	71.5	28.5	2.51

In Appendix II the author has calculated what the composition would be at higher temperatures, and finds that at 1,500 deg. it would be CO = 92.4, and CO_2 = 7.6, so that if the iron was in contact with any gas containing more than 7.6 per cent CO_2 it would be oxidized. But the burned gases in a steel furnace contain very little CO, and consequently reaction is possible. But the higher the temperature the greater will be the difference between the gases in contact and the gases in equilibrium, so that the higher the temperature the greater the oxidation.

This result can be obtained in another way by the Le Chatelier principle, for on giving the reaction heat, it must proceed so as to absorb heat. It has a negative heat of reaction, and must in consequence proceed from left to right, that is, more FeO will be formed. Exactly the same result is obtained with the second reaction, so that neither of these can be the dominant reaction during the melting period.

3. The action of steam on iron gives

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2 + 38.5 \text{ cal.}^2 \quad (3)$$

With increasing temperature the amount of hydrogen gets less, and the same result follows from the Le Chatelier principle, so that the rate of oxidation is in accord with the slag condition as observed in practical working.

If the loss due to scaling is to be minimized and as little of the charge as possible is to find its way into the slag as oxides, three conditions have to be observed:

1. Melt down rapidly.
2. Melt down at high temperature.
3. Have a low steam content in the burned gases.

Nos. 1 and 2 give together hot and quick working. It is often held that during the melting-down period the temperature of the bath must be constant, since there is solid and liquid metal in contact; but this is only true if there is equilibrium, which never holds for steel-melting furnaces. So long as the liquid bath is growing at the expense of the solid scrap there is a difference in temperature between them, and the quicker the rate of melting the greater must this difference be. Pyrometer observation shows, in fact, that the temperature of the liquid bath is rising steadily during the melting period.

The presence of steam in the burned gases arises from the combustion of the hydrogen in the producer-gas together with any undecomposed steam which has passed through the producer. The composition of the gas has therefore a direct bearing on the working of the furnace and on the loss of metal due to scaling.

*A paper presented in a symposium on "The Occlusion of Gases by Metals," *Transactions* of the Faraday Society, vol. 14, p. 213.

[1]Baur and Glässner, *Z. physik. Chem.*, 1903, vol. 43, p. 354.

[2]Deville, *Liebig Ann.*, vol. 156, p. 76; Preuner, *Z. physik. Chem.*, 1904, p. 385.

As a result of this reaction the steel has an opportunity of absorbing hydrogen. There is no experimental evidence as to the extent of the solubility of hydrogen in iron in the liquid or solid state. Baraduc-Muller[3] found that the rate of evolution of hydrogen during solidification was not much greater than the rate of evolution after the steel had become completely solid. If there is little difference in the solubility in the liquid and in the solid state, it is unlikely that hydrogen is ever the cause of blow-hole formation in steel.

Boiling Period

After melting, the liquid bath has a covering of slag containing FeO and other oxides (which, however, take no part in the subsequent reactions), together with silica. Independently of how these constituents are combined one with the other, the slag can be regarded as an impure solution of ferrous oxide in silica. The addition of iron ore increases the strength of this FeO solution, and since there is no contrary evidence it must be inferred that iron oxide so added cannot act on the steel bath without first going into solution in the slag. The first action of the slag is to oxidize any Si and Mn in solution in the liquid metal; but these reactions need not be considered here, since they do not give rise to gaseous reaction products. After they have been removed, however, the carbon is attacked according to the equation

$$FeO + C = CO + Fe \qquad (4)$$

The FeO is derived from the slag, but there are many reasons for believing that the reaction is by no means confined to the surface layers of metal, but takes place equally throughout the whole mass of liquid. If the slag is scraped off during the boiling period, the metal still goes on boiling vigorously, and can do so for a considerable time, although there are only traces of slag in contact with the steel. Clean pieces of Swedish charcoal iron containing 0.16 per cent carbon lose all their carbon when melted in a magnesia crucible in an electric vacuum furnace.[4] When a local area in the bottom of an open-hearth furnace gets bad, the boil takes place much more vigorously over that area than elsewhere, and the slag may be projected some distance above the general level through the energetic action. Such facts point to the CO being liberated simultaneously throughout the mass of metal, and since the carbon is in solution, it entails that the FeO must also be in solution in the steel.

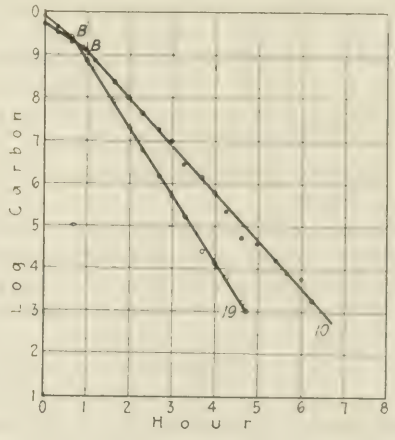
On this assumption the FeO is divided between two solvents, the slag and the steel, and the application of the partition law to such a system indicates that the concentration of the FeO in the steel must bear a constant ratio to that of the slag if the molecular condition of both solutions be the same. If FeO in the steel be removed from solution, then more FeO will pass from the slag into the steel, until a balance is once more obtained, and if the FeO be continuously removed, then a continuous flow of FeO will come from the slag and will endeavor to replace the loss. If no addition of FeO be made to the slag (in the form of iron ore), then the percentage content will fall continuously.

The mechanism of the carbon reduction in the open-hearth process can now be understood, for as the ore is added to the slag it dissolves as FeO, which is transferred in solution to the bath, and reduced by the carbon there with the production of CO. The reaction will follow the laws of chemical kinetics, so that, stating the concentration of the FeO in the slag as C_{FeO}, the concentration in the steel will be aC_{FeO}, where a is the partition coefficient. If C_C and C_{CO} stand for the corresponding concentrations of the carbon and the carbon monoxide, the reaction velocity will be

$$\frac{dx}{dt} = K(aC_{FeO} - x)(C_C - x) - k(C_{CO} - x) \qquad (5)$$

where K and k are constants.

The carbon monoxide which is first given off dissolves in the steel, but whenever the steel becomes saturated the excess gas will escape into the atmosphere. This is the commencement of the boil. The steel from this moment is therefore saturated with gas, so that the CO term in equation (5) can be neglected. On integrating, this equation takes the usual logarithmic form, and the log of carbon against time should plot a straight



line. It is to be remembered at this stage that this will only be true if no external addition is made to the FeO after the reaction starts—that is, if no ore is added to the charge after the boil commences. The accompanying figure gives curves taken from results obtained by the author. Samples were taken every 20 min. during the course of two acid open-hearth charges from the time the metal was melted until it was tapped out. It will be seen that the straight line fits the points surprisingly well, considering that in a melting furnace under steelworks conditions it is impossible to keep other complex influences constant, as the theory assumes.

The curves are interesting in another way, for each really consists of two parts. The first part relates to the loss of carbon before the boil commences, when the bath still contains some silicon and manganese. The commencement of the boil is marked by a distinct angle between the two parts of the curve, and the rate of loss of carbon when the other elements are present is much less than when they are absent.

As the carbon in the bath gets less, the rate at which it is being reduced also gets less, until it ultimately becomes of the same order of magnitude as the rate of the reverse reaction brought about by the presence of the CO. When it becomes equal to the latter, then equilibrium is established and no further carbon is oxidized. When this takes place, equation (5) reduces itself to

$$\text{Constant } \frac{K}{k} = \frac{C_{CO}}{aC_{FeO}\,C_C} \qquad (6)$$

[3] *Jour. Iron and Steel Inst., Car. Res. Mems.*, 1914, p. 216.
[4] Yensen, *Bull. Illinois Univers.*, No. 72, p. 41.

How far the attainment of equilibrium is possible in a melting furnace is a difficult question to decide. The carbon, for one thing, is never constant, but is always dropping slowly, and the time element in practical working necessitates the adoption of other means for controlling the oxides in solution. But the conditions, however they may vary, are always trying to approach equilibrium, and alterations in the external conditions will have the same effect whether it is attained or not.

Since the steel is saturated, the upper term will remain constant in equation (6), and so the lower the carbon in the steel at the final stage, other things being equal, the higher the amount of FeO and vice versa, which accounts for the fact that mild steels are more difficult to deoxidize than higher carbon steels made under the same conditions.

Supposing lime is added to a slag which is in equilibrium with the metal underneath, then the FeO concentration of the slag is reduced and the metal is no longer in equilibrium, but contains excess FeO which will act on the carbon available until equilibrium is once more attained. For this reason CaO can replace ore with advantage toward the end of the boil, but it is obvious that this action cannot take place at the beginning of the boil, since the effect would then be directly opposite and it would retard oxidation. Any diluent, such as manganese ore, magnesia, etc., would act exactly in the same manner.

The influence of temperature is very important, and in the author's opinion it is the one method of control which is neglected in practical steel-making. It is not sufficient to tap a charge which leaves no ladle skull and possesses an excess of heat which is irregular and varies from charge to charge. Much more than that is implied by "temperature control." It is the production of charges of steel which have been worked in the furnace, and which have been cast with a constant and known amount of superheat over the temperature of solidification.

In Appendix I the calculations are given which show that for a variation of 50 deg. in the finishing temperature a decrease of more than 33 per cent is possible in the amount of FeO which the steel carries in solution. The author has already shown the great influence which this fact has on the number of non-metallic inclusions present in the finished steel.[5] The reduction in the FeO content of the steel with rising temperature reacts correspondingly on the slag, with the well-known result of thickening it. High temperature working gives siliceous slags.

Reduction of Silicon

With a highly siliceous slag in contact with iron and carbon, reduction of the silica may take place in two possible ways:

$$SiO_2 + 2C = Si + 2CO - 122 \text{ cal.} \quad (7)$$

$$SiO_2 + 2Fe = Si + 2FeO - 51 \text{ cal.} \quad (8)$$

and in both an increase in temperature will lead to a greater reduction and the formation of more silicon.

From the results of a large number of estimations the author has found that in acid open-hearth working the reduction of silicon during the finishing stages, when the carbon is in the region of 0.15 to 0.20 per cent, is practically negligible. It is within the limits of chemical error. In acid electric-furnace work, on the other hand, it is quite appreciable, and it is possible to reduce 0.2-0.3 per cent direct from the slag. In crucible melting, the killing of the melt results from the reduction of the silica of the clay pot, but crucible charges are usually high in carbon, and it is much more difficult to kill low carbon charges in this manner. The experiments of MacWilliam and Hatfield[6] showed that this reduction may be brought about in open-hearth furnaces, but it is noticeable in their figures that when reduction takes place the carbon is about 0.40 per cent.

It is fairly evident, therefore, that it is the carbon which reduces the silica and not the iron. The reverse reaction in equation (8) is important when additions of silicon are made later for deoxidation purposes.

Manganese behaves similarly, and need not be considered separately.

Carbon Monoxide

The presence of CO in solution in iron entails a further reaction with the FeO

$$FeO + CO = CO_2 + Fe \quad (9)$$

a reaction which has been studied over a considerable range by Baur and Glässner[7] for solid Fe and FeO. Their results, however, will not enable us to arrive at quantitative conclusions regarding the equilibrium of the same materials when they are in a state of solution. Qualitative deductions in accordance with experimental facts can, however, be made. This equilibrium is independent of pressure, and the ratio of $CO:CO_2$ under reduced pressure is therefore constant. This is shown by the results of Baraduc-Muller[8] in the composition of gas drawn off an ingot in four periods between the time of casting and the solidification of the metal:

No.	CO	CO_2	Ratio $CO:CO_2$
1	43.2	5.2	8.3
2	56.8	4.0	14.2
3	40.8	4.8	8.5
4	24.8	2.8	8.8

Excepting No. 2, the constancy is extremely good when the difficulties of the experiment are remembered.

A lowering of the temperature of working greatly decreases the ratio (see Appendix II). Thus in cast iron[9]

Cast. Temp.	Ratio $CO:CO_2$
1,428	30.2
1,348	13.7
1,264	7.2

The bearing which this has will be considered in the next section.

The Formation of Blow-Holes

It is a general law that the solubility of gases in liquids increases as the temperature is lowered, but at the freezing point the solubility is much less in the solid state than in the liquid condition. As a result, all gases will show strongly the effects of primary segregation—that is, the concentration of the solution in the last portions to solidify. If during the progress of this concentration the limit of solubility is reached, then the excess gas will escape and blow-holes will be formed. At the finishing stages in the open-hearth furnace, as previously explained, the steel is saturated with CO and the amount of gas will depend only on the temperature. If this is constant, then all steels will start with the same amount of gas in solution. Starting, then, with a quantity of liquid steel containing CO and CO_2, and

[5] *Journ. Iron and Steel Inst.*, 1918, part 1, p. 289.

[6] *Ibid.*, 1902, part 1, p. 54.
[7] *Z. physik, Chem.*, 1903, vol. 43, p. 461.
[8] *Jour. Iron and Steel Inst., C. S. M.*, 1914, p. 216.
[9] *Jour. Iron and Steel Inst., C. S. M.*, 1916, p. 66.

neglecting for the moment all other reactions except (9), cooling will result in more CO_2 being formed at the expense of the CO. But the steel in the solid state may have a very limited solubility for CO_2, and if this be exceeded, blow-holes will be formed at the instant of solidification. The formation of blow-holes not only depends on the quantity of dissolved gas but also on the variety of gas. No attention has hitherto been paid to this possibility, and to explain all the peculiarities in the relations between these gases and steel it is only necessary to assume that steel in the solid state has a much greater solubility for CO than for CO_2.

When equilibrium is established according to equation (9)

$$K = \frac{C_{CO_2}}{C_{FeO} \cdot C_{CO}}.$$

When there is much ferrous oxide in solution, the ratio CO_2:CO will be correspondingly great, and when the steel solidifies, if the amount of CO_2 is greater than the metal can hold in the dissolved state, blow-holes will be formed. If on the other hand the ferrous oxide be removed, the amount of CO_2 will shrink until the ratio CO_2:CO corresponds to give the correct value of K, and on solidification the saturation limit may never be attained. It is important to notice that the total volume of gas (expressed as c.c. per g. of metal) may remain quite unaltered by the reduction of the FeO, so long as direct reduction of the gases does not take place. How well this accords with the experimentally determined volumes of gas by different observers will be seen by the following results. Boylston,[10] using all the well-known deoxidizers, found

	C.c. per 100 g.
Average for deoxidized metal	126
Average for oxidized metal	125

Goerens,[11] using quite a different method for the estimation of the gas, gives the mean of two charges in a basic open-hearth furnace, the samples being taken from the bath before and after deoxidation

	C.c. per 100 g.
Average before deoxidation	67
Average after deoxidation	88

Baker,[12] from two similarly melted charges of crucible steel

	C.c. per 100 g.
Steel without blow-holes	132
Steel with blow-holes	67

With regard to the latter, the two charges were melted in separate pots at the same time, and it is admittedly difficult to determine similarity of condition during melting so far as gas content is concerned.

It may, however, be taken as proved that deoxidation does not necessarily mean the diminution of the total gas in solution.

Since deoxidized steel contains less FeO, the gas given off should have a higher CO_2:CO ratio than oxidized steel, and the results of Goerens again enable this to be confirmed. Taking samples from two electric-furnace charges after the removal of the phosphorus slag and again after deoxidation with ferrosilicon and ferromanganese, and extracting the gas, it was found

	CO_2:CO Ratio per Cent	
Before deoxidation	8.8	7.3
After deoxidation	60.0	21.3

In the first charge the manganese was 0.08 per cent and in the second 0.13 per cent at the time of taking the first sample, showing that the former was in a more highly oxidized state than the latter, and consequently it gives a greater difference after deoxidation. The theoretical deductions are strikingly confirmed.

As calculated in Appendix II, the composition of the gas in equilibrium with solid iron and FeO at the solidifying temperature, taken as 1,500 deg. C., is roughly CO_2 = 7.8 per cent, CO = 92.4 per cent, so that even if pure CO_2 were given off from the solidifying steel it would immediately be reduced again to CO by reaction with the solid iron until the composition of the gas approached this value. The fact that the gas liberated from an ingot burns with the blue flame of CO does not imply that it was given off as such during the solidification.

Estimation of Gases in Steel

In steel, from what has previously been said, the gas content in the solid state will be proportional to the gas content in the liquid solution, but the determination of the exact composition and quantity of this gas presents grave practical difficulties.

Two methods only so far have been used—the extraction of the gas by heating the sample in a vacuum (Baker, Boylston, Donaldson, etc.) and the fusing of the sample in a vacuum with tin and antimony, which have practically no dissolved gas themselves (Goerens). In the first method, any gas which is evolved which does not possess the composition necessary for equilibrium according to equation (7) for the temperature of the experiment will tend to react with the steel until it does possess that composition. Thus the composition found must have been modified in a quite indeterminate manner by reaction taking place at a lower temperature. The sum of the volumes of CO_2 and CO, however, gives the exact volume of the mixed gases at the temperature of solidification. The composition may not be the same.

With regard to the second method, the carbon contained in the steel is insoluble in the alloy and floats to the surface, where it remains, at the same time reducing the CO_2 in accordance with the reaction

$$CO_2 + C = 2CO \qquad (10)$$

This reaction not only varies with the temperature but also with the pressure of the gases, so that the results obtained only give the volume of the gas originally contained exactly, when expressed as CO_2 equivalent. That is, the volume of CO_2 plus ½(volume of CO) gives exactly the volume of mixed gases originally contained by the steel.

How far the composition is altered depends on the rate of evolution, so that the effect is merely to mask the differences in composition by an uncertain amount. Qualitative deductions can, however, still be drawn from the results, and it is the object of this paper to show how such deductions give an insight into the complex conditions existing in liquid steel during manufacture.

Appendix I

The heat of reaction at ordinary temperatures for the reaction

$$FeO + C = CO + Fe - 35.6 \text{ cal.}$$

is —35.6 cal., and the heat of reaction at the temperature of a melting-furnace, 1,600 deg. C., can be calculated in the following manner:

[10] *Jour. Iron and Steel Inst., C. S. M.*, 1910, p. 157.
[11] *Ferrum*, vol. 12, p. 78.
[12] *Jour. Iron and Steel Inst., C. S. M.*, 1902, p. 224.

From Nernst's theorem, using the accepted symbols

$$Q = Q_0 + \beta T^2$$
$$\frac{dQ}{dT} = 2\beta T = C_r - C_p.$$

There are no measurements of the molecular heat of ferrous oxide, since it has never been isolated pure, but Richards gives the value at 0 deg. C. of the specific heat of

Fe_2O_3 as 0.1456
Fe_3O_4 as 0.1447

so it can be assumed that the specific heat of FeO is in the neighborhood of 0.145, which gives a molecular heat of 10.45.

Mol. heat of carbon at 17 deg. C.	1.92
Mol. heat of CO at 17 deg. C.	6.71
Mol. heat of Fe at 17 deg. C.	6.15

(These values are calculated from Kaye and Laby, *Physical Constants.*) From these results,

$$C_r - C_p = 12.37 - 12.86 = -0.49 = 2\beta T,$$

and since the values were calculated at 290 abs.

$$\beta = -9.0 \times 10^{-4}$$

At $T = 290$ deg. abs., $Q = -35{,}600$, so that at $T = 1{,}873$, $Q = -38{,}700$. The difference is therefore negligible, and no appreciable error is introduced by taking the values at ordinary temperatures.

To find the difference in the value of the equilibrium constant K

$$\frac{d}{dt} \log K = -\frac{Q}{RT^2} \qquad (11)$$

and on integrating

$$\log \frac{K_1}{K_2} = -\frac{Q}{R}\left\{\frac{T_1 - T_2}{T_1 T_2}\right\}.$$

The ratio between the value of K at 1,600 deg. C. and K at 1,550 deg. C. is consequently

$$\log \frac{K_1}{K_2} = \frac{38{,}700 \times 50}{2 \times 2.30 \times 1{,}873 \times 1{,}823} = 0.124$$
$$\frac{K_1}{K_2} = 1.33.$$

Since $K = \dfrac{C_{CO}}{C_{FeO}\, C_C}$, an increase in K implies an increase in CO or a diminution in the product of the bottom terms. The steel is, however, saturated with CO, and, like all gases in solution, the saturation strength must diminish very considerably with a rise in temperature. At the finishing stage, pigging back is usually started when the carbon is in the neighborhood of 0.17 to 0.20, so that the carbon concentration is practically constant and independent of other conditions. An increase in the value of the equilibrium constant of 33 per cent, as found above, means a reduction in the amount of ferrous oxide in solution of more than 33 per cent.

Appendix II.

The reaction

$$FeO + CO = CO_2 + Fe_1 + 3.7 \text{ cal.}$$

can be treated in exactly the same manner as the previous reaction in Appendix I, but it presents some peculiar features. To begin with, the log K from Baur and Glässner's results plotted with 1/T does not give a straight line, which implies that Q varies with temperature to an appreciable extent.

The heat of reaction at ordinary temperatures is $+3{,}700$ cal. and the molecular heat of CO_2 is 8.9. This gives, as before

$$2\beta T = C_r - C_p = 17.16 - 15.05 = 2.11,$$
$$\therefore \beta = 3.6 \times 10^{-3}$$

This value is unusually high. At 825 deg. C. the heat of reaction Q_{825} is

$$Q_{825} = 3{,}400 + \beta(1{,}098)^2 = 7{,}750 \text{ cal.}$$

The equilibrium constant K has the following values:

750 deg. C.	1.56
900 deg. C.	2.51

which, calculating back by means of equation (8), Appendix I, gives

$$Q_{825} = 7{,}650 \text{ cal.}$$

This agrees very well with the previous value, found by quite a different method.

Substituting $Q_0 + \beta T^2$ in the integration of equation (11), Appendix I, the value of K at different temperatures will be:

1,200 deg. C.	5.8
1,300 deg. C.	7.5
1,400 deg. C.	9.5
1,500 deg. C.	12.1
1,600 deg. C.	15.2

The gas given off from a steel ingot immediately after solidification gave a ratio for K of 11.0,[13] and at lower temperatures 3.1 to 4.2. In the former case the temperature cannot have been far removed from the temperature of solidification, which was in the neighborhood of 1,475 deg., and in the latter case the temperatures were probably about 700 to 800 deg. C. These figures show the great importance of equilibrium conditions, and support the contentions of the author regarding the methods of estimating the gases in solution in steel.

[13] Baraduc-Muller, *loc. cit.*

Northwest Magnesite Co. Not a Monopoly

One of the principal arguments used against tariff on magnesite before the Ways and Means Committee was that the magnesite production of the United States is in the hands of the Northwest Magnesite Co. This concern was characterized as a monopoly. This charge is declared by Roy N. Bishop, general manager of the Northwest Magnesite Co., as being entirely unjustified. In the hearings on magnesite before the Senate Finance Committee Mr. Bishop said in that connection:

"Because we put $750,000 into a plant and developed magnesite so badly needed by the country during the war, we were charged in the previous hearings before the Ways and Means Committee with being a monopoly. A complete refutation of that is that we own only one-eighth of the raw material in the United States and that we never have produced more than 35 per cent of the magnesite that has been produced in the United States. As soon as a tariff is granted on it, those who own the other seven-eighths of the raw material will become very active competitors."

The cost of magnesite to the Northwest company, Mr. Bishop testified, is a little over $21 a ton. He declared that the company had sold at that price during the war, but "the people to whom we sold it in turn sold it to the steel companies with an addition of about $10 a ton to our price. For practically indorsing the bill of lading, they made a greater profit out of the magnesite than we did."

The Sterilization of Water by Means of Ultra-Violet Rays*

Records and Information on Potable Water Installation for Isolated Plant Supply—Fluctuations of Bacteria Counts in Raw Water — Exposure Required for Ray Sterilization — Water Consumption Rates and Quantities per Capita — Capacity of Ultra-Violet Ray Apparatus

By WALTER L. DECKER†

SCANNING the pages of history, we note that time after time this and that community has been visited by some dire epidemic which has caused the death of thousands and thousands of people. Failing to realize the cause, it was often attributed to the wrath of God. Having run its course and passed away, people settled down again to their former mode of existence.

With advancing knowledge and research, investigators began to doubt the wrath of God theory and began, by the process of elimination, the systematic study of cause and effect. Eventually it was found and proved that the water used by the community was the cause of the trouble. Chemical analysis failing to show the presence of any deleterious salts in the water that would cause sickness, resort was had to the microscope. This finally revealed the presence of certain organisms, invisible to the naked eye, which if eliminated from the water removed the cause of the trouble.

Suitable Drinking Water

Our former ideas of a suitable drinking water must be modified. Water may appear clear, cool and sparkling and yet contain organisms which are inimical to one's health.

A pure water may be defined as one which contains no disease-producing bacteria or an excess of organic matter of any kind. An impure water is generally defined as one which receives more or less sewage, one therefore that is not fit for human consumption. A pure water supply is one of the best safeguards of the health of a community. A relatively small number of diseases are transmitted by impure water. These diseases are typhoid fever, dysentery and Asiatic cholera. A pure water supply seems to affect the general health of a community and to decrease its death rate wholly apart from the decrease due to the elimination of the specific diseases mentioned. This is doubtless due to the fact that the impure water so affects the average health of a community that the individuals become more readily susceptible to other diseases.

The increased growth of our cities, with increased contamination of our water supplies, has brought about a general awakening of the community to the importance of the arts of sanitation. Bacteriology has ceased to be a subject of interest and importance to the medical profession only, but has become intimately connected with the work of the chemist, the biologist and the engineer. To the sanitary engineer the subject of bacteriology is indispensable.

Micro-Organic Life

Bacteria are the most numerous and the most widely distributed of living things. They are found in the surface of the earth, in the water under the earth, and in the air above the earth. Wherever there is life, waste matter is constantly being produced, and this finds its way to the earth or to some body of water. The excretions of animals, the dead tissues and broken down cells of both animals and plants, as well as the wastes of domestic and industrial life, all eventually find their way to the soil. In a majority of cases these substances are not of such chemical composition that they can be utilized at once by green plants as food, but it is first necessary that they go through a decomposition or transformation in which their chemical nature becomes changed, and it is as the agents of this transformation that bacteria assume their greatest importance in the world of life. When a bacterium cannot multiply, the only vital activity which can take place is a katabolic wasting away, which soon proves destructive, and the higher the temperature the more rapidly the fatal result is reached.

Bacteriology may be defined as that branch of science which treats of the forms, functions and activities of bacteria. The lines of demarcation between bacteria, yeasts, and molds of the vegetable kingdom, and certain protozoa of the animal kingdom are very poorly marked. It is not difficult to differentiate between the higher animals and plants, since there are many points of contrast plainly to be seen. With the microscopic organisms much greater difficulty is experienced, and some intermediate forms are known that constitute a complete series of intergradations between the two groups.

Types and Growth of Micro-Organisms

Four types of cells are found among bacteria: spherical, rod shaped, spiral and filamentous, these in turn being called coccus, bacillus, spirillum, and trichobacteria. All bacteria multiply in but one way, by a simple splitting of a cell into two. This may be termed vegetative reproduction. Some bacteria produce specialized resistant cells fitted to reproduce the species after a period unfavorable for growth. These are termed spores.

Chemicals may stimulate the growth of an organism, they may partially or completely inhibit its growth, or they may destroy it. Thus, a germicide is any substance which will kill micro-organisms, and an antiseptic is one which inhibits their growth without necessarily destroying them.

In general it may be stated that the plant cell differs from that of the animal by the possession of a firm and well differentiated wall, wholly distinct from the contained protoplasm. The typical cell wall of plants is made up of cellulose; the limiting membrane of the animal cell is nitrogenous.

Plenciz first clearly stated the germ theory of disease in 1762, claiming that each disease was caused by a particular kind of organism. This relationship was

*A paper read before the Cleveland Engineering Society, January, 1920.

†Construction Engineer, The American Shipbuilding Co.

later worked out more satisfactorily by Pasteur, Koch and Weigert.

Bacteria live upon organic matter, taking in oxygen and giving out carbonic acid. In the absence of dissolved oxygen gas in water they take their oxygen from the organic matter itself; that is, they decompose it, giving out not only carbonic acid, but also carbon monoxide, methane and other gases. This process has been sometimes called anaërobic respiration, that is, respiration without air. It is also called putrefaction.

Bacteria in Water and Their Quantitative Determination

Sedimentation is only one method by which bacteria are removed from water. We find that the bacteria furnish food for the protozoa; they in turn provide food for the rotifera and crustacea; they in turn are consumed by fish; and fish in turn provide food for men. Pathogenic germs when scattered through a mass of water cannot be detected by ordinary microscopical methods on account of their small size and because they

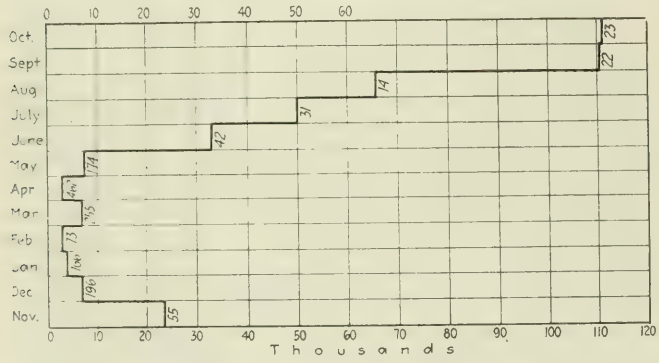


FIG. 1. MONTHLY FLUCTUATION OF BACTERIA IN RAW WATER AT WYANDOTTE

are greatly outnumbered by the ordinary water bacteria. Perhaps the most important service that the microscopical examination renders is that of explaining the cause of the taste and odor of water and its color. The microscopic organisms found in water show variations in their seasonal occurrence as great and almost as characteristic as those of land plants.

The *Bacillus coli* is a normal inhabitant of the intestinal tract of man and many other animals, and occurs regularly in their excreta, and on this account it is of the highest importance to sanitarians, since its presence in water supplies is a direct evidence of sewage pollution. Specific disease germs are difficult to isolate even when they are present, and water may be grossly polluted with sewage without any specific disease germs being present. All sewage pollution, however, is potentially dangerous, since where fecal matter exists, disease germs are at any time likely to be present.

A test for fecal matter as distinguished from infected material is therefore essential, and for such a test the colon group of bacilli are especially well suited. They are not dangerous in themselves, but they are significant indices of the probable presence of disease germs. What we dread in drinking water is the presence of pathogenic bacteria, mainly from the intestinal tract of man, and it is quite certain that the related nonpathogenic bacteria from the same source will behave more nearly as these disease germs do than will any chemical compound.

The procedure for the quantitative determination of bacteria in water consists in mixing a definite amount of a suitably collected specimen of the water with a sterile solidifiable culture medium and incubating it for a sufficiently long time to permit reproduction of the bacteria and the formation of visible colonies which may be counted. The typhoid bacillus and the colon bacillus stand at the opposite ends of a series of many different varieties of organisms which are intermediate in their properties, which produce a more or less characteristic growth on solid media.

Wyandotte (Mich.) Drinking Water Supply

It was during the height of the German drive in 1918, when all of us at home were diligently striving for increased production or increased means for production, that the question of an adequate supply of drinking water arose at the Wyandotte plant of the American Shipbuilding Co., Wyandotte, Mich.

At the time, the writer was engaged in supervising the construction of some fifty-odd buildings at the various plants of the company. Lack of time prevented him from giving the subject the amount of thought and study which it merited. It was a case where decision must be made at once and the results left to the hope of future accomplishment. Due to continual sickness in Wyandotte and to the fact that another thousand employees must be added to this plant at the earliest possible moment, it became necessary, more than ever, to give some thought toward the prevention of sickness among such a body of men if the work was not to be delayed by their enforced absence.

Due to its adverse location just below Detroit, and due to Detroit's rapidly increased growth and population, the increased amount of sewage that was dumped into the Detroit River rendered Wyandotte's problem of an adequate source of drinking water a more and more perplexing problem. Wyandotte was taking its source of water directly from the Detroit River and treating same with bleaching powder before distribution in its city mains. On account of excessive contamination and the lack of a filtration basin the amount of chlorine that had to be used was exceedingly high. The water as a rule smelled and tasted of chlorine, which made its use objectionable from more than one standpoint. Fig. 1, showing a comparison of the contamination of the Detroit River above and below Detroit, gives a clear idea of Wyandotte's problem. The curve shows the monthly fluctuation of the average number of bacteria in the raw water and the numbers on the curve show for comparison the average number of bacteria as found in the raw water supply of the city of Detroit.

Sterilization With Chlorine

Chlorine as a disinfectant was first used about the year 1800, and hypochlorite of lime (bleaching powder) as early as 1854 was used by the English Royal Commission for deodorizing the sewage of London. The first practical use of chlorine in water treatment in this country was in 1908, when Johnson used hypochlorite of lime in the treatment of the Bubbly Creek water at the Union Stock Yards in Chicago. After treatment and filtration, laboratory tests showed the effluent from the filters to be more nearly free from pathogenic bacteria than the water being furnished to the City of Chicago taken from Lake Michigan long distances from the shore. At present over 1,000 cities are treating their water supplies with either chlorine or hypochlorite of lime.

Laboratory experiments indicate that there is little

difference in the effectiveness of hypochlorite of lime and liquid chlorine as a sterilizing agent, but on account of losses in handling and mixing the bleach it requires a larger amount of chlorine in the bleach treatment than when liquid chlorine is used. In treating a water supply which is to be used largely for domestic purposes it must be considered that one of the primary qualities required in such a supply is an agreeable taste, and any treatment which cannot make water safe for drinking purposes without causing a disagreeable taste cannot be considered a successful and satisfactory method of treatment.

Since 1913, when the first commercial liquid chlorine machines were used, the popularity of this process has increased in a remarkable manner. Prior to this, water supplies were treated mainly with hypochlorite of lime. This process requires the use of mixing tanks for mixing the hypochlorite with water to a creamy consistency; storage tanks for holding the day's supply of chemical; and mixing tanks for regulating the amount of solution that is to be added to the raw water. The discharge of the hypochlorite solution is usually regulated either by maintaining a constant head on an orifice of variable dimension or by varying the head on an orifice of fixed dimension. Sludge is continually being formed in the storage tanks and the depth of same must be kept below the discharge outlet to prevent plugging of the pipe lines and measuring devices. For a small plant the bleach treatment is out of the question, as a trained chemist must be kept in attendance at all times in order to test the strength of each solution as it is made up.

PERCENTAGE REDUCTION, 15 MIN. CONTACT

Available Chlorine p.p.m.	Nature of Test Organism						
	B. Cloacae	*B. Faecatis Alkaligenes*	*B. Paratyphosus*	*Proteus Mirabilis*	*B. Enteritidis*	*B. Lactis Aerogenes*	*B. Choleroesuis*
0.1	.....	99.98	.....	27.3	.....	.....	.....
0.2	99.69	99.99	99.97	45.5	99.83	99.17	95.8
0.3	99.75	100.00	100.00	63.7	99.98	99.98	100.0
0.5	100.00	.....	.....	72.7	100.00	100.00	.....
0.7	.....	.....	.....	63.7	.....	.....	.....
1.0	.....	.....	.....	63.7	.....	.....	.....
3.0	.....	.....	.....	90.9	.....	.....	.....
5.0	.....	.....	.....	90.0	.....	.....	.....
Original number of organisms per c.c.	160,000	9,500	3,000	8,000	180,000	180,000	500

The dosage or amount of chlorine to be added to raw water depends upon the following four points:

Content of readily oxidizable matter.

Temperature of water.

Method of application.

Contact period.

The amount of chlorine required for germicidal action is small and tests made by Race show that 1,000 *B. coli* per c.c. in absence of organic matter can be reduced to two *B. coli* per 100 c.c. (the U. S. Government standard) by 0.1 p.p.m. of available chlorine in 10 min. at 65 deg. The accompanying table shows the results of tests by Lederer and Bachmann upon the percentage reduction of various bacteria with a 15-min. contact period.

There is no marked difference in the resistance of ordinary water bacteria to chlorine, and the common intestinal organisms are also very susceptible to destruction by chlorine. The spore-forming bacteria usually found in water are derived largely from soil washings and from sewage and manure. The spores of these organisms are very resistant and survive all ordinary concentrations. In practice no attempt is made to destroy the spore-bearing organisms, as they have no sanitary significance and the concentration of chlorine required for their destruction would cause complaints as to tastes and odors if the excess of chlorine were not removed.

Action of Ultra-Violet Rays

What was desired at our Wyandotte plant was some system that would do away with this constant supervision, some system that would function day and night, whether the incoming water contained 100 bacteria or 100,000 per c.c. Upon inquiry, I found that there was such a system in existence, but that little reliance or faith was placed in it. To me the system appeared of value and I felt that the fault was mainly due to its practical application.

In order to have a better understanding of the system, we will revert back to the experiment that used to be performed in the physical laboratory. If a ray of sunlight, which appears white to the eye, is allowed to fall on a prism we have projected on the screen a succession of various colors called the spectrum. According to their refrangability the colors are arranged with violet the highest, then blue, green, yellow, orange and red as shown in Fig. 2.

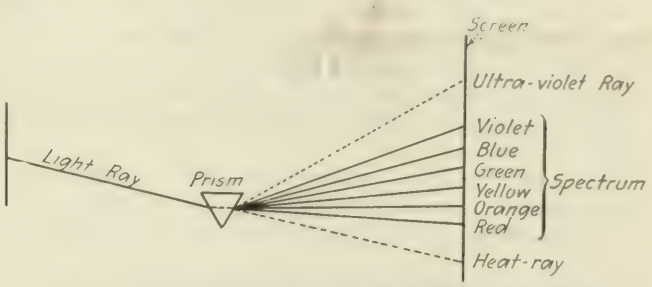


FIG. 2. DISSOCIATION OF SUNLIGHT INTO ITS PRIMARY COLORS

The vibrations of the ether are capable of producing other effects besides illumination. They constitute what is called radiant heat, and they are also capable of producing chemical effects, as in photography. Vibrations of high frequency are the most active chemically, those of low frequency have usually the most powerful heating effects. The color of lowest pitch is deep red, its frequency being about 400 million million vibrations per sec. The color of highest pitch is deep violet, its frequency being about 700 million million vibrations per sec. Fig. 3 shows a comparison of the frequency of vibration of the light waves with other invisible waves. Dividing the velocity of transmission (188,000 miles per sec.) by the various frequencies gives us the wave length of the various waves. Almost every source of light produces with the visible rays some wave lengths shorter than those which are perceptible to our eyes, these being called ultra-violet rays.

In so far as when intercepted they are converted into heat, all rays are heat rays, but neither the ultra-violet nor any other radiation is heat, but it may become heat when it ceases to be a radiation. Thus all radiations are chemical rays if they strike a body which is responsive to them. When a beam of radiation impinges upon a body it is resolved into three parts: one part is reflected, one part absorbed (converted into heat energy or chemical energy or some other frequency of radiation), and one part passes through and out of the body if it is not too thick. No body reflects, or absorbs, or transmits all the radiation, as even the most perfectly reflecting body absorbs and transmits some radiation.

The ultra-violet rays are extremely destructive to the eye; exposure even to a moderate intensity of them for a very few minutes produces a severe and painful inflammation, the after effects of which last for years, and long exposure would probably result in blindness.

Radiation impinging on the tissue of the human body or other living organisms exerts an influence depending on the intensity, power and frequency. The effect of radiation on the living protoplasm of the cells is stimulating if of moderate intensity, destructive if of excessive intensity. The intensity of light which is destructive to life largely depends on the amount of light to which the organism is accustomed. Those organisms that live in the dark may be killed by an amount of light which is necessary for the life of other organisms.

As men have lived for ages in the light, the cells of the human body are far more resisting to the light than the disease germs, which for ages have lived in the dark. Light, and more particularly the high frequency ultra-violet and the X-rays, thus have found a useful application in killing disease germs in the human body.

That the chemical activity of radiation is some form of resonance is made probable by the relation which exists between the active frequency and the weight of

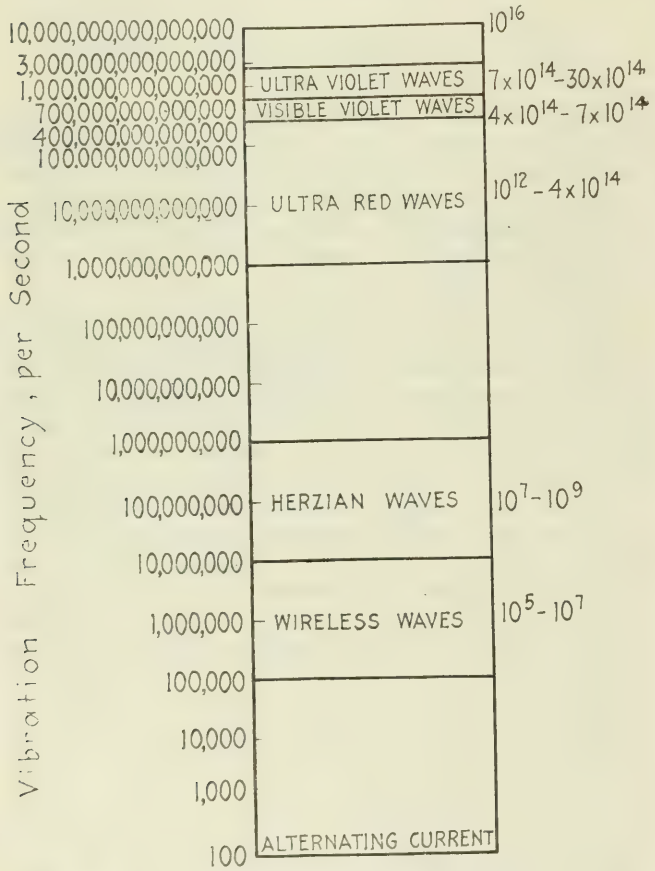


FIG. 3. COMPARISON OF VARIATION FREQUENCY OF DIFFERENT WAVES

the atom or molecule which responds to vibration. Thus, while the fairly heavy silver atom (atomic weight 108) responds to rays near the violet end of the spectrum, the much lighter oxygen atom (atomic weight 16) responds only to much higher frequencies. These very short radiations energetically produce ozone (O_3) by dissociating some of the oxygen molecules (O_2) into free atoms, and these free atoms then join existing molecules to form ozone.

Response to long waves of red and ultra-red light thus may be expected from atoms or groups of atoms which are very much heavier than the silver atom, and this indeed seems to be the case in the action of radiation on the life of plants. Those parts of the plants which contain chlorophyll, mainly the leaves, take carbon dioxide (CO_2) from the air through breathing openings, absorb the radiation and convert its energy into chem-

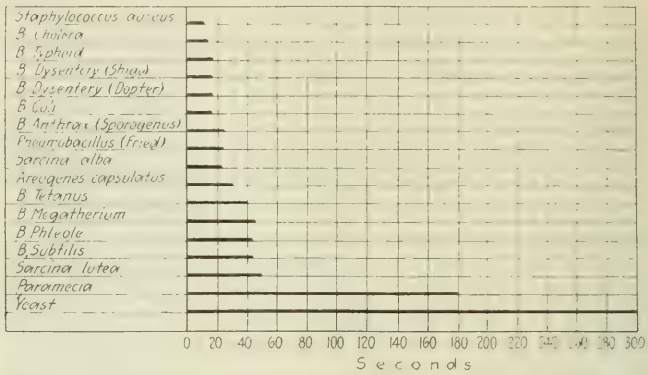


FIG. 4. SECONDS NECESSARY TO KILL DIFFERENT TYPES OF GERMS AT 200 MM. FROM A QUARTZ LAMP OPERATING AT 66 VOLTS, 3.5 AMPS.

ical energy, and use this energy in splitting up CO_2, exhausting the oxygen and using the carbon in producing the complex carbon compounds of their structure.

Sterilization With Ultra-Violet Rays

Ward was the first to demonstrate that the typical characteristic of ultra-violet light is the bactericidal power of these radiations. He threw the spectrum on an infected agar plate with the result that the parts of the plate which were exposed to the violet end of the spectrum did not show any growth of colonies, while the parts which were exposed to the red end of the spectrum developed growth.

The great source of ultra-violet radiations is the sun. Rivers and lakes are freed from a great part of their bacterial contents by the bactericidal power contained in the sun's rays. Small amounts of ultra-violet are produced by practically all artificial light sources. Electric discharges between metal electrodes are powerful producers of ultra-violet radiations. The disintegrated metal has to be replaced after being volatilized by the heat of the arc. The replacement is easiest if the disintegrated metal condenses easily and can be made to flow back, as is the case if mercury is chosen as electrode. The material in which the arc is enclosed has to be transparent to the discharge of ultra-violet rays. The only industrial material filling this demand is fused quartz. Glass which is transparent for visible light is nearly opaque

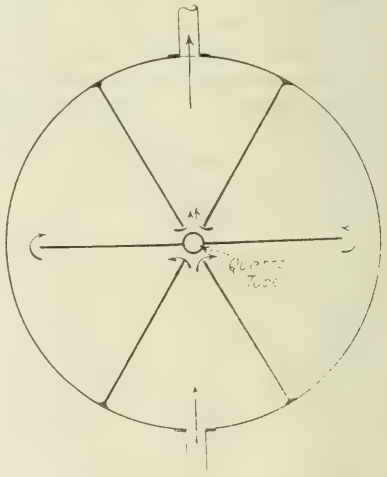


FIG. 5. ARRANGEMENT OF BAFFLES IN STIRRING APPARATUS

to ultra-violet light, hence cannot be used for this purpose.

The next step then was to determine whether ultra-violet rays would sterilize water. Accordingly various germs were placed in clear water and subjected to the action of these rays, and the length of time of exposure necessary to kill the various germs is shown in Fig. 4. Experiments have demonstrated that as the mercury vapor lamp can be run at different temperatures, by increasing or decreasing the voltage on the electrodes, its destructiveness of bacterial life is accordingly increased or decreased. An increase in watts, that is to say, of temperature, produced a much greater increase of the red and yellow than of the blue and violet, but it was found that the ultra-violet end of the spectrum increases about like the red end.

Water, if clear, is practically as transparent as air to ultra-violet rays. In many cases, however, it must first be filtered to free it from suspended matter and, if possible, also from colloidal matter, which would otherwise retard the passage of the rays. Careful observation of well-filtered water, however, nearly always reveals the presence of a small amount of suspended matter of a large enough size to allow microbes to be protected against the rays. To sterilize such water with safety it was found advantageous to agitate it while passing through the illuminated zone and to expose it several times to the light of the same lamp. This stirring up is best accomplished by a proper arrangement of baffles in the apparatus as shown in Fig. 5.

Having decided to try out this system of sterilization, the next point was to determine what system of records

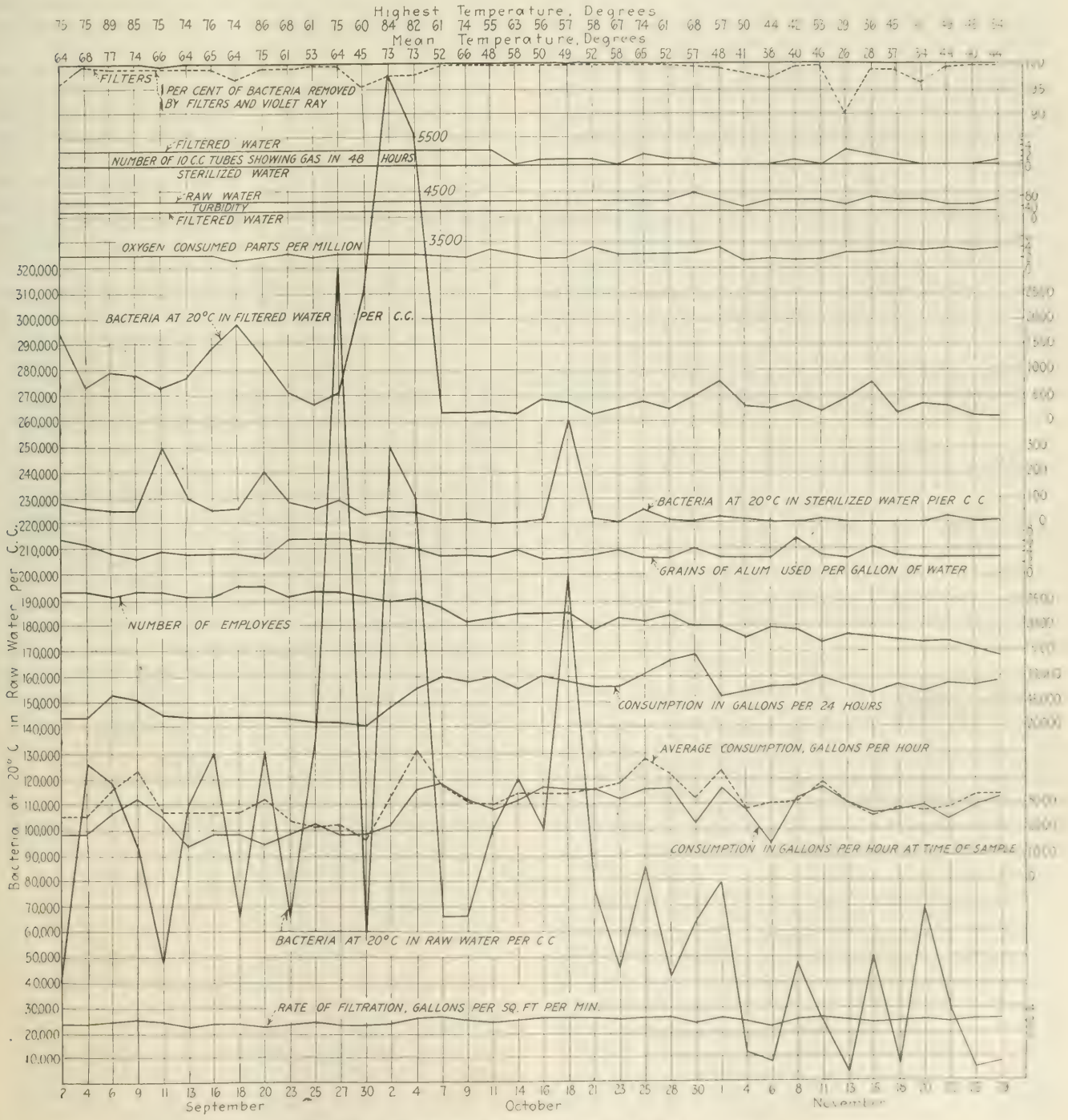

Highest Temperature, Degrees
Mean Temperature, Degrees
FILTERS
PER CENT OF BACTERIA REMOVED BY FILTERS AND VIOLET RAY
FILTERED WATER
NUMBER OF 10 C.C. TUBES SHOWING GAS IN 48 HOURS
STERILIZED WATER
RAW WATER
TURBIDITY
FILTERED WATER
OXYGEN CONSUMED PARTS PER MILLION
BACTERIA AT 20°C IN FILTERED WATER PER C.C.
BACTERIA AT 20°C IN STERILIZED WATER PIER C C
GRAINS OF ALUM USED PER GALLON OF WATER
NUMBER OF EMPLOYEES
CONSUMPTION IN GALLONS PER 24 HOURS
AVERAGE CONSUMPTION, GALLONS PER HOUR
CONSUMPTION IN GALLONS PER HOUR AT TIME OF SAMPLE
BACTERIA AT 20°C IN RAW WATER PER C C
RATE OF FILTRATION, GALLONS PER SQ. FT PER MIN.
Bacteria at 20° C in Raw Water per C.C.
5500
4500
3500
September
October
November

FIG. 6. RECORD OF OPERATIONS AT WYANDOTTE

it would be advantageous to keep for the operating end. It was deemed advisable that a continuous record of performance would be an ideal one, for in this manner the operating department would have a clearer conception of what was taking place and the result of any changes that were made from time to time toward the betterment of the system. Accordingly, it was determined that it would be of interest to keep a continuous record of the following points: the bacteria in the raw water; the bacteria in the filtered water; the bacteria in the sterilized water; the turbidity of the raw and filtered water; the per cent of efficiency of bacterial removal in the filters alone; in the combined filters and apparatus; the grains of alum used per gal. of water in the filters; the rate of filtration in gal. per sq.ft. per min.; the hourly and daily consumption of water; the number of men working; the oxygen consumed in the raw water; the presence or absence of pathogenic germs in the treated water. A record of operations involving the above points is shown in Fig. 6. The system as at present installed consists of one 60-in. quartz filter, two 30-in. bone black filters, and two ultra-violet ray sterilizers in series, the normal capacity of which is 3,000 gal. of water per hr. free from pathogenic organisms.

The most important curve of the series is the second one from the top of the sheet reading, "Number of 10 c.c. tubes showing gas in 48 hr." It is this curve that denotes the presence or absence of pathogenic bacteria in the drinking water as same issues from the sterilizers. This curve is to be taken in conjunction with the curve marked, "Bacteria at 20 deg. C. in sterilized water."

You will note that with the excessive contamination with which we had to deal this latter curve denotes the presence of bacteria in numbers from 1 to 400.

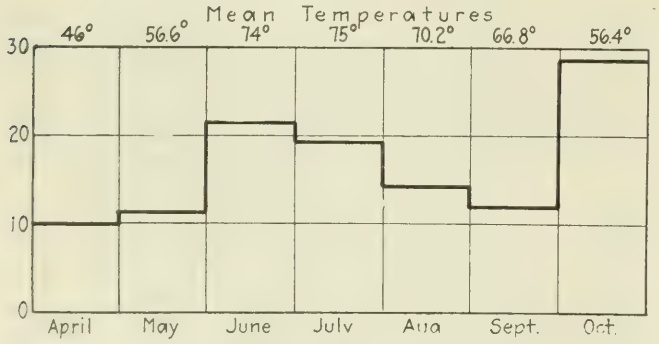


FIG. 7. GAL. OF WATER USED PER MAN PER 24 HR.

Remembering that the spore-forming bacteria are much harder to kill and that the objection to them *per se* is nil, as they are not inimical to one's health, the point then in question is to what family do the bacteria belong whose presence is shown in the curve of sterilized water.

Luckily, the pathogenic bacteria, together with the *B. coli*, are made to reveal their presence by a certain method of treatment. If placed in a tube of standard lactose solution they ferment same with the production of gas. Thus it is a simple matter to simply note the presence or absence of gas in the tube after 48-hr. incubation to determine with reasonable certainty the presence or absence of these objectionable bacteria.

In each case three tubes are planted for the filtered water and three tubes for the sterilized water. You will note that in the majority of analyses the water after passing through the filters showed the presence of *B. coli* in all three of the tubes. The curve for the sterilized water is a straight line zero curve, showing that the violet-ray sterilizer has functioned properly in killing all the *B. coli* germs that were left after passing the filters.

Rates of Consumption of Water

One of the interesting points developed was the excessive use of water per man. Being unable to find any record of the amount of water used per man in a distinct and separate system of drinking fountains, we had to simply fall back on an assumption of how much water might be used during the hottest days of summer and then multiply this by a factor of safety, or more properly speaking, a factor of waste. Fig. 7 shows the amount of water used per man per day for a period of seven months, from April to November. The water meter, being located next to the apparatus, naturally recorded the passage of all water, whether consumed or running to waste through some leak or leaks in the system of underground piping or in the drinking fountains. The sudden increase in the curve for October was unexpected and was due to a break in one of the underground mains, which continued to waste water until located. It was this loss of water that brought the average for the month higher than any other month, even though the number of men employed was considerably reduced.

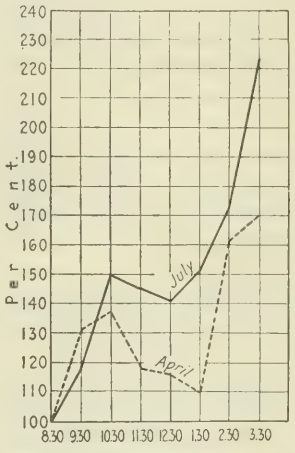


FIG. 8. PERCENTAGE OF WATER USED DURING THE VARIOUS HOURS OF THE DAY DURING THE MONTHS OF APRIL AND JULY

Fig. 8 shows a comparison of the amount of water used during the main working hours of the day. That used between 7:30 and 8:30 was arbitrarily assumed at 100 per cent and the amounts used during the other hours of the day as a percentage of this amount. The curve was first drawn up for July. It shows a very decided and pronounced increase from 1:30 to 3:30, which was quitting time. In order to ascertain if this same tendency for a drink during the last two hours of

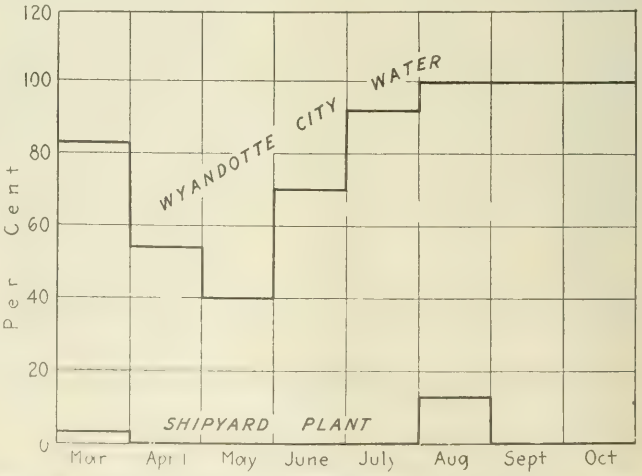


FIG. 9. PERCENTAGE OF TEST TUBES SHOWING PRESENCE OF PATHOGENIC BACTERIA

work existed during the cooler months, the month of April was picked out and the quantities for this curve were derived. From a study of the curves it would lead one to believe that the operator in the plant that recorded the readings had as good, or perhaps a better, survey of the amount of activity going on than the superintendent on the ground.

According to the old adage that "the proof of the pudding is in the eating," Fig. 9 is the proof that the system adopted provided a drinking water that was superior in all respects to that furnished by the city, and that our hoped-for results had been at least fairly well accomplished. Analyzing this record, with the inclusion of the November record, which was also zero, we find that during the nine months period on only three days was there any question as to the absence of pathogenic germs in the drinking water. On two days in August we fell down on our record for the reason that there was a sudden high increase in the bacterial count

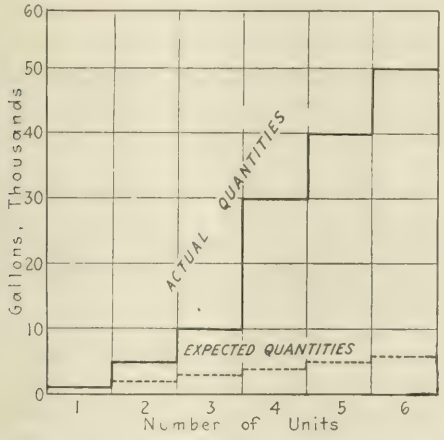


FIG. 10. GAL. OF WATER PER HR. PER UNIT OF VIOLET RAY APPARATUS

in the raw water, and at the same time the system was operating at 50 per cent overload, and one day in March when the capacity of the system was being increased and before all proper adjustments had been made.

An interesting development of the violet-ray apparatus is that the amount of water that can be treated does not vary in arithmetical progression with the number of units used. If the destruction of pathogenic germs depends upon the length of time of exposure to a light source, it would be only natural to assume that if one unit treated 1,000 gal. of water per hr. at a stated velocity through the apparatus should the velocity be increased by two, it would be necessary to put a second unit in series with the first so that the total length of time of exposure in the two would equal the one unit at half the velocity. Repeated tests, however, have demonstrated that such is not the case.

In the new units that are being developed it has been found that the amounts of water that can be treated by six units in series is as shown in Fig. 10. Beyond six units in series there is no further effect in the reduction of pathogenic organisms.

Recent tests have developed the unique and interesting fact that water treated with ultra-violet rays has a residual effect. If to a sample of water that has been sterilized fresh bacteria are added it was found that in an hour's time 90 per cent of these added bacteria had succumbed. What was in the water that killed them is at present open for study and research.

Belgian Industries One Year After the Armistice

THE Belgian Ministère de l'industrie, du Travail, et du Ravitaillement has just completed a survey of the status of unemployment and of the extent to which various Belgian industries had recovered in December, 1919. The investigation was conducted jointly by the Administration of Mines and the Labor Inspection Service, the former considering conditions in the extractive and metallurgical industries, and the remaining industries being covered by the labor inspectors, whose inquiry was extended to all establishments employing more than twenty workmen in 1914. Comparisons are made on the basis of production and employment on corresponding days in December, 1913, and December, 1919. It is obvious that comparisons made on the basis of one day's output may sometimes be misleading.

At first glance the results of the investigation are discouraging from the standpoint of comparative labor output. From the standpoint of actual production in comparison with pre-war output, they indicate, however, the remarkable industrial revival already commented upon by all recent visitors to Belgium. The effect of the general introduction of the 8-hr. day and of the large amount of work necessary to restore plants and mechanical equipment in some industries is shown by the following figures:

In December, 1919, the coal mines produced 94 per cent of the 1913 output, although labor employed amounted to 104 per cent of the pre-war figure. Coking plants were producing 37 per cent of the pre-war output while employing 53 per cent of their 1913 personnel. Plants for making briquets for the railways and other industrial uses attained 98 per cent of the pre-war production, with an increase of 9 per cent over the pre-war labor force.

The poor showing made by the iron and steel industry is no doubt attributable to the unusually severe damage suffered by such plants and the consequent necessity of employing large numbers in rebuilding and repairing foundries and mills and installing new machinery or stolen equipment recovered from Germany. With 60 per cent of the pre-war personnel, the iron foundries and steel mills produced in December only 34 per cent of their pre-war output, but this was a considerable increase over preceding months.

Still more serious is the condition of the zinc foundries, which in December were turning out 18 per cent of the pre-war production with 54 per cent of the labor employed in 1913. Special difficulties in obtaining ores and other raw materials are probably responsible for this large proportion of labor to output. The production of lead was only 9 per cent of the 1913 total, while copper production was about 28 per cent. In the quarries, an important and very diversified Belgian industry, production was slightly less than 50 per cent with a personnel of about 54 per cent.

According to the finding of the Administration of Mines, 115 establishments, including coal mines, coke and metallurgical plants, and quarries of various kinds, gave war destruction as the chief reason for subnormal production, eighty plants specifying lack of transportation facilities, fifty-two lack of adequate coal, forty-nine labor shortage, thirty reduction of working day, twenty-three lack of raw materials other than fuel, and thirty-three (all quarries) lack of orders.

Legal Notes

By Wellington Gustin

Pointers to Inventors and Users of Secret Processes

Some of the distinctions in the remedies one may have in courts of equity as against courts of law are given in a case from the Court of Chancery of Delaware involving the claims of an inventor who discovered a new process for making powder. (O'Neil vs. E. I. du Pont de Nemours & Co., 106 A., 50.) In his bill which states his cause of action the complainant alleges that in 1909 and 1910, while employed by the government of Brazil, he discovered an improved process for the manufacture of propellant explosives. This formula he submitted to one of the directors of a powder corporation for the purpose of selling it to that company. This corporation is alleged to have manufactured and sold great quantities of powder made in accordance with this process, without the knowledge or consent of the inventor. In October, 1915, the defendant corporation purchased all the assets and assumed the liabilities of this powder company, and in December, 1915, the inventor entered its employment.

The inventor further alleges that as soon as he learned of the use made of his process, he made inquiries and on Aug. 9, 1915, the defendant company presented to him applications for patents of his process, with assignments to be executed by him to it of the full and exclusive right to the process and invention. The assignments were made, as the inventor alleges, "with express understanding that your orator would be compensated for the value of the said process and invention, and relying upon the promises and inducements so held out to him, and relying further upon the bonus plan which had been promulgated by the said defendant company and the promises of reward therein contained."

Inventor Alleges Promises Were Fraudulent

Continuing, the inventor alleged that he was later informed by the company that the bonus plan did not apply to him. However, in July, 1918, he received notice that certain benefits under the bonus plan of the company had been granted to him, but these he refused to accept as not being fair or adequate compensation for the assignments. Then, it was alleged, by reason of undue advantage taken by the defendant company of the confidential relations between employer and employee, and of the distressful financial condition at the time the assignments were made, the assignments were secured by the defendant without consideration, and as the result of the fraudulent promises and practices of the defendant company, he had been deprived of the use of the process, and by its use the company made large profits to which he was entitled, and the defendant company was chargeable with the profits it made.

The relief asked for by the inventor were an injunction against the taking of any steps to obtain the patents on the process; for a reassignment of the applications for patents; and for an accounting by the defendant.

To these allegations of the complaint the defendant demurred, raising the question whether his remedy was in court of law or in equity, assuming of course, that the facts claimed gave the inventor a right to enforce compensation from his employer. If he has a full, adequate and complete remedy in a court of law then he has no right to relief in a court of equity, said the Chancellor. In either court he must prove the contract, or facts from which the law will imply a contract, and his damages or compensation for the use of his invention. At law he has power to examine the books of the defendant company as fully as in equity. Indefiniteness in the terms of the agreement, or his inability to prove the making of it, do not entitle him to equitable relief, said the Chancellor. The demand for payment would not create a right in equity, or at law. Neither would the tender of certain benefits as stated have any greater weight in equity than at law if used as evidence of a recognition of a duty to compensate the inventor. And the prayer for an accounting of the profits derived from the use of the process does not of itself give jurisdiction to equity.

Conclusion of the Court

The following are the holdings and conclusion arrived at by the court. Where an inventor disclosed his new process to his employer, relying on promises of compensation if it proved valuable, and the employer without his knowledge used it and made large profits, and also obtained for a nominal consideration an assignment from him of applications for patents, and thereafter tendered him compensation which he deemed insufficient, he has an adequate remedy at law for breach of contract, and therefore cannot maintain a suit in equity for an accounting.

Where an inventor for a nominal consideration assigned his applications for patents to his employer, which in addition agreed to compensate him if the invention proved valuable, but no price for such compensation was fixed, his action is in a court of law in a suit on a quantum meruit. Further, if the employer used the invention and derived a profit through such use, the employee inventor could not maintain a bill in equity for cancellation of the assignment of the application for patents; there being no fraud, actual or constructive, and his remedy being at law for recovery on the agreement to compensate.

Again, said the court, where an inventor disclosed his invention and assigned his application for patents thereon for a nominal consideration to his employer, which agreed to compensate him, failure so to compensate him would not in itself give a right to equitable relief, on the ground of the existence of a confidential relation between the parties. Further, where the employer, in addition to the nominal consideration, agreed to compensate the inventor if the process proved valuable, his employer's mere failure to compensate him under such agreement is not ground for recission of the agreement or cancellation of the assignments of the applications by the inventor, affording relief in a court of equity.

Regarding the inventor's right in his invention before issuance of patent, the Chancellor said he had a property right before the patent is obtained, which right is enforceable in a court, where he has agreed that another may use the invention in consideration that compensation be paid him in case the invention is found valuable.

Allegations of a bill in equity as to fraud must show the subject matter constituting the fraudulent conduct, as distinct from the evidence to prove the subject matter, said the Chancellor; and though a bill in equity characterizes defendant's acts by the expressions "fraud," "fraudulent," "fraudulent conduct and practices," where it avers no substantive facts as to fraud, no case of fraud is made out, so as to bring the case within equitable jurisdiction.

Aluminum Rolling-Mill Practice—IV Slabbing

Design of Rolling Mills and Plant Layout Are Discussed by the Authors, Together With a Detailed Account of All Hot and Cold Slabbing Operations Before Delivery of the Metal to the Finishing Department*

BY ROBERT J. ANDERSON AND MARSHALL B. ANDERSON

MILLS for rolling aluminum have been fairly well standardized as to design, and the essential features have not been changed in recent years. In the design of aluminum rolling mills, it is convenient to couple up a number of mills from one main drive so as to form a train. There is no advantage to be gained in driving the mills separately except in the case of strip mills.

ALUMINUM HOT MILL

An aluminum hot mill is a two-high mill employed mainly for breaking ingots down into slabs. Fig. 1 is a photograph of an aluminum hot mill, taken so as to show the front of the mill, while Fig. 2 is the same mill from the rear. The coupling stand for coupling up additional mills is shown in the foreground of both figures. In Fig. 1, a roughing mill is shown coupled into the system, at the left hand side of the photograph, thus forming part of a roll train. The hot mill illustrated in the photographs is a typical breakdown mill with geared mechanism on top of the mill for raising and lowering the upper roll.

Rolls are made of gray cast iron with a heavily chilled face, and their breakage is a heavy expense item in aluminum rolling. When the rolls become hot, the differential expansion of the gray and white iron, together with the internal strains usually present in a chilled roll, is often sufficient to cause fracture. Rolls fracture more often when the breakdown temperatures are too high or where there is lack of uniformity in the temperatures of successive ingots.

The hot mill shown in the photographs has rolls 28 x 84 in. (0.61 x 2.13 m.) running at the rate of 24 r.p.m. or a peripheral speed of 176 ft. per min. (53.6 m.). The flywheel in the system shown weighed 32 tons, and such a wheel is heavy enough to balance ten finishing mills, five hot mills, or a train of say one hot mill, two roughing mills and six finishing mills.

In the case of an aluminum hot mill, it is convenient to have a dial, shown on top of the mill in Fig. 2, divided into fifty equal parts, numbered consecutively. This dial is geared to the mechanism and motor for raising and lowering the upper roll in such a way that one revolution of the dial corresponds to a lateral movement in the upper roll of 1 in. Hence, fifty numbers equal 1 in., or one number equals 0.02 in. (0.5 mm.). By this arrangement the hot roller can figure his reductions readily. Due to wear in the journals and strain in the mill, the pointer of the dial may get out of alignment with the numbers and the position of the roll, and it is advisable to make adjustments at least daily. When a shift comes on, and before any rolling is performed, the screw boy should run the upper roll down tightly against the lower one; if the dial pointer is not at 50, i.e., zero, proper adjustment should be made.

Front and back floor plates (shown in Figs. 1 and 2) are important parts of breakdown mills, and unless these are of the correct design, much difficulty will be had in rolling. The front plate should be equipped with six small rollers set not more than 2 or 3 in. from the lower roll and if so placed the workmen will be relieved of much lifting. Back floor plates should consist of a heavy rod, set in the grooves from housing to housing; eight cast iron fingers, with small rollers on the end, are placed in a groove in the top of the rod. If a slab becomes stuck to the mill, the fingers will fly back and remove the strain from the back floor plate rod, as the slab goes around on the roll. Then the mill can be shut down and the slab removed. With rigid fingers, a slab stuck as mentioned will push on the fingers and break the back floor plate.

Roughing and finishing mills are similar in their general characteristics, and slabbing is done on a mill similar to a hot mill. Both roughing and finishing mills are of lighter construction than hot mills and slabbing mills because the work performed by the former is not so heavy. The upper roll is raised and lowered by hand, in the case of roughing and finishing mills, by means of a hand wrench on either side; the mechanism is shown in Fig. 1. Geared mechanism with motor drive is not used on these mills because the upper roll is not moved far, either up or down, as is the case with hot mills and slabbing mills. Roughing and finishing mills run at somewhat faster speeds than breakdown mills; for example, rolls in the former mills may run at the rate of 34 r.p.m., or a peripheral speed of 250 ft. (76.2 m.) per min. for 28-in. (0.71-m.) rolls. Roughing and finishing mills are built in various sizes

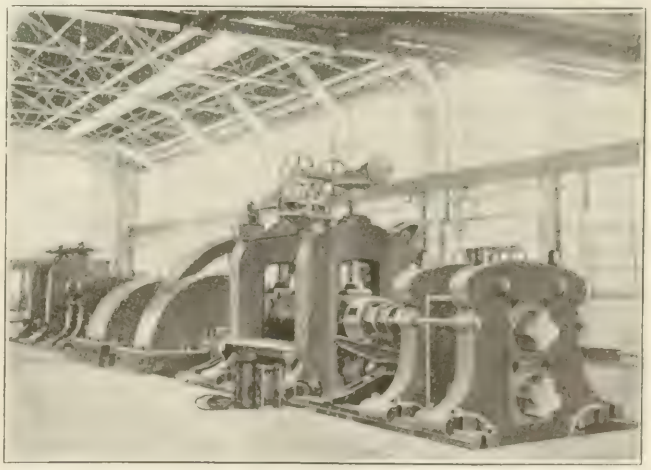


FIG. 1. ALUMINUM HOT MILL, 28-IN. ROLLS, IN TRAIN, FRONT VIEW

*For Parts I, II and III, see CHEM. & MET. ENG., vol. 22, Nos. 11, 12 and 13, March 17, 24 and 31, 1920, pp. 489, 545 and 599.

according to requirements; thus the rolls may be 28 x 60, 28 x 84, and up to 120 in. (0.71 x 3.05 m.).

Strip mills are usually operated as separate units, and this is so largely because of the amount of space required on both sides of a strip mill for handling coils. A typical single-unit strip mill has rolls 20 x 36 in. (0.51 x 0.91 m.), running at 25 r.p.m., or a peripheral speed of 131 ft. (40 m.) per min. Single-unit strip mills are driven by an individual motor, and they have mechanism similar to the hot-mill mechanism for raising and lowering the upper roll. This mechanism may be controlled by hand wheels rather than hand wrenches. A two-high continuous strip mill, with five mills in a row driven by one motor, is used for rolling strip faster than is possible in a single-unit strip mill. The reductions may be so arranged that the mills are set as follows:

Mill	Takes metal, in. thick (1 in. = 25.4 mm.)	Breaks to, in. thick (1 in. = 25.4 mm.)
First	0.375	0.300
Second	0.300	0.225
Third	0.225	0.150
Fourth	0.150	0.090
Fifth	0.090	0.064

A 0.375-in. slab will thus enter the first mill and emerge from the last as finished 14-gage strip, in one operation. The precise details in design of aluminum rolling mills vary with different builders, and the above brief descriptions give only the main points with regard to their construction. Furthermore, the layout for aluminum rolling mills will vary according to the amount of the output, the variety of the output, and other factors.

Layout of a Rolling Mill

In planning the layout of a mill, it is necessary to correlate carefully the capacities of the various mills with the melting and annealing equipment so that the complete mill will not be overbalanced in any department. No mention of the construction of mill buildings will be made other than to say that they should be well lighted, properly heated and ventilated and of modern design. Considering a mill of moderate size which shall have an output of 14,000 to 15,000 lb. (6.3 to 6.8 metric tons) of heavy sheet and 10,000 to 12,000 lb. (4.5 to 5.4 metric tons) of light sheet per day, the necessary equipment will comprise the following: Two 5,000-lb. (2,300-kg.) melting furnaces, one hot mill, two roughing mills, four finishing mills, and a strip mill. An ingot-heating furnace and two annealing furnaces will make up the metal-heating equipment.

Two 5,000-lb. melting furnaces can produce 9,000 lb. (4,100 kg.) of rolling ingots in 8 hr., or 27,000 lb. (12,250 kg.) per day. One five-track ingot-heating furnace will have sufficient capacity for preheating the ingots. A day shift can break down 27,000 lb. of ingots in the hot mill, and the same amount of metal can be cold slabbed on this mill by a night shift. Roughing, finishing and strip rolling performed continuously day and night with the equipment mentioned will turn out 24,000 to 27,000 lb. (11 to 12 metric tons) of finished aluminum sheet per day. In this case, we are assuming that about 33 per cent of the output consists of metal lighter than 20-gage and 66 per cent heavier, since heavy sheet can be rolled faster than light gage—for example, 14-gage cold-rolled aluminum sheet can be turned out about 1.5 times as fast as 20-gage, while the disproportion is larger with wider variations in gage.

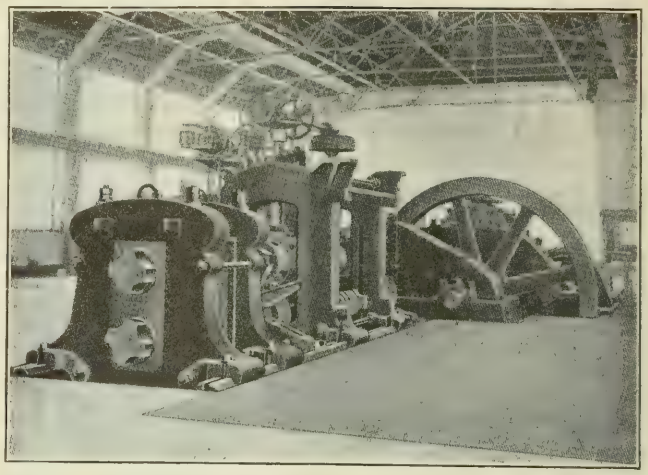


FIG. 2. ALUMINUM HOT MILL, 28-IN. ROLLS, IN TRAIN, REAR VIEW

With a mill as outlined, the hot mill, two roughing mills and four finishing mills would be run on one roll train with direct motor drive; the strip mill would be operated as a separate unit. In breaking ingots down into slabs, it is advisable to employ two hot mills in a plant of double capacity than the one outlined. With two hot mills, a crew of four men (one roller and three catchers) would be employed. After rolling metal on one mill for 30 min., that mill would be cooled, and the crew would move over to the other mill; the catchers would work on shifts, one catcher resting every 30 min. With one hot mill, ingots are being rolled only about half the working time because of the necessity for cooling the rolls at intervals.

A well-designed mill of the capacity mentioned should have at least five shears: A circle shear, a gang shear, a slab shear, and a large and a small shear for finishing and re-squaring. Slabs and light sheets should not be cut on the same shear. In addition to the equipment already mentioned, a mill of moderate size should include a flatter and a strip cleaner. The latter should be placed in a separate building if gasoline is used for cleaning. A suitable overhead electric crane, with say 5- and 20-ton hoists, should run the length of the main mill building.

Hot-Mill Crew

A hot-mill crew consists of the following men: An ingot pusher, a trucker, a roller, two catchers, and a screw boy. Strictly speaking, the ingot pusher should be classed as an ingot-furnace operative, and the trucker as partly an ingot-furnace and partly as a hot-mill operative. These distinctions are, however, somewhat academic in discussing rolling-mill practice from the metallurgical viewpoint, but they do become important in cost finding.

These operatives perform the following work: The ingot pusher stacks up cold ingots at the charging end of the ingot-heating furnace and operates the pushing ram so as to keep pace with the withdrawal of hot ingots from the front of the furnace. The trucker withdraws hot ingots from the front of the furnace by means of tongs, trucks ingots to the hot mill, and places them in position on the hot-mill floor plate for rolling. The roller is in charge of the work and puts the metal through the rolls from his side of the mill. The catchers, working on the opposite side of the mill from the roller, catch the rolled metal with tongs after each

pass, return it over the upper roll of the mill to the roller, and, after the final pass, place the resultant slab in a pile adjacent to the mill. The screw boy controls the reduction of the ingot with each pass by operating the electrically-driven upper roll through a hand controller.

Under good conditions, such a crew can roll, on an average, 275 4 x 12 x 14 in. (10 x 30 x 35 cm.) ingots in 10 hr. to 38 x 86 x 0.25 in. (96 x 218 x 0.6 cm.) slabs, the number being dependent upon the size of the ingots and the required slabs.

Rolling Temperatures

Allowing for the cooling of a hot ingot during the elapsed time between its withdrawal from the furnace and the first pass, the metal is rolled at a temperature of from 410 to 435 deg. C., although these figures are simply estimates. Some actual temperature measurements have been made by the writers in the case of ingots rolled directly from the molds. These measurements showed that the temperatures of succeeding ingots varied considerably, due to different pouring and mold temperatures and variations in time elapsed after pouring and before rolling. Furthermore, the interior of an ingot may be at a different temperature than the exterior; it may be higher than the exterior in ingots rolled directly from the molds, and lower in ingots preheated for too short a time, or cooled for too long a time after heating, prior to rolling. In any event, there is doubtless considerable variation in temperature not only between individual ingots but also in different parts of the same ingot. Fire-cracked slabs have been mentioned previously as being the result of too high breakdown temperatures. Fire cracks can be largely eliminated in the subsequent rolling if there is sufficient thickness after roughing so that the cracks can be eliminated on finishing.

Rolling Practice

Ordinarily, an aluminum ingot is rolled by giving it two or three passes so that the ingot is elongated to a length sufficient to make the desired width of the slab, whereupon this resultant thick slab is turned at right angles to the original direction of rolling and cross-rolled to the desired thickness. Provided an ingot of the correct size has been rolled, the resultant slab will be of the required dimensions. In breaking down, the first pass should be light so that the roller can obtain an idea of the condition of the metal; if too hot, the ingot will probably break or crack; if too cold, that fact will be noticed in the mill. If the required sheet is not too wide, say under 60 in. (1.5 m.), and 4 x 12 x 17 in. (10 x 30 x 43 cm.) ingots are being broken down, it is good practice to roll to the width with a heavy reduction on the second pass; on the other hand, if the required sheet is to be wider than 60 in., it is better to take only a fairly heavy second pass and roll to width on the third or fourth pass. In hot rolling ingots for wide sheets, it is better to make the passes reasonably light, otherwise the slab is likely to become distorted out of square and thus cause high scrap losses at the hot mill. Where the length is extremely disproportionate, it is difficult to keep the slabs even approximately square at the corners. Broadly speaking, the heaviest reduction should take place on the second pass, but the practice is necessarily variable.

Partial curling up or sticking of slabs to the hot-mill rolls is due to lack of kerosene, which should be liberally sprayed on the rolls before rolling each ingot. Kerosene is much better than so-called "solutions," made by mixing lubricating oils in water; it is often difficult to start an ingot when such solutions are used, and at times, after the ingot does start into the rolls, it will turn suddenly at right angles and roll on the wrong dimension. If an ingot curls up even though kerosene is used, it often helps if a little cup grease is rubbed on the surface; on the succeeding pass the slab will then straighten out.

Supposing now for explanatory purposes, 16-gage (1.29-mm.) cold rolled sheet is desired which shall, when finished, cut without an undue amount of scrap to 36 x 144 in. (0.91 x 3.66 m.). In order to obtain the required slab to make such a sheet, an ingot whose dimensions are 4 x 12 x 17 in. is first given a light pass in the hot mill—the 4 x 12 in. side entering the angle of nip on the rolls—and then a heavy pass (reducing about 1 in.) in the same direction and then a light pass so that the resultant thick slab after these three passes has approximate dimensions of 1.8 x 12 x 38 in. (4.6 x 30 x 97 cm.). The slab is then turned 90 deg. with the first direction of rolling and cross-rolled to ¼ in. (6.3 mm.) thick, when it will have approximate dimensions of 0.25 x 85.9 x 38 in. (0.63 x 218 x 97 cm.). The first three passes are calculated to produce a length of 38 in. (97 cm.), and when this thick slab is turned for cross rolling this 38-in. length becomes the width

TABLE XV. SCALE FOR HOT ROLLING 3.5 x 12 x 24-INCH INGOTS TO VARIOUS WIDTHS AND THICKNESSES

Width in.	Dial pointer stands at first pass	second pass	third pass	fourth pass	fifth pass	sixth pass	seventh pass	Thickness, in.
15	40	**20**	45	15	29	..	..	0.500
16	40	**15**	45	12	29	..	..	0.500
17	50	**30**	12	29	..	..	..	0.500
18	50	**34**	12	29	..	..	..	0.500
19	50	**38**	12	29	..	..	..	0.500
20	40	**20**	**34**	12	30	..	..	0.500
21	40	**20**	**40**	12	30	..	..	0.500
22	40	**20**	**41**	12	30	..	..	0.500
23	40	**20**	**42**	12	30	..	..	0.500
24	40	**20**	**47**	12	30	..	..	0.500
25	40	**20**	**50**	15	30	..	..	0.500
26	40	**22**	**40**	**1**	24	36	..	0.375
27	40	**22**	**40**	**3**	24	36	..	0.375
28	40	**22**	**40**	**5**	24	36	..	0.375
29	40	**24**	**40**	**7**	24	36	..	0.375
30	40	**24**	**40**	**10**	24	36	..	0.375
31	40	**24**	**42**	**11**	24	36	..	0.375
32	40	**24**	**42**	**12**	24	36	..	0.375
33	40	**24**	**44**	**14**	24	36	..	0.375
34	40	**24**	**45**	**15**	24	36	41	0.250
35	40	**24**	**45**	**16**	24	36	41	0.250
36	40	24	50	18	24	36	41	0.250
37	**42**	24	50	18	24	36	41	0.250
38	**42**	24	50	18	24	36	41	0.250
39	**50**	24	50	18	24	36	42	0.250
40	**2**	24	50	18	24	36	42	0.250
41	**3**	24	50	18	24	36	42	0.250
42	**40**	24	50	18	24	36	42	0.250
43	**40**	**13**	45	18	24	37	42	0.250
44	**40**	**14**	45	18	24	37	42	0.250
45	**40**	**16**	45	18	24	37	42	0.250
46	**40**	**18**	45	18	24	37	42	0.250
47	**40**	**19**	45	18	24	37	42	0.250
48	**50**	**20**	48	18	30	36	42	0.250

Ingot is cross-rolled on the passes where the dial numbers are printed in bold face type (see text).
Many variations are possible in breaking down ingots.
1 in. = 2.54 cm. 1 dial division = 0.55 mm.

The exact reductions which are given to ingots may vary considerably for the reason that there are numerous combinations possible. An empirical scale for hot rolling is given in Table XV for breaking 3.5 x 12 x 24 in. (9 x 30 x 61 cm.) ingots to various widths and thicknesses, the length being allowed to run. The dial numbers refer to the numbers at which the pointer should stand after each set of the rolls, and those numbers in bold-face type indicate that the ingot should be turned at right angles (cross-rolled) on the pass. In each instance, the ingot is normally rolled by putting

the 3.5 x 24 in. side through the rolls on the first pass, so that cross-rolling may be interpreted as rolling at right angles to this dimension, i.e., on the 3.5 x 12-in. side. Where bold-face figures appear for the first pass, the 3.5 x 12 in. side enters the rolls; before each pass indicated by a bold-face number, the ingot will be turned.

After each ingot is broken down, the resultant slab is piled in a pile adjacent to the hot mill, and all lots are kept separate. After a track of ingots has been rolled, the rolls are cooled with a water spray from a perforated pipe for about 15 min. During this time the rolls are revolving. The water cooling should not be continued too long, as otherwise a coating may form on the rolls; this coating will then come off when the next ingot is rolled, and possibly scrap the slab.

Cold Slabbing

All aluminum slabs made on the hot mill, except those intended for strip rolling and sheets to finish 0.101 in. (10-gage, 2.59-mm.) or heavier, are slabbed cold on a slabbing mill. In a small plant, it is often necessary to slab cold on the hot mill at night, and run the hot mill on ingots only during the day. Whether that is done or a separate mill is employed does not alter the principles involved, since slabbing mills are the same as hot mills to all intents and purposes, so far as construction goes. Slabbing may also be done on a roughing mill.

On a slabbing mill there will be one roller, one helper, and two catchers. The roller and his helper work in front of the mill and the two catchers behind the mill. In slabbing, the roller and helper push the slab through the mill, and the two catchers receive it and pass it back over the top roll. In the manufacture of sheets, aluminum is handled with tongs only at the hot mill; during slabbing, roughing and finishing it is manipulated by hand.

The majority of hot-mill slabs are slabbed cold to one-half the original hot-roll thickness; for example, 0.25-in. slabs are reduced to 0.125 in., 0.30-in. slabs to 0.15 in., and so on. The exceptions to this rule have been stated previously in connection with the examples for calculations, and the slabbing thicknesses for sheets of various gages and sizes are given in Table IX.* The desired object is accomplished by giving the slab about five to fifteen passes with two or three sets of the rolls. Slabbing is a continuous operation, and there is no "spelling." Normal production will be about 2,000 lb. (910 kg.) of metal per hr. Kerosene should be swabbed on the rolls and metal during the slabbing operation in order to prevent the metal from sticking.

Slab Shearing

After cold slabbing, all slabs going to make sheet aluminum are sheared on both ends and cut to such lengths as will make (with certain exceptions to be noted later) the required finished sheets. Slabs are cut into from two to twenty-five pieces. Where only one large sheet is to be made from a slab, a hot-mill slab is sent directly to the finishing mill without cold slabbing, shearing or roughing. All slabs destined for the strip mill are sheared on both ends, and the edges are trimmed to remove any cracked metal; shearing the edges helps to prevent further cracking during strip rolling, and provides for straight edges. In the case of strip-roll slabs, two or four pieces are cut from the hot-mill slab.

Slab shearing follows cold slabbing in the mill scheme with the exceptions already described. The amount of scrap made by slab shearing averages from 10 to 12 per cent of the hot-mill production, but will vary with conditions. With correct shearing, it should be close to 10 per cent. Slab shearing is performed upon large power shears of well-known types, and the slabs should be sheared as fast as they are rolled on the slabbing mill. The slab shear is operated by a shearman and two helpers. After shearing, the slabs are stacked near the roughing mill, if they are to be roughed; some slabs are sheared and sent directly to the finishing mill; in either case, the sheared slabs should be piled near the proper mills.

In the example for calculating sheets, it was pointed out that very large shearing losses may arise in the manufacture of aluminum sheets because of miscalculations with regard to the size of ingots rolled. If the right size ingots are rolled, the slab-shear scrap should not exceed 10.1 per cent of the hot-mill output. There is 10 per cent allowed for rounded ends and other irregularities in shape, and 0.10 per cent is added because most of the calculations cannot come out exactly. An example is given in the following: In calculating an order for 16-gage sheets, 40 x 144 in., the figures are:

0.150 ÷ 0.050 = 3
160 ÷ 3 = 53+
106 ÷ 53 = 2, the number of cuts to a slab. This results in practically exact figures. Comparing this with an order for 20-gage sheets, 25 x 60 inches, the figures are:
0.125 ÷ 0.031 = 4
80 ÷ 4 = 20
177 ÷ 20 = 8 + 17, or there will be eight cuts to a slab and 17 in. of scrap.

The 17-in. scrap end is weighed with the slab-shear scrap, and 0.10 per cent allowed as an average will provide for such cuts. Excessive slab-shear scrap is due to wrong calculating, to wrong shearing by the shearman, and to poor breakdown practice at the hot mill.

(Part V, the last of the series on Aluminum Rolling-Mill Practice, dealing with finishing operations, will be published in our next issue.)

*See Chem. & Met. Eng., vol. 22, No. 13, March 31, 1920, p. 601.

Imports and Exports of Chemicals

Imports and exports of certain chemicals, as reported by the Bureau of Foreign and Domestic Commerce, for January, 1920, and the figures for January, 1919, as finally revised, are as follows:

EXPORTS OF CHEMICALS

	Jan., 1919 Lb.	Jan., 1920 Lb.
Acids:		
Carbolic	229,497	440,832
Nitric	49,411	13,270
Picric	22	5,567
Sulphuric	1,067,763	1,768,749
Calcium acetate	55,765	3,632,782
Calcium carbide	2,286,388	736,959
Calcium chloride	1,579,847	2,983,782
Copper sulphate	2,847,199	346,947
Potassium chlorate	410,979	409,154
Soda:		
Caustic	17,402,125	14,180,004
Sal soda	1,453,780	552,193
Soda ash	15,034,056	5,676,972
Sodium silicate	2,008,597	1,771,143
	Value	Value
Dyes and dyestuffs	$2,318,061	$1,449,153

IMPORTS OF CHEMICALS

	Jan., 1919 Lb.	Jan., 1920 Lb.
Calcium acetate and chloride (crude), carbide and nitrate	11,260,828	5,684,135
Dyes	216,952	539,144
Gums	4,694,962	12,328,990
Potassium carbonate, including crude or black salts	120,953	1,289,938

Methods for Analytical Control of Electrolytic Zinc Production

A Description of the Methods Used at the Electrolytic Zinc Plant Laboratory of the Judge Mining & Smelting Co., Park City, Utah, for the Analysis of Leach and Electrolyte Solutions, Concentrates, Calcines and Leach Residues, Zinc Dust Precipitate and Anode Scale From Cells

By H. F. BRADLEY

IT IS not the purpose of this paper to describe analytical methods for all elements likely to be determined in electrolytic zinc work, but to present a few methods which have been tested and found especially suited to the materials produced in the process outlined below. These methods are in use at the electrolytic zinc plant laboratory of the Judge Mining & Smelting Co. No special originality is claimed, except possibly in suitably combining and modifying standard procedures.

The materials to which the methods apply are produced in the following process:

Concentrates consisting chiefly of zinc blende and pyrite are roasted to convert the zinc to forms soluble in sulphuric acid. The calcine is agitated with a slight excess of dilute H_2SO_4, and the excess acid neutralized with $CaCO_3$ or $Ca(OH)_2$. After settling and filtering, the solution is purified by agitation with zinc dust. The resulting pure electrolyte is electrolyzed with lead anodes and aluminum cathodes, the "cell tail" solution being used again as leach liquor.

Analysis of Leach and Electrolyte Solutions

Leach Solution

The solution used has been neutralized with lime but not purified by agitation with zinc dust.

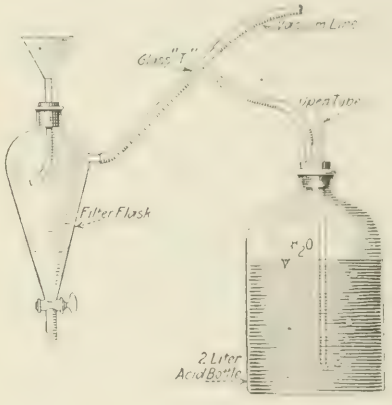
Copper. With pipette take 25 c.c. of solution, add 5 c.c. 50 per cent acetic acid, a little sodium or ammonium phosphate solution to precipitate any iron present, then 10 c.c. of 25 per cent solution of NaI. Titrate as usual with "hypo" (1 c.c. = 0.0025 g. Cu).

This method gives results very slightly higher than the precipitation as sulphide and subsequent titration with "hypo." In this solution, the As and Sb are in the higher oxidized condition, and do not interfere.

Cadmium. Measure a convenient amount of solution (depending on the cadmium content), say 100 to 200 c.c., add 15 c.c. H_2SO_4 for each 100 c.c. taken; then add slowly, with stirring, enough Na_2S (10 per cent solution of crystals) to precipitate the copper. Boil about 2 min., test with a drop of Na_2S, and if the copper is completely precipitated, filter hot, washing with hot water. Any CdS precipitated by the Na_2S dissolves again on boiling with the above strength of H_2SO_4 (27 per cent).

Cool the filtrate, and add 15 c.c. strong NH_4OH for each 15 c.c. H_2SO_4 originally added, stirring the solution during the addition. Cool again, dilute to twice the original volume of solution taken, and pass in H_2S 30 min. or more. The dilution and treatment with NH_4OH has reduced the acid strength to about 9 per cent, which is suitable for the precipitation of CdS. (It is usually necessary to start the precipitation by adding a few drops of NH_4OH after passing the gas 5 minutes).

Let the precipitate settle 20 min., and filter by suction on fine papers (such as Munktell's Swedish No. 0), used double with filter cone. A Shaw filter flask,* pear-shaped, with stopcock at the bottom, will be found convenient for suction filtering. A simple vacuum regulator, to prevent breaking the paper, is shown in the accompanying figure. Wash the CdS once with water, then dissolve it in a small volume of hot 1:1 HCl, opening the inner fold of the paper to expose all the precipitate, and finally washing four times with hot water. To the solution add methyl orange, then carefully add NH_4OH until the neutral point is just passed, then add 10 c.c. trichloracetic acid solution (40 per cent). Cool, dilute to 100 c.c., and repeat the H_2S precipitation, filtering and washing five times with Na_2SO_4 solution (about 15 per cent of anhydrous salt). If washed with water, CdS is likely to run through the filter after two or three washings.



Tear the filter into several pieces and place in the original beaker, which now contains 60 to 80 c.c. of cold 1:1 HCl. Add starch and titrate immediately with iodine (2.35 g. per liter) to a distinct blue color, which remains at least 30 sec. while the solution is stirred. The sulphur formed in the reaction causes a pale blue color which must not be confused with the true end-point. Whether or not the true end-point has been reached can be determined by adding more iodine and noting whether the color becomes permanently deeper. 1 c.c. iodine = 0.0010 g. Cd. Standardize the iodine against standard "hypo" (Cu × 0.884 = Cd).

If preferred, an excess of iodine can be added, the solution stirred for 2 or 3 min., then titrated back with "hypo" (see references 1 and 2). This method checks very closely with the gravimetric method in which the CdS is changed to and weighed as $CdSO_4$.

Solutions containing less than 0.05 g. cadmium per liter should be analyzed by the method given under "Pure Electrolyte." When very low concentrations of cadmium are precipitated with H_2S in acid solution, the results are usually too low by a considerable amount.

* Sold by Eimer & Amend, New York, N. Y.

Antimony. (References 3 and 4.) To 250 or 500 c.c. of solution add 10 per cent by weight of H_2SO_4, heat to boiling, and pass in H_2S about 60 min. Let the precipitate settle a few minutes, and filter on a Büchner funnel, washing five or six times with warm 5 per cent H_2SO_4 to which a little Na_2S has been added, then once with water. Boil the paper and sulphides with 50 c.c. of Na_2S (5 per cent solution of crystals), filter and wash with small volumes of hot water. Treat the filtrate for Sb exactly as in "Pure Electrolyte," below, from the point where $NaClO_3$ is added, etc.

Total Iron. Rapid method. (Reference 5.) To about 300 c.c. of neutral filtered solution add *two drops only* of H_2SO_4, then add $KMnO_4$ from a burette to a *faint* pink color. With pipette take 5 c.c. of this oxidized solution and place in a vial or colorimetric tube of clear glass. Add 2 c.c. of conc. salicylic acid (2 g. per liter), dilute to 25 c.c., mix and compare with standards. If the color is too strong for a comparison, dilute the oxidized solution to two, three or five volumes and repeat the color test, taking the dilution into account when calculating the Fe.

For Acid Solution. Take 20 c.c. of solution and titrate the acid with Na_2CO_3 and methyl orange indicator. Now titrate another 20 c.c. *without* indicator, stopping the titration a little short of the previous reading, so that the solution contains about 0.5 g. H_2SO_4 per liter. Dilute to 40, 60 or 100 c.c. and treat with $KMnO_4$ and salicylic acid as above.

Preparation of Color Standards for Iron. Dissolve 0.249 g. $FeSO_4$ crystals (purified by alcohol) in distilled water, add six drops of H_2SO_4, add $KMnO_4$ from a burette to a faint pink end-point, and dilute to 1,000 c.c. This solution contains 0.050 g. Fe per liter, and can be used straight or diluted to make standards of different values, measured amounts being treated with salicylic acid as above. Standards must be freshly prepared every three or four weeks.

For the determination of Zn, Mn, CaO and MgO, see "Pure Electrolyte," below.

Pure Electrolyte

Traces of impurities remaining in the electrolyte after agitation with zinc dust to displace ions electronegative to Zn are determined as follows:

Antimony and Copper. (Distilled water and pure reagents must be used throughout.) With a graduate measure 1,000 c.c. of solution, add 6 or 7 per cent by weight of H_2SO_4, then add slowly, with stirring, 30 to 50 c.c. of Na_2S (3 per cent solution of crystals; this must be free from chlorides if copper is to be determined). Heat to boiling and boil 1 or 2 min. Let the precipitate settle about 30 min., add a little more Na_2S, and filter by suction on Büchner funnel (10 cm.). (Whatman No. 30 papers, used double, are the best for this purpose.)

Wash four times with dilute H_2SO_4 to which a little Na_2S has been added, and once with water. Continue the vacuum about 1 min. after washing. Fold the paper as usual and place in ordinary funnel, opening the inner fold to expose all of the precipitate; wipe out sulphides adhering to the Büchner funnel and add to the main precipitate.

Now wash the paper with 30 c.c. of hot 3 per cent Na_2S, passing first part of filtrate through again (Whatman No. 30 papers filter rapidly at this point). Wash twice with small volumes of hot water.

To the filtrate add about 0.7 g. $NaClO_3$, heat nearly to boiling, add 15 to 20 c.c. of strong HCl, and boil off most of the chlorine. Cool 1 or 2 min., add 3 c.c. of freshly made 10 per cent Na_2SO_3, and boil a few minutes. (A sheet of asbestos paper under the beaker will prevent bumping.) Cool again about 2 min. and repeat the above treatment with Na_2SO_3 twice more to insure complete reduction of Sb. Add about 0.3 g. tartaric acid and boil down to about 25 c.c. to remove SO_2 and As.

Cool, add a piece of litmus paper, carefully neutralized with NH_4OH, make slightly acid with HCl, and cool again. Add starch, dilute to 100 c.c., add an excess of $HNaCO_3$ or HNH_4CO_3, and titrate immediately to a distinct blue end-point, using the same iodine as in titrating Cd. (See "Leach Solution," above.) The end-point is much sharper in the presence of tartrates than in their absence. One c.c. iodine = about 0.0011 g. Sb (Cu $\times$ 0.945 = Sb).

A synthetic solution resembling our electrolyte was made up from spelter, c.p. H_2SO_4, $CaCO_3$, distilled water and other materials known to be practically free from Sb. Various amounts of Sb (as tartar emetic) were added to 1,000 c.c. portions of this solution and the assays carried through exactly as above, with the following results:

Sb Added, Grams	Sb Found, Grams	Sb Added, Grams	Sb Found, Grams
None	0.0003	0.0020	0.0020
None	0.0004	0.0030	0.0029
0.0010	0.0012	0.0040	0.0040
0.0010	0.0011		

The "blank" appears to be practically compensated by some other factor, probably the small amount of Sb_2S_3 remaining in solution.

Copper. After washing with Na_2S, the filter paper still contains the CuS. Pour upon it a few drops of neutral zinc nitrate solution (made by adding a slight excess of ZnO to 1:3 HNO_3; both this solution and the Na_2S used above must be free from chlorides). Place the paper on a scorifier and burn in a muffle at a red heat. The zinc nitrate changes to ZnO and effects the complete oxidation of the CuS to CuO, etc.; any chlorides present will cause loss of $CuCl_2$ by volatilization.

Dissolve the ZnO and CuO in not more than 1 c.c. of 1:2 HCl (warming for a few seconds may be necessary). Add 5 per cent KOH until a permanent white precipitate forms; dissolve the precipitate with an excess of acetic acid, keeping the volume as small as possible; add a few drops of sodium or ammonium phosphate solution to precipitate traces of iron, then about 1.5 g. solid NaI and a little starch. Titrate with weak "hypo" (5 or 10 g. crystals per liter).

The above treatment with zinc nitrate, etc., making unnecessary the usual evaporation with HNO_3, can be applied to as much as 0.020 g. of Cu, possibly more, if the CuS has been precipitated in a fine granular condition. The use of phosphate for Fe was noted in *Chem. News,* vol. 118, pp. 193-4 (R. H. Deakin).

Cadmium. (Use distilled water throughout). To 500 c.c. of solution add 50 g. NH_4Cl, heat to about 60 deg. C., add NH_4OH gradually until zinc hydrate dissolves, then about 15 c.c. excess. Dilute to about 800 c.c., and add slowly, with stirring, 20 c.c. of Na_2S (1 per cent solution of crystals). Heat to boiling and boil about 30 sec.

Let the precipitate settle about 40 min. and filter on a Büchner funnel, using fine double papers (Munktell's Swedish No. 0). Wash several times with warm 1:6 NH_4OH, to remove soluble zinc. Continue the vacuum 1 min. after washing.

Tear the paper into several pieces and place in a 250 c.c. beaker, wiping out any sulphides adhering to the

Büchner funnel. Add 30 c.c. 25 per cent H_2SO_4, boil 2 or 3 min. and filter hot, by suction, washing four times with water.

The filtrate contains Cd and some Zn. Add methyl orange, just neutralize with NH_4OH, add 10 c.c. trichloracetic acid (40 per cent), and determine Cd by two precipitations with H_2S and titration exactly as in "Leach Solution," above. The above method was derived from a method of spelter analysis formerly used by the Anaconda Copper Mining Co.

Zinc. For fairly accurate work, measure 5 c.c. of solution with pipette, add a few g. NH_4Cl, 0.5 to 1 g. ammonium persulphate, dilute to 100 c.c., add 15 c.c. NH_4OH, and boil 6 to 8 min. Filter off Mn and Fe hydrates, washing with dilute NH_4OH. To the filtrate add $CuSO_4$ solution to give a distinct blue color, acidify with 6 to 8 c.c. excess HCl, and add 5 c.c. of Na_2S (20 per cent solution of crystals) to precipitate Cu. Heat not above 75-80 deg. C., and titrate as usual with ferrocyanide.

The $CuSO_4$ acts as a better indicator than methyl orange, and the presence of CuS appears to give a less deceptive end-point than when Cu is absent. But the end-point will often be very deceptive if the solution has been heated to boiling before titrating.

For very accurate work, some standard gravimetric method is preferable.

Manganese. Pipette 20 c.c. of solution into a 100 c.c. measuring flask (calibrated against the pipette), dilute to the mark with distilled water, transfer the beaker, and mix well. If the Mn in the original solution is 0.4 g. per liter or less, take an aliquot of 20 c.c.; if more than 0.4, take 10 c.c., etc. Place the aliquot in a 150 c.c. beaker containing 0.020-0.023 g. $AgNO_3$ and 4 or 5 c.c. HNO_3.

Dilute to 30 c.c., cover, and heat to incipient boiling. Add about 1 g. ammonium persulphate and heat gently (just below boiling) for 1 min. after the pink color appears. Cool to room temperature, dilute to 100 c.c., and add 3 c.c. of NaCl (5 g. per liter). Titrate with sodium arsenic until the pink color just disappears and only the white of the AgCl is visible.

Sodium Arsenite Solution. Dissolve 0.675 g. As_2O_3 in hot distilled water containing 2 g. Na_2CO_3, and dilute to 1,000 c.c. (1 c.c. = 0.0002 g. Mn). Theoretically, about 0.908 g. of As_2O_3 is required, but the reaction actually does not proceed according to the usual equation. Apparently, this is not realized by some writers giving this method.

Standardize the arsenite as follows: From a burette run 10 c.c. $KMnO_4$ (0.574 g. per liter) into a small beaker containing the $AgNO_3$ and *colorless* HNO_3. Dilute to 100 c.c., add the NaCl and titrate as above. Run at least three standards and take the mean. If 1 c.c. $KMnO_4$ = 0.0010 g. Fe, 10 c.c. contains 0.001967 g. Mn.

Traces of chlorides do not interfere, but any considerable amount should be avoided. If a large number of determinations are made daily, time can be saved by using "Analoid Tablets" (see reference 8).

Total Iron. This is usually less than 0.002 g. per liter. To about 200 c.c. of neutral solution add *two drops only* of H_2SO_4. Add weak $KMnO_4$ from a burette to a faint pink end-point. Treat 25 c.c. with salicylic acid and compare with standard. (See "Total Iron in Leach Solution," above.)

Any considerable amount of strong acid destroys the color. Acetic acid may be present, but large amounts of Na or Zn acetate weaken or modify the color so as to render the test useless.

Arsenic. This is seldom determined at our plant, being present only in traces in the pure electrolyte. We should say that the Gutzeit method might be applied here. (Reference 6.)

CaO and MgO. Pipette 20 or 40 c.c. of solution, add 20 to 30 g. NH_4Cl and 3 g. ammonium persulphate. Dilute to 75 c.c., add 15 c.c. NH_4OH, boil 8 min., and filter by suction on fine papers, to remove Mn. Wash with dilute NH_4OH.

To the filtrate add 1 g. oxalic acid, or ammonium oxalate, boil, filter, and wash once with NH_4Cl solution. Dissolve the precipitate in hot 1:3 HCl, add a little NH_4Cl and oxalic acid, dilute to about 60 c.c., make alkaline with NH_4OH, boil and filter. Wash well with hot water and determine CaO as usual.

Combine the two filtrates from the calcium oxalate and determine MgO by the usual phosphate method, making a double precipitation.

"Cell Tail" Solution

H_2SO_4. Pipette 10 c.c. of solution into a beaker. If the solution contains suspended MnO_2 or the pink color of $HMnO_4$, add a very small pinch of ferrous sulphate and agitate until colorless. Dilute to 100 c.c. with distilled water, add methyl orange, and titrate with Na_2CO_3 (22 g. per liter) until the pink color has just disappeared and the solution is pure straw yellow. (1 c.c. = 0.020 g. H_2SO_4.

Add the Na_2CO_3 drop by drop when approaching the end-point; otherwise, the end-point will be passed before the indicator changes color, on account of the precipitation of zinc carbonate.

Unless H_2O_2 is available that is free from acid it should not be used to destroy the $HMnO_4$. This destruction of the $HMnO_4$ uses up some of the acid in the solution, but not enough to affect the results to any appreciable extent. $HMnO_4$ often destroys the indicator color or produces a false end-point which occurs too soon.

Determinations of other elements are made as given above.

Ores and Residues

Concentrates, Calcines and Leach Residues

Total Soluble Zinc (acid soluble + water soluble). The following method is due to C. A. Hansen of the General Electric Co., and gives the percentage of the total zinc solubles in 6 per cent H_2SO_4 under ordinary leaching conditions:

To 0.5, 1.0, or 2.0 g. of ore add 100 c.c. of hot dilute H_2SO_4 (7.5 g. per liter). Boil 5 min., cool 1 or 2 min., add a little NH_4Cl, 5 c.c. H_2O_2 (or ammonium persulphate if much Mn is present), then add 10 c.c. NH_4OH. Boil, filter and determine zinc as usual in the filtrate.

Actual tests have shown that the above result agrees closely with the zinc actually dissolved from calcines under leaching conditions at our plant.

Water-Soluble Zinc. Leach the sample with hot water, filter, precipitate Mn by boiling with NH_4OH and ammonium persulphate, filter and determine zinc as usual. The addition of $CuSO_4$, as in the case of zinc in "Pure Electrolyte," is helpful in determining the end-point.

Uranium nitrate usually gives a more satisfactory end-point than the acetate.

Cadmium. Dissolve 4 g. finely ground ore in HCl and HNO_3, add 15 c.c. H_2SO_4, and boil to fumes of SO_3. Cool, dilute to 100 c.c., boil, and filter, washing with small volumes of water.

To the filtrate add, with stirring, 4 or 5 c.c. 10 per cent Na_2S, heat nearly to boiling and pass in H_2S until Cu is completely precipitated (about 30 min.). Heat to boiling and filter hot, washing with hot water. CdS remains in solution in the above strength H_2SO_4 when the solution is hot.

Cool the filtrate, add 15 c.c. NH_4OH, cool, dilute to 200 c.c., and determine Cd exactly as in "Leach Solution," from the point where the Cu has been removed and NH_4OH added.

Manganese. Dissolve 1 g. ore in HCl and HNO_3, add 10 c.c. H_2SO_4, and boil to fumes. Cool, dilute to about 75 c.c. with distilled water, and heat to boiling. Cool, dilute to 100 c.c. in measuring flask, mix well, take a 20 c.c. aliquot and determine Mn as in "Pure Electrolyte."

Sulphur Present as Sulphate. Take a factor weight of ore, or any convenient fraction of the factor weight, add about 4 g. of c.p. $HNaCO_3$, then add 60 c.c. of boiling distilled water and boil gently 30 min. This converts practically all sulphates except $BaSO_4$ to the soluble form. Filter hot, washing with hot water. Carefully acidify the filtrate with 4 or 5 c.c. excess HCl, dilute to 250 c.c. and determine sulphur by the usual $BaSO_4$ method. (See reference 7.)

Zinc Dust Precipitate

Copper, Cadmium and Zinc. This material consists chiefly of these metals and their oxides, with small amounts of Pb and SiO_2.

To 1 g. of the precipitate add a little water, 5 c.c. HCl and 5 c.c. HNO_3, and heat. Solution is very quickly effected. Add 15 c.c. H_2SO_4 and boil to fumes. Cool, dilute to 90 c.c., and let stand a few minutes (boiling is unnecessary). Filter off the SiO_2 and $PbSO_4$, washing with small volumes of cold water.

To the filtrate add slowly, with stirring, Na_2S (10 per cent solution of crystals) until Cu is completely precipitated. About $\frac{3}{4}$ c.c. of Na_2S is required for each 1 per cent Cu present. If any CdS is observed, the Cu is completely precipitated. Boil about 2 min. The CdS dissolves again when boiled with this strength acid. Test solution with a drop of Na_2S, and filter hot, washing with hot water.

The paper containing the CuS is burned and Cu determined as usual.

Cool the filtrate, add 15 c.c. strong NH_4OH, dilute to 200 c.c., and determine Cd as in "Leach Solution."

The first filtrate from the CdS is boiled a few minutes to remove most of the H_2S, cooled, 5 c.c. H_2O_2 added, the Fe precipitated with NH_4OH, and Zn determined as usual. (See "Pure Electrolyte.")

Anode Scale From Cells

This consists chiefly of MnO_2 and PbO_2, and some Sb, probably as Sb_2O_5. Any coarse metal present should be screened out before analysis.

Antimony. To 10 or 20 g. of the scale add 100 c.c. distilled water and 15 to 20 c.c. H_2SO_4. Heat, gently at first, and add tartaric acid in small portions until the residue becomes rather light brown in color and the solution can be boiled without much foaming. Cool and filter on a Büchner funnel, washing with cold water.

To the filtrate add 60 to 80 c.c. of 3 per cent Na_2S, heat to boiling (take precautions against bumping), and treat the precipitate for antimony exactly as in "Pure Electrolyte."

Manganese. Scale to the amount of 0.295 g. is boiled with 20 c.c. of 1:1 HCl until dissolved. The chlorine may be boiled off, or it may be quickly destroyed by adding a little zinc dust, agitating a moment, and filtering off the lead sponge, etc. Mn is then determined by Volhard's method. If 1 c.c. $KMnO_4$ = 0.010 g. Fe, then 1 c.c. = 1 per cent Mn for 0.295 g. of ore.

Lead. Dissolve 1 g. of scale in HCl, take to fumes with H_2SO_4, and use Alexander's molybdate titration.

If preferred, the Mn can be determined in the filtrate from the $PbSO_4$.

References

Cadmium:
1. Blair, Chemical Analysis of Iron, 8th ed., pp. 66-68.
2. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 87.

Antimony:
3. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 27.
4. Low, Technical Methods of Ore Analysis, 6th ed., pp. 27-39.

Iron:
5. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 223.

Arsenic:
6. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 40.

Sulphur:
7. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 394.

Manganese:
8. Analoid Method for the Determination of Manganese, Scientific Materials Co., Research Dept.
9. Blair, Chemical Analysis of Iron, 8th ed., p. 125.
10. Scott, Standard Methods of Chemical Analysis, 1st ed., p. 267.

Acknowledgments

Thanks are due to the following persons for their suggestions and co-operation: C. A. Hansen and E. R. Crutcher, former superintendents, and J. T. Ellsworth, present superintendent, of the Judge Electrolytic Zinc plant; also to K. P. Girard, formerly assistant chemist.

Chemical Industry in Holland

The *Journal* of the Society of Chemical Industry concludes from articles in the *Schweiz Chemiker Zeitung* and the *Zeitschrift für Angewandte Chemie* that things are in a bad way with Dutch chemical industries. The year 1918 was a much better year than 1919. Large quantities of Chilean nitrate have been imported, which affects adversely the fertilizer manufacturers. Great fluctuations in prices make necessary immediate deliveries of all products. Many firms have difficulty in getting export permits, while no obstacles impede the importation of manufactured wares from central Europe and products of German origin are offered below the cost of raw materials. The paper industry did well during the war, but adverse conditions have intervened. Japan and America have captured a good part of the home and foreign markets. Coal is high and so is transportation, while labor is scarce and wages are high.

The manufacture of foods, condiments, wines, etc., has a better outlook. The sugar output is below normal owing chiefly to labor conditions. Margarine production has increased and the outlook is good. Brewers lack raw materials. Ample supplies are available to the cocoa and chocolate producers, but there is trouble about exports and it is feared that the old market for Dutch cocoa and chocolate will be captured by England and Switzerland.

Nitrate Industry in Chile*

Geography, Geology and Economic Situation of Chilean Nitrate — Present-Day Recovery of Nitrate From the Raw Material Is Far From Satisfactory and There Is Urgent Need for Improvements

By ALEJANDRO BERTRAND

CHILE'S nitrate deposits are limited to a strip of territory extending between the southern latitudes 19 deg. and 26 deg., i.e., for a length of 670 km. (about 400 miles) and along the seventieth meridian. The width of the deposits is very irregular. Thus in the northern districts of Tarapaca and Toco they are found in a series of separate but narrow strips of 5 km. (about three miles) maximum width. In the Antofagasta and Aguas Blancas districts they are scattered over polygonal areas of about 40 km. (25 miles) diameter, and those of the Taltal district are at least 40 km. wide. Fig. 1 gives the geographical location of the deposits.

Although geographically the location might indicate a tropical zone, in reality it is a veritable desert and offers a great contrast with the luxuriant vegetation, climate and hydrography of the Brazilian coast along the same latitudes. There is only one river worth mentioning in the nitrate region, the Rio Loa. The Cordillera de la Costa, sloping down to the coast, end in palisades of about 800 m. (2,600 ft.) high all along the Pacific coast and present only four outlets to the ocean: Quebrada de Tiliviche, to the Bay of Lisagua, located at latitude 19 deg., 33 min.; Rio Loa, the only water stream, at latitude 21 deg., 23 min., Antofagasta, at latitude 23 deg., 40 min., to which runs the Bolivian Railway, and the Quebrada de Taltal, at latitude 25 deg., 25 min.

There is not much rainfall in this region, but frequent clouds form heavy fogs, called *camanchacas*, which render the atmosphere damp and cover the soil with dew. The wind blows regularly from west to southwest, especially in the afternoons; it often reaches a great force and acts as a strong erosion factor. The temperature varies between 25 and 35 deg. C. (77 and 96 deg. F.) during the day and between 4 and 8 deg. C. (40 to 46 deg. F.) during the night. Freezing temperature occurs only exceptionally.

Many symptoms show the existence of a strong radioactivity in the nitrate region. The electric tension of the atmosphere is sufficiently strong to produce visible sparks when rubbing woolen clothes and to cause frequent telegraphic and telephonic disturbances.

Administrative Districts of the Nitrate Region

All the nitrate deposits are grouped into five administrative districts:

1. The Tarapaca district is the oldest and comprises a number of contiguous concessions. It is served by three railways (one broad gage and two narrow gage) connecting the workings with the harbor of Pasagua and Iquique. Branches extend to Junin and Caleta Buena. This district extends to about 21 deg. south latitude, south of which there is about 100 km. (62 miles) of land in which no nitrate deposits have yet been located.

2. The Toco district covers a length of about 70 km.

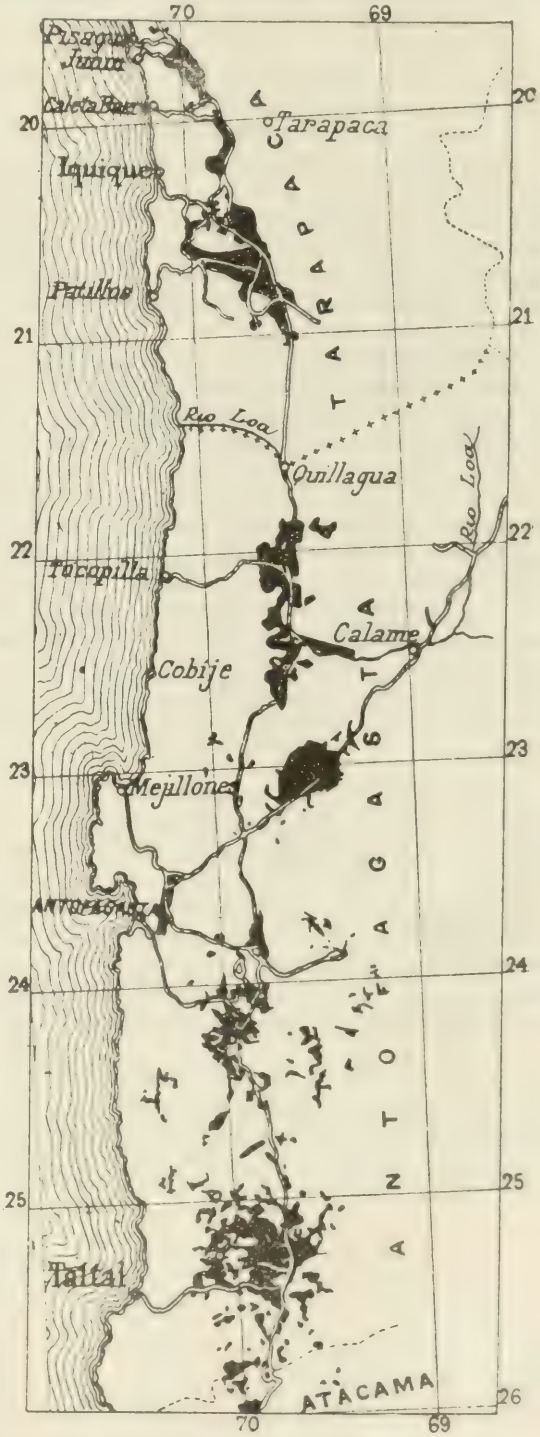


FIG. 1. GEOGRAPHIC DISTRIBUTION OF THE CHILEAN NITRATE

*Abstracts from a paper presented at the Nov. 26, 1919, meeting of the Société de Chimie Industrielle and printed in the January, 1920, issue of *Chimie et Industrie*.

FIG. 2. TYPICAL CHILEAN NITRATE PLANT

(44 miles) on the left bank of the Rio Loa. Its maximum width is about 20 km. (13 miles).

3. To the south of Rio Loa the nitrate deposits form two convergent series joined near the harbor of Antofagasta (latitude 23 deg., 38 min.). The first consists of scattered and insufficiently explored deposits in intermittent depressions, the second constitute the exploited saltpeter district of Antofagasta, whose maximum width is 15 km. (9.5 miles). It is served mainly by the Bolivian Railway.

4. Between latitudes 23 deg. 30 min. and 24 deg. 40 min. there are a number of groups of deposits, the principal group being the Aquas Blancas, 80 km. (about 50 miles) long, north to south, and 40 km. (about 25 miles) wide, east to west.

5. After a few kilometers of practically sterile land the nitrate deposits reappear, reaching the maximum width of 90 km. (56 miles) and ending at about south latitude 26 deg.

There are nine harbors to which the mined nitrate is taken for exportation. Table I shows the export tonnage capacity in metric tons of these harbors.

TABLE I. HARBORS AND THEIR EXPORT TONNAGE CAPACITY

Name	Yearly Capacity	Name	Yearly Capacity
Pisaqua	120,000	Mejillones	550,000
Junin	80,000	Antofagasta	480,000
Caleta Buena	310,000	Coloso	200,000
Iquique	700,000	Taltal	300,000
Tocopila	260,000		
Total			3,000,000

Table II gives the railways which reach these harbors, their gage, total length and average yearly tonnage.

The different railway gages are a great handicap to their efficient utilization, as can well be imagined.

Formation of the Nitrate Deposit

The nitrate deposits form generally horizontal beds covered usually by three distinct superposed layers. In some places one or even two of these layers may be missing.

TABLE II

Name of Railway	Width of Gage in Meters (1 Meter = 3.281 Ft.)	Length in Km. (1 Km. = 0.6214 Miles)	Nitrate Metric Tons (Metric Ton = 1.102 Short Tons)
Nitrate Railways Co.	1.44	607	1,000,000
Junin	0.76	90	80,000
Aqua Santa	0.76	116	300,000
Tocopilla Railways	1.07	122	260,000
Bolivia and Aquas Blancas Rys.	0.76	600	1,060,000
Taltal Railways	1.07	350	300,000
Longitudinal	1.00	630	
			3,000,000

A typical vertical section shows the following arrangement:

1. A layer of "chuca," which is a gray incoherent mass containing 45 to 65 per cent of quartzose silica and quite variable proportions of nitrates, chlorides, sulphates, carbonates, phosphates and iodates of potassium, magnesium, calcium, iron, aluminum, manganese, etc. The clear color indicates an appreciable quantity of crystallized sodium sulphate.

2. Next, a layer of "panqueque" (from the English pancake), a spongy, less friable variety of chuca, richer in calcium sulphate.

3. "Costra" (crust), next below, a kind of breccia of a color varying from dark brown to light gray. Costra contains from 40 to 70 per cent of insoluble matter. Among the soluble salts between 10 and 15 per cent is sodium nitrate. This layer is intimately associated with the following layer, which is the "caliche," the useful nitrate deposit.

Caliche, Its Composition and Properties

"Caliche" is an extremely complex and variable conglomerate. Its insoluble matter is cemented by a great variety of soluble salts. The proportion of insolubles varies from zero to 50 or even 60 per cent. The maximum percentages of the most important of the salts are shown in Table III. The salts for which the percentage is not indicated are usually present in small quantities or completely absent.

TABLE III. MAXIMUM OF THE MOST IMPORTANT SALTS CONTAINED IN CALICHE

	Per Cent Maximum		Per Cent Maximum
Sodium nitrate	80.0	Potassium sulphate	....
Potassium nitrate	5.0	Magnesium sulphate	....
Magnesium nitrate	....	Calcium sulphate	*10.0
Calcium nitrate	....	Aluminum sulphate	*8.0
Sodium chloride	60.0	Iron sulphate	....
Potassium chloride	....	Potassium perchlorate	....
Magnesium chloride	1.0	Sodium sulphonitrate	....
Calcium chloride	....	Calcium iodate and borate	....
Sodium sulphate	10.0	Sodium iodochromate	....

* Exceptional.

The caliches are classified according to their properties and their content in nitrates and other soluble salts.

Color. The color varies from white to black (manganic and ferrous), brown (earthy and argillaceous), sulphur yellow (chromous), orange (bromine salts), violet (iodine salts), etc.

Structure. The physical structure is extremely vari-

FIG. 3. VIEW OF A NITRATE DEPOSIT

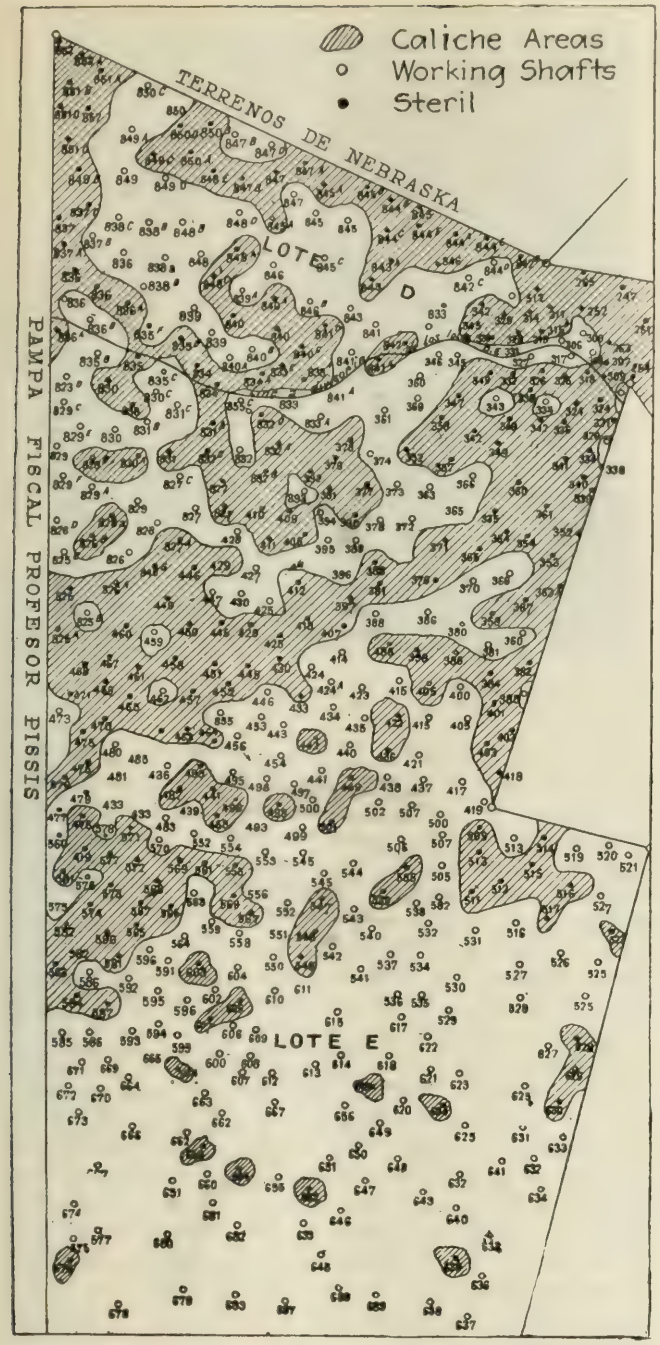


FIG. 4. PLAN OF A PROSPECTING CLAIM

able and has a great influence on the success of lixiviation. Breccia-like is the most common structure, with stony nodules of medium hardness. Others are porous, spongy, argillaceous and very compact (bony). Some are hydroscopic due to their contents of calcium nitrate.

Hardness. Hardness is a function of the structure. This property is of importance and serves to classify the caliche on the basis of the facility with which it is crushed.

Density. The density is not over 2.3 and can be as low as 1.9; for spongy caliche (45 to 52 per cent voids), it is 1.25 and even 1.0.

Substrata

Continuing in the typical vertical section there are usually three strata underlying the caliche, namely:

1. "Conjelo," which is breccia-like, the cement being sodium chloride and sulphate. The proportion of these salts may reach up to 75 per cent. Sometimes this conjelo is missing or is thoroughly intermingled with the caliche.

2. "Banco." This is also in the form of a breccia containing, besides sodium chloride and sulphate, some sodium nitrate, gypsum, etc.

3. "Coba." This is always present. It is composed of an earthy mixture with pebbles. It rests on volcanic rocks which constitute the skeleton of the Cordilleras.

It is impossible to fix the average thickness of the various layers. Caliche is never thicker than 2 m. (6.5 ft.), but coba can reach a thickness of 20 m. (65 ft.).

Prospecting for Nitrates

No plausible explanation of the origin of the deposits has as yet been given. This is a remarkable example of the imperfect human knowledge about nature's processes in the formation of a product existing on such a big scale as the Chilean nitrates.

Fig. 3 gives an idea of the usual appearance of a nitrate deposit.

A typical example of a prospecting claim is shown in Fig. 4. It is a portion of a plan published by the Chilean Government and shows the prospecting done since 1910. The government keeps geologic records on all the shafts.

The workmen have a practical way of judging the quality of caliche. They throw a small quantity of a pulverized sample on incandescent tinder. Caliche with less than 5 per cent nitrates does not give sparks, with 6 to 10 per cent nitrates the sparks are barely visible, with 10 to 20 per cent the sparks are more and more visible and numerous, with 20 to 30 per cent the sparks are visible in full sunlight. Caliche with more than 35 per cent nitrates will produce complete deflagration and flames appear. Sodium chloride decrepitates.

The prospecting holes are usually 100 m. (330 ft.) apart. Augers and scoops are used in the rudimentary prospecting work, explosives being employed but seldom.

Tables IV and V show typical examples of obligatory reports to be presented to the Chilean Government.

Separation of the Nitrate

The nitrate being present in the form of a mixture with other soluble salts and insolubles, its separation does not require any chemical reactions. Theoretically this separation appears to be extremely simple, because the only other soluble salt found in appreciable quantity in the caliche is sodium chloride and the solubility curves found experimentally and shown in Fig. 5 suggest an easy and purely physical separation of the nitrate from the chloride.

Experience has proved that the separation of the nitrate and chloride can be made to a limit of only 6 per cent chloride in solution by dissolving the caliche in boiling water. By cooling this solution to 0 deg. C. nearly 88 per cent of the nitrate free of chloride is precipitated.

This method of separation, although very simple in theory, is neither economical nor efficient, due to the great quantity of heat required and other physical conditions.

Methods of Separation

Two methods of operation are to be considered in practice. First, whether all the mass of caliche and insolubles shall be treated to boiling temperature with

TABLE IV. TYPICAL ECONOMIC SHEET OF A PROSPECTING NITRATE LOT

Santa Laura

	Sq. Meters
Area of the caliche deposit	1,063,949.76
Area sterile	305,426.00
Total area	1,369,370.76
	Number
Holes indicating the presence of caliche	144
Holes sterile	40
Total number of prospecting holes	184
	Meters
Average thickness of caliche	0.980
Average thickness of sterile ground	0.705
Total thickness	1.685
	Per Cent
Average nitrates in caliche	16.39
Average chlorides in caliche	20.00
Average iodine in caliche	0.0665
Average sulphates in caliche	7.36
Theoretical volume of the caliche, cu.m	1,042,665.860
Quantity of caliche per cu.m., tons (Average density, 2.231)	2.231
	Tons
Total weight of caliche	2,226,187.53
Less 23 per cent waste	535,023.13
Weight of working caliche	1,691,164.40
Weight of recuperable nitrate	293,571.85

the solvent. Second, whether there shall be a preliminary separation of insolubles at ordinary temperature and then treat the solution for the separation of nitrate by heating and cooling. The first method is the one which finds favor with the nitrate producers.

In the early days of the working of the Chilean nitrate (during the first half of the nineteenth century) only the caliche containing over 50 per cent nitrate (usually 60 to 80 per cent) was thought worth working.

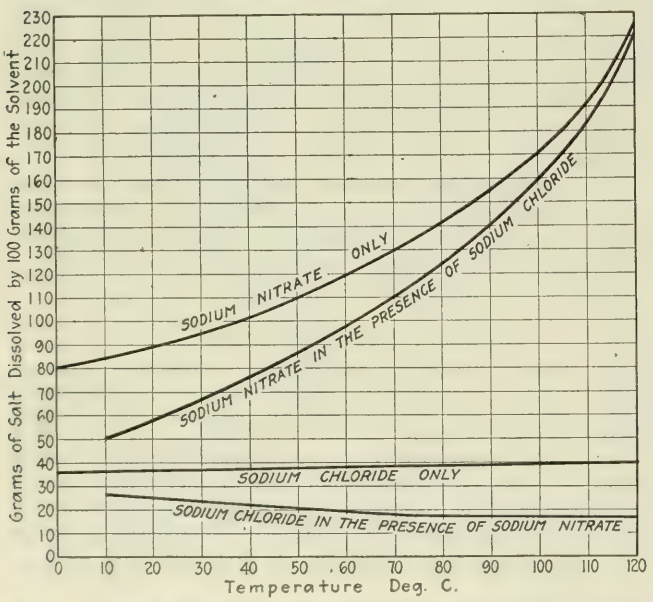

Grams of Salt Dissolved by 100 Grams of the Solvent
Temperature Deg. C.
SODIUM NITRATE ONLY
SODIUM NITRATE IN THE PRESENCE OF SODIUM CHLORIDE
SODIUM CHLORIDE ONLY
SODIUM CHLORIDE IN THE PRESENCE OF SODIUM NITRATE

FIG. 5. SOLUBILITY CURVES OF SODIUM NITRATE AND SODIUM CHLORIDE

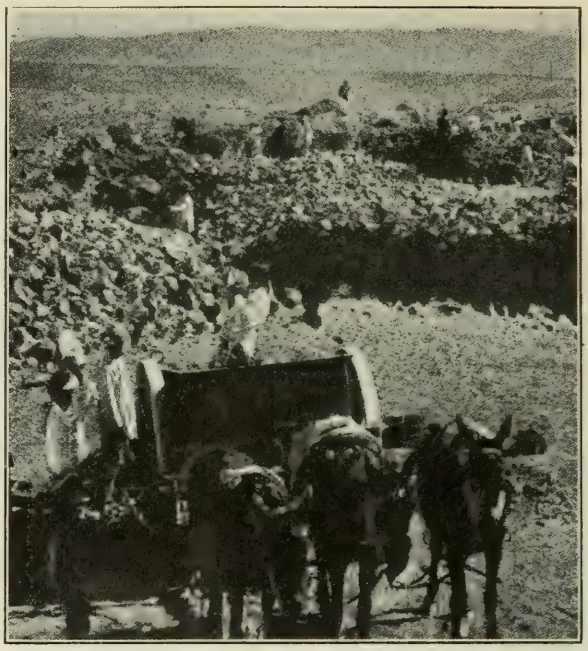


FIG. 6. METHOD OF TRANSPORTING THE CALICHE FROM THE MINE TO THE PLANT

This caliche was placed in round open tanks, treated with water, heated by open fire to boiling temperature; the solution decanted into settling tanks, where the insolubles in suspension and the sodium chloride were separated. The clarified solution was then transferred to crystallization vats or "bateas." The residue in the settling tanks usually retained from 15 to 25 per cent nitrate. This was sometimes re-treated with a new batch of caliche, but oftener it was considered as waste. Previous to 1856 about 200,000 tons of nitrate was obtained by this rudimentary method.

Beginning with 1856 improved methods of treatment were introduced. The first improvement was the substitution of steam heating for direct fire heating of the dissolving tanks. This improvement served two purposes, namely: To avoid burning the bottom of the tanks, and to agitate the mass by injection of live steam under a pressure of 3 to 4 kg. per sq.cm. (43 to 57 lb. per sq.in.). Tanks were, therefore, replaced by rectangular boilers of the Cornish type.

Next, direct steam heating was replaced by indirect steam heating.

These were the principal improvements during the period 1856-1876 when about 4,000,000 tons of nitrate was produced from caliche containing an average of 50 per cent nitrate.

The above rudimentary processes of operation resulted in excessive accumulation of residue "borras" from the

TABLE V. TYPICAL EXTRACT OF THE PROSPECTING SHEET AT SANTA LAURA. LOT D

Number of Prospecting Hole	Thickness of Superposed Layers, Meters: Sterile	Crust	Thickness of Caliche, Meters	Thickness of Subtrata, Meters	Total Thickness, Meters	Percentage Contents: Nitrates: Crust	Caliche	Chlorides	Iodine	Sulphates	Product (Thickness Multiplied by Percentage Contents)
239	0.20	....	1.20	0.85	2.25	....	17.3	....	.....	....	20.760
240	0.25	....	1.25	1.50	3.00	....	16.5	23.8	0.0291	9.56	20.625
246	0.80	....	1.20	0.75	2.75	....	12.8	....	.....	....	15.360
247	0.75	....	0.75	0.95	2.60	....	18.8	....	.....	....	14.100
248	0.40	....	0.90	1.27	2.57	....	15.0	....	.....	....	13.500
249	0.16	....	0.67	2.12	3.95	....	10.2	....	.....	....	6.834
250	0.15	....	1.55	1.50	3.20	....	11.5	....	.....	....	17.825
251	0.10	....	0.90	1.67	3.67	....	17.2	....	.....	....	15.480
252	0.90	....	0.75	2.30	4.05	....	16.7	....	.....	....	12.525
253	2.30	0.70	....	0.38	3.38	7.4	....	....	.....	....	5.180
254	0.22	2.08	....	2.05	4.35	11.4	....	....	.....	....	29.952

NOTE: 1 m. = 3.281 ft. 1 sq.m. = 10.76 sq.ft.

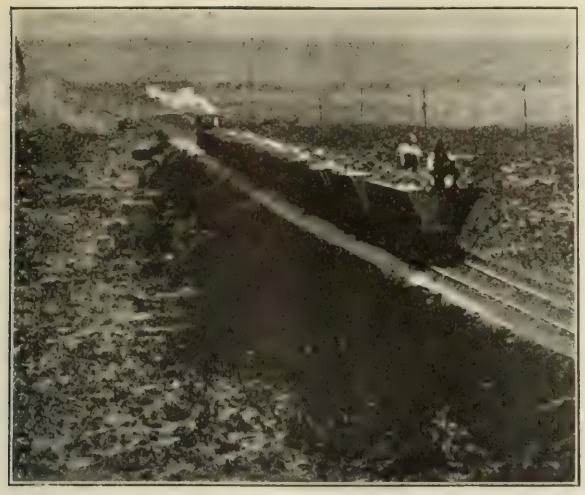


FIG. 7. RAIL TRANSPORTATION OF CALICHE

treatment, which residues contain up to 50 per cent of that nitrate originally in the caliche, in addition of the untreated waste "ripios," containing up to 30 per cent nitrate.

In 1876 the Shank process of lixiviation was introduced, thus enabling the treatment of caliches of poorer percentages of nitrate. Since first introduced it has been adopted by hundreds of plants and about 55,000,000 tons of nitrate has been thus extracted from the caliche.

This process, in which all the raw caliche and the solvent are brought to boiling temperature (the above-mentioned first method of operation) was a great improvement over the previous process during the early years of its introduction, because then the caliche treated contained on the average 50 per cent nitrate and only maximum 20 per cent of insolubles, and the useless heating of this last

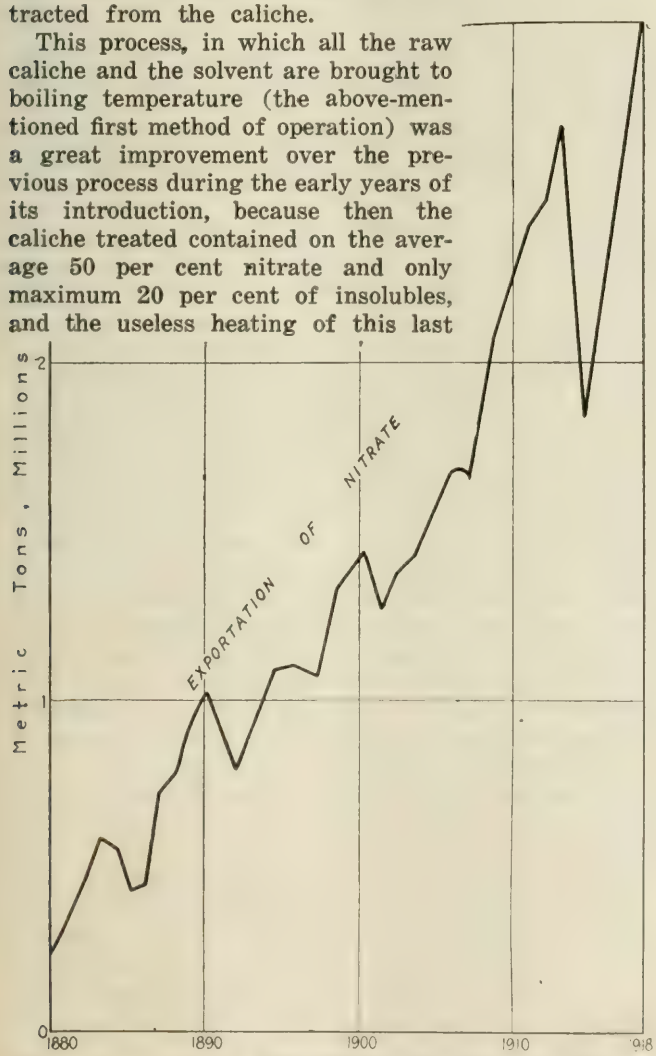


FIG. 8. PROGRESS OF THE EXPORT OF CHILEAN NITRATE FOR THE PERIOD 1880-1918

amount was relatively small. At the present time the Shank process is expensive and inefficient, because the caliche to be treated contains at the most 17 per cent nitrate and the insolubles reach about 60 per cent. These conditions require ever-increasing quantities of water per unit of nitrate produced and a corresponding increase in fuel consumed. Whereas in 1885 the separation of twelve units of nitrate required a consumption of one unit of fuel, now only five and in some cases as little as two and a half units of nitrate are produced per unit of fuel. Besides, the nitrate

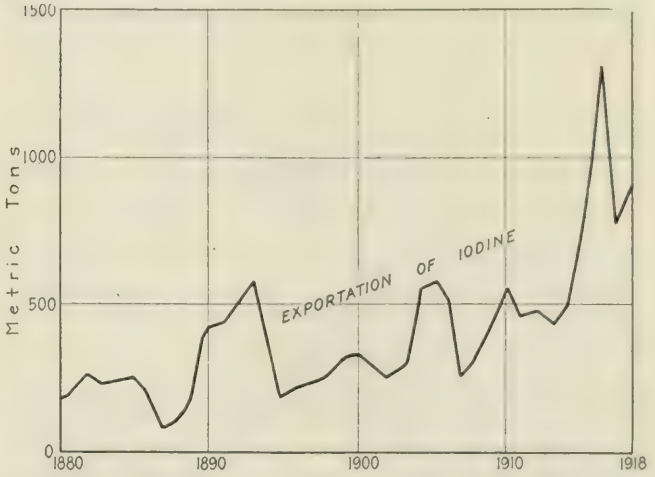


FIG. 9. PROGRESS OF THE EXPORT OF IODINE FOR THE PERIOD 1880-1918

recoveries by the process do not exceed 60 per cent, the average being 50 per cent, although the contents of the ripios have been reduced to even less than 5 per cent.

Need of an Improved Process

Up to the present the processes for the separation of the sodium nitrate from the caliche are based on the preparation of a hot saturated solution, from which the sodium nitrate crystallizes on cooling.

It is to be expected that other factors will be taken into consideration when improved processes are looked for, such as the use of reagents with catalytic effects.

Translator's Note: The author finishes by making a strong plea for technical research leading to a more efficient treatment of the Chilean nitrate, and states that in a subsequent paper he will dwell at length on the technologic questions involved in the treatment of caliche.

Industrial Growth in Norway

According to an official report bearing upon the industrial development of Norway from 1897 to 1917, the population of Norway increased from 2,157,000 to 2,629,000 inhabitants. Within the same period the number of industrial establishments increased from 9,422 to 32,174. During this period the increase of 22 per cent in the population of the country was accompanied by an increase of 112 per cent in the number of industrial workers of various kinds. The number of horsepower in Norway in 1917 was 1,613,283, as compared with 172,397 in 1897. The increased use of electricity for motive power is evidenced by the fact that in 1900 there were only 417 electric motors in all Norway, and their total capacity was only 4,121 horsepower. In 1917 there were 26,040 motors with a capacity of 342,251 horsepower.

Synopsis of Recent Chemical & Metallurgical Literature

Strength of Steel at High Temperatures.—G. P. McNIFF, in a written discussion, called attention to various independent researches corroborating the results obtained by H. J. French on the Tensile Properties of Boiler Plate at Elevated Temperatures, presented before the February meeting of the A.I.M.E., and abstracted in CHEMICAL & METALLURGICAL ENGINEERING for March 3, 1920, vol. 22, p. 393. He presented several photographs pertinent to this subject, of an experiment carried out at the Shelby works (Ellwood City, Pa.) of the National Tube Co., during 1913 and completed in January, 1914. One of the photographs showed a general view of the testing machine with the test piece in place surrounded by an electric tube furnace very similar to the set-up used by French. A Le Chatelier rare metal thermocouple was used for the temperature readings.

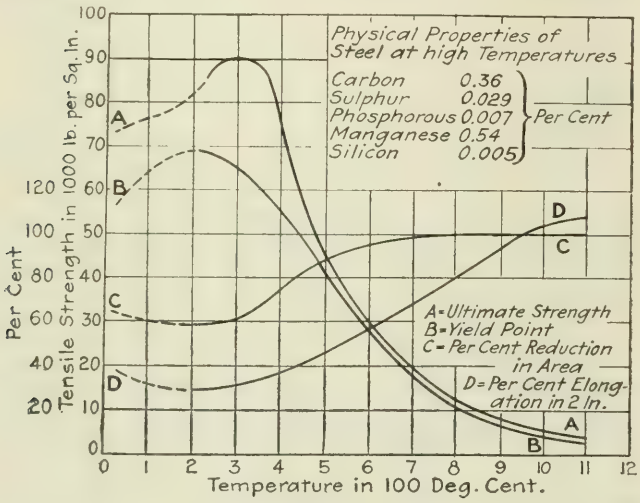


FIG. 1.

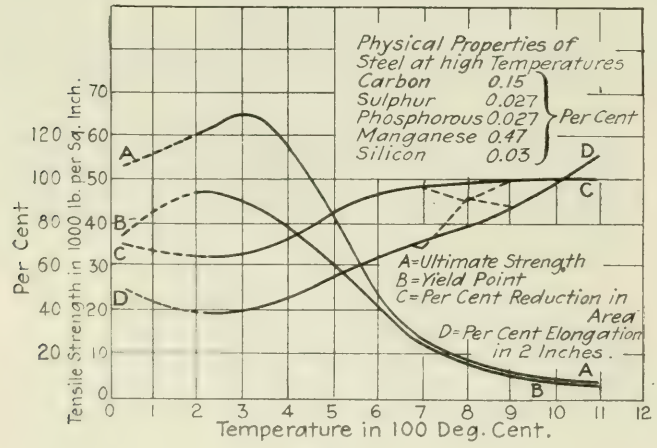


FIG. 2.

The material investigated was seamless tubing of several different carbon contents. A summary of the results obtained is shown on the curves attached. Fig. 1 gives results on a 0.36 per cent carbon steel, Fig. 2 on a 0.15 per cent (boiler tube grade) and Fig. 3 gives a comparison between the results of Kollmann[1] and Howard[2] previous investigators on this subject, results at the Shelby laboratory and those obtained recently by French.

In each case the results obtained are fairly concordant and seem to indicate that for all carbon steels their strength and characteristics at temperatures above normal are a direct function of these same characteristics at normal temperatures, and show no great variation with the carbon content.

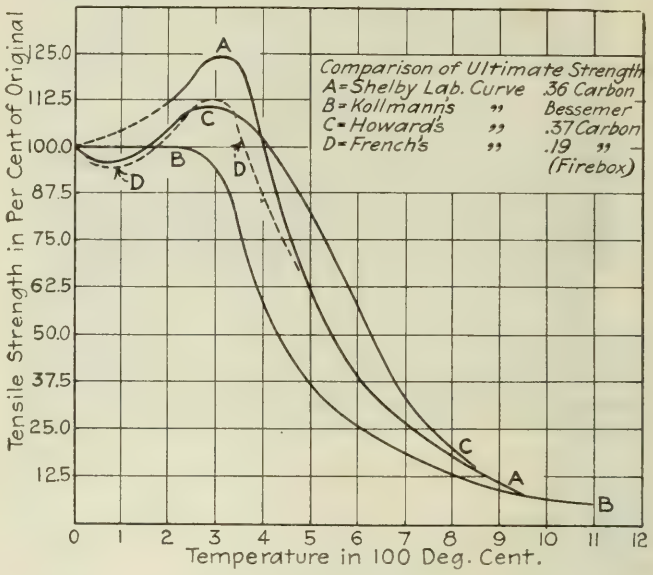

Comparison of Ultimate Strength
A=Shelby Lab. Curve .36 Carbon
B=Kollmann's " Bessemer
C=Howard's " .37 Carbon
D=French's " .19 " (Firebox)
Tensile Strength in Per Cent of Original
Temperature in 100 Deg. Cent.

FIG. 3.

H. D. Hibbard also mentioned that the Watertown Arsenal[2] had obtained very similar results a great many years ago.

British Blast-Furnace Practice.—According to the *Engineer*, March 5, 1920, vol. 129, p. 246, the paper which W. H. BUCKLEY, M.I. Mech. E., read on "British Blast-Furnace Practice" before the members of the Manchester Association of Engineers on Feb. 28 covered a large amount of ground, including descriptions of the furnace stack, stoves, and connections, dust catchers, charging arrangements, storage arrangements, pig-bed equipment, slag disposal, blowing plant, boilers, pumping plant, and gas-cleaning plant. The author said that the prevailing conditions in connection with British blast furnaces were open to considerable improvement in many directions. Future blast-furnace plants were not likely to exist as isolated units, but they would be operated in conjunction with and in close proximity to coke ovens and steel works. Thus the cost of handling and the loss of heat would be reduced to a minimum. Mr. Buckley said that electrical smelting on a large scale was not likely to be developed in the immediate future, until such times as our potential sources of power production were further developed. Enrichment of blast with oxygen had been tried in Belgium, but so far it was not a practicable success. The conservation of heat about a blast-furnace system was likely to receive more attention in future. Radiation losses could be considerably reduced if efficient means of insulation were provided. The recovery of heat from slag was also a question of vital importance, and so far only experimental work in that direction had

[1] *J. Frank. Inst.*, vol. 112, p. 241 (1881).
[2] *Iron Age*, April 10, 1890.

been carried out. If slag be granulated in water so that low-pressure steam be developed, such steam was not fit for use in low-pressure turbines, and an intermediate system of evaporation must be introduced, but there did not appear to be any reason why such dirty steam—which, incidentally, contained about 5 per cent of incondensable gases—should not be used for gas producers, in conjunction with air blowers. Potash was already recovered in large quantities from the fine dust in the gas, and the coarser dust—which had a comparatively low potash content—was likely to have a higher value in future, as some might be used on plants nodulizing fine ores. If waste heat could not be satisfactorily utilized for steam raising, there was a big field for the use of it in either drying ores or preheating blast, or air for combustion.

Nickel:Chromium Alloys and Thermocouples.—W. A. GATWARD recently read a paper on this subject before the Engineers' Society of Western Pennsylvania, in which he sketched the development and present status of this industry. Since both constituents melt at a high temperature, nickel takes carbon into solution, and chromium is easily oxidized, the alloys are very difficult to make. At no time in their development was it possible to predict the properties of untried combinations. Since 1906 about 2,000 tons of Ni:Cr metal has been used in the manufacture of heating devices alone. They actually contain varying percentages of Mn, Al, Fe or Si. Seven commercial alloys are described which may be used for heating elements, all of them quite durable at 800 deg. C. As the temperature goes up, their life rapidly shortens. The best of them, however, rapidly assume a closely-adhering coat of protective oxide. The author lists thirteen requisites of a good heating element. Principal among them is a low temperature coefficient. Experience shows that the presence of a cold body near a certain part of a heating element causes that portion to advance slightly in temperature. If the wire possesses too large a coefficient, this will cause that portion to become increasingly hotter until it melts.

Specific resistance should be high so that large sections and short lengths are possible for a given resistor. This is responsible for rugged elements, small in bulk, operating at a low temperature. It is desirable but apparently impossible to obtain a high heat conductivity at the same time, in order that the heat developed below the surface of the wire can be radiated effectively.

Nickel:chromium alloys have been invaluable in pyrometry, producing the first good positive element for base-metal couples. The secret of their success is proper protection, maintaining a strictly oxidizing atmosphere at all times. If graphite, carborundum or silfrax protecting tubes are used, a gas-tight lining should be provided. Luckily one of the same alloys, "chromel," is impervious to CO at working temperatures, and can therefore be used for this purpose.

If fusible material of almost any kind comes in contact with the hot wire, the protective scale is destroyed and a burn-out soon follows, from this cause if not from short-circuiting. Cyanide and sulphur fumes also cause rapid deterioration. Welding of clean surfaces may be done by feldspar and flame or an electric arc. Carburizing boxes or other sound castings can now be made weighing up to 1 ton and to 15 ft. long. Such pieces would have walls about 1 in. thick, or somewhat heavier than cast iron. They resist molten lead quite well.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Chlorpicrin.—The process of preparing chlorpicrin by treating picric acid with bleaching powder in the presence of water is difficult to control. The reaction is violent; the evolution of CO_2 and HCl and the absorption of these gases in the $Ca(OH)_2$ simultaneously produced cause foaming; the heating is excessive; the yield varies from zero to nearly theoretical without apparent reason; oxidation occurs, reducing the yield by the formation of resinous byproducts. ROBERT J. KING of Stamford, Conn., prefers the following: 10.8 parts of calcium picrate is dissolved in about 30 parts of water and added gradually to a solution of 88 parts of bleaching powder (35 per cent available chlorine) in 170 to 770 parts of water. A vigorous reaction takes place and the yellow color of the mixture rapidly disappears. The chlorpicrin is separated by steam distillation. (1,327,714; Jan. 13, 1920.)

Powdered or Granulated Aluminum.—When molten aluminum is subjected to violent agitation during cooling, at a temperature just below the melting point the mass will be broken up into granules. The degree of granulation may be controlled by the violence of the agitation. (1,327,743; LEWIS B. TERRETS, 2d, of St. Louis, Mo.; Jan. 13, 1920.)

Synthetic Ammonia.—When air or nitrogen is passed through a solution in which nascent hydrogen is being evolved, ammonia is formed. The nascent hydrogen may be produced electrolytically or by the action of acids or alkalis upon appropriate metals. (1,328,082; ROBERT F. GARDINER of Clarendon, Va.; Jan. 13, 1920; application filed under the act of March 3, 1883.)

Explosive.—There are two classes of high explosives similar in their explosive properties to existing standard grades of dynamite. The first comprises mixtures of small percentages of TNT with nitroglycerine for the production of the so-called low-freezing dynamite. These are expensive to manufacture, the liquid constituent tends to exude, and users are liable to contract severe headaches in handling the explosive. In the second class, low percentages of TNT are used with relatively large percentages of explosive salts having a high oxygen content such as ammonium nitrate, ammonium perchlorate, potassium chlorate, etc. These explosives are relatively insensible to detonation, are liable to become extremely hard in storage and are usually very dusty. A more satisfactory explosive is suggested by LEON O. BRYAN and WENDELL R. SWINT of Wilmington, Del. The following composition is typical: Nitrogycerine, 5 per cent; trinitrotoluol, 40 per cent; sodium nitrate, 55 per cent. Other examples are given which are equivalent to standard industrial dynamites. (1,327,859; assigned to E. I. du Pont de Nemours & Co.; Jan. 13, 1920.)

Calcium Carbide and Wood Distillation Products.—JAMES HENRY REID of Newark, N. J., describes a process for the production of wood distillation products and calcium carbide in one operation. A mixture

of sawdust and calcium oxide is heated in an electric furnace. At first products of the destructive distillation of the sawdust are obtained. Later, the temperature is raised until calcium carbide is formed. In a modification, coking coal is used instead of sawdust. A third patent describes an automatic controlling device for the furnace electrodes. (1,327,736; 1,327,737; 1,327,738; assigned to International Nitrogen Co.; Jan. 13, 1920.)

Purifying Ammonium Sulphate.—Damp crude ammonium sulphate crystals containing free acid, pyridine bases or sulphates of pyridine bases are placed in rotary container and heated to about 250 deg. F. by a current of hot air. Simultaneously, ammonia vapor is passed into the container. Ammonium sulphate is formed by neutralization of the free acid and the pyridine sulphates are decomposed. The pyridine bases are volatile at this temperature. The final product is dry ammonium sulphate, free from acid and pyridine. (1,328,342; WILLIAM A. SLOSS of Toledo, Ohio; Jan. 20, 1920.)

Sulphuric Acid Manufacture.—The efficiency of the chamber process is increased by removing the acid mist which forms in the first chamber and passing it through an electrical precipitator. The presence of the mist particles of nitrosyl sulphuric acid in the chambers tends to inhibit the completion of the reaction. Additional advantages claimed by HARRY V. WELCH of Los Angeles, Cal., are: Circulation of the gases in the chamber by withdrawing the vapors at one end of the chamber and returning them (after having passed through the precipitator) at the opposite end; cooling of the gases so that the heat of reaction does not raise the temperature above the optimum. Chamber acid flows through the precipitators and the strong acid thus formed is fed to the Glover tower. (1,328,552; assigned to International Precipitation Co.; Jan. 20, 1920.)

Artificially Cooled High-Frequency Coil.—The temperatures attainable in the Northrup induction furnace are materially increased by making the inductor coil hollow so that it may be cooled by water, oil, etc. Temperatures above 2,500 deg. C. may be reached. (1,328,336; EDWIN F. NORTHRUP, assignor to the Ajax Metal Co.; Jan. 20, 1920.)

Reduced Sulphite Waste Liquor.—Commercial neutral waste sulphite liquor of 30 deg. Bé. is acidified with 1 or 2 per cent of H_2SO_4 and iron filings or iron wire added. The reduction may be hastened by adding a little copper to form a couple. The reduced liquor, after removing undissolved iron and iron salts, is evaporated to 20 to 30 deg. Bé. It may be used as a dye, producing shades of greenish brown or unmordanted wool. The liquid also has considerable insecticidal value. It may be used with the usual spraying apparatus. Retaining some of the physical properties of the original sulphite liquor, it adheres well to leaves, vines, etc. (1,327,862; FRANK E. COOMBS of San Francisco, Cal.; Jan. 13, 1920.)

Sodium Ferricyanide.—The process which is commonly used for the manufacture of potassium ferricyanide from potassium ferrocyanide—namely, oxidation by means of a halogen according to the equation:

$$2K_4Fe(CN)_6 + Cl_2 = 2KCl + 2K_3Fe(CN)_6$$

fails when applied to the corresponding sodium salts. It is very difficult to separate the sodium chloride and sodium ferricyanide by fractional crystallization. ROGER WILLIAMS of Providence, R. I., has found that sodium chloride dissolves readily in anhydrous liquid ammonia while sodium ferricyanide does not. Accordingly, when the solution of the two salts is evaporated to dryness and the residue treated in a suitable apparatus with liquid ammonia, the sodium chloride is completely extracted. The final residue may be dissolved in sufficient water to form a saturated solution and allowed to crystallize. To favor the production of particularly large crystals, some additional water may be gently poured upon the top of the concentrated solution, which when allowed to stand will then deposit large red crystals. The ammonia is recovered from the solution of sodium chloride by heating, cooling and compressing. In order to reduce losses of ammonia to a minimum the apparatus employed should be air-tight. (1,328,938; assigned to Nitrogen Products Co.; Jan. 27, 1920.)

Calcium Fluoride.—When prepared by the interaction of dilute solutions of calcium chloride and hydrofluoric acid, the precipitate of calcium fluoride is slimy and great difficulty is experienced in filtering and washing. By using concentrated solutions, WALLACE S. CHASE of Lakewood, Ohio, finds that the character of the precipitate is greatly improved. If the precipitate is dried at a temperature between 100 and 150 deg. C. and then pulverized, washing and filtering may be accomplished with ease. This process of preliminary drying is also applicable to other slimy precipitates. (1,329,072; assigned, by mesne assignments, to National Carbon Co.; Jan. 27, 1920.)

Stabilizing Nitrostarch Explosives.—There are certain substances, such as rosaniline base, and diphenylamine, which are well recognized as stabilizing agents in connection with nitrocellulose products. Owing to the greater ease with which nitrostarch tends to colloid, the introduction of these materials into the manufacture of nitrostarch explosives has been limited, and accordingly the use of these valuable stabilizing agents has in a measure been prevented. The colloiding action of these stabilizers may be prevented by dissolving them in a heavy mineral oil before adding to the explosive. A further advantage is the uniform distribution of the stabilizer. (1,329,211 and 1,329,212; WALTER O. SNELLING and WILLIAM R. LAMS of Allentown, Pa., assignors to Trojan Powder Co.; Jan. 27, 1920.)

Acetone and Butyl Alcohol by Fermentation Process.—The process of fermenting carbohydrate material to form acetone and butyl alcohol, using bacteria of the amylobacter group, is accelerated by a preliminary treatment with molds or enzymes having a strong proteolytic action. The mold used must not produce organic acids or alcohols which would interfere with the subsequent fermentation. CHARLES WEIZMANN and GEORGE A. HAMLYN of London, England, cite the following example: A sterilized mash prepared from rice, corn or other grain is inoculated with *Aspergillus oryzae*, which is allowed to grow for three or four days at 30 to 37 deg. C. The mash is then inoculated with cultures of amylobacter, which normally do not produce active fermentation. Fermentation sets in very rapidly and continues for 48 to 60 hr. The product is then distilled. The yield of acetone and butyl alcohol varies from 15 to 20 per cent of the weight of grain used. (1,329,214; Jan. 27, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Chemical Warfare Service

None of the opposition which was manifested in the committee against a separate Chemical Warfare Service was voiced in the House when that section of the Army reorganization bill came up for consideration. The committee's report for a separate Chemical Warfare Service was adopted without a record vote.

In the bill proper the duties of the Chemical Warfare Service were not prescribed. This was remedied by an amendment which reads as follows:

> The duties of the Chemical Warfare Service shall comprise the investigation, development, manufacture, or procurement and supply to the Army of all smoke and incendiary materials, all toxic gases, and all gas-defense appliances; the research, design, and experimentation connected with the chemical warfare and its matériel; and chemical projectile filling plants and proving grounds; supervision of the training of the Army in chemical warfare, both offensive and defensive, including the necessary schools of instruction; reorganization, equipment, training, and operation of special gas troops.

As passed by the House the Chemical Warfare Service is to consist of one chief, with the rank of Brigadier General, ninety officers, in grades from Colonel to Second Lieutenant, and 1,500 enlisted men. An effort by Representative Dent to amend the bill so as to designate the specific number of officers of each grade, as well as the number of chemical engineers to be employed, was lost. In explaining his amendment Mr. Dent pointed out that the Chemical Warfare Service is a development of the war and that "if it has any unfriendly administration we all know that unless the personnel is fixed the Service itself is liable to prove a failure."

Mr. Dent was asked by one of the members of the House how the Service would secure its expert chemists, since the bill provides that the officers must have served during the war in order to be entitled to a commission. In reply Mr. Dent expressed the opinion that it would be necessary to get chemists from outside the military service, which he thought would be precluded by the wording of the bill. He used that as an argument for recommitting the bill to the committee so that its defects might be remedied. This the House declined to do, however.

In the course of the discussion several tributes were paid to General William L. Sibert, who until recently was the head of the Chemical Warfare Service. That the House is not satisfied with the explanation of the Secretary of War that General Sibert's removal from the Chemical Warfare Service to be commander at Camp Gordon was simply to prevent a loss of one grade in rank became very evident during the debate. It was plainly intimated that the real reason for the change in assignment, in the opinion of some members, was due to its criticism of the legislation as recommended by the General Staff. Mr. Dent declined to express himself in that connection, but said it is his personal opinion that the Chief of the Chemical Warfare Service should be a Major General rather than a Brigadier General.

Despite the pressure for a vote on the bill Mr. Dent insisted on reviewing the accomplishments of General Sibert as head of the Chemical Warfare Service, which he referred to as one of the greatest developments of the war. His reference to General Sibert is as follows:

> A native Alabamian, William L. Sibert graduated from West Point with high distinction. He was assigned to the Corps of Engineers. He performed valuable river and harbor work upon the Ohio River in particular. Without any political pull, when the Panama Canal was to be constructed, President Roosevelt selected him as one of the commissioners to build the canal. He was assigned to the specific duty of constructing the Gatun Dam and Locks. He dammed the Chagres River when the late Senator Morgan, of Alabama, who for years had advocated some form of transcontinental canal, said that that river could not be dammed. After his service there the Congress of the United States, along with the other members of that commission, extended to him its thanks, authorized a promotion above the grade that he occupied, and further authorized his voluntary retirement before reaching the age of sixty-four. This he has continuously refused to accept. After his work with the Panama Canal he was assigned to the Pacific coast in charge of the Coast Artillery as a line officer. He succeeded well and ably in that work. When the war broke out he was assigned to the organization and training of the first division that went to France.
>
> He organized it, trained it, and carried it to France. He commanded that division in France and was for a time placed second in command to General Pershing. For some reason he was returned to this country and placed temporarily in command of the Southeastern Department at Charleston, and then when the Chemical Warfare Service was established the Secretary of War very properly called General Sibert to take charge of the organization and development of that branch of the service. General Sibert took charge of it, developed it during the war, and has made out of it, in my humble judgment, one of the greatest developments that the war established.

Tungsten Bill Reported to Senate

Arguments to the effect that the tungsten resources of the United States are so limited that the existing deposits should remain untouched as a safeguard in a future emergency evidently were not accepted by the Senate Finance Committee, as it has reported favorably to the Senate a tariff bill which is believed to grant sufficient protection to permit the development of domestic mining industry. The Senate committee from its investigation found the cost of domestic production averaging $13 per unit. The data showed foreign costs to be from $2 to $4 per unit. It pointed to the fact that tungsten was selling at New York from $6 to $7.50 per unit and that fully 50,000 units per month are being imported, duty free. As the domestic mines cannot meet those prices, all of them are closed and prompt action is necessary to prevent the destruction of the industry, the committee reports. It is the belief of the committee that eventually the entire domestic requirements for this metal can be met from our own mines. During the period of development, it is pointed out, a substantial revenue should be received by the Government from importations of ore.

Fifth Annual Meeting of T. A. P. P. I.

The fifth annual meeting of the Technical Association of the Pulp and Paper Industry will be held in New York on April 13, 14 and 15. The business and technical sessions will be held at the Waldorf-Astoria Hotel and the annual banquet will take place at the Hotel Astor. The order of meetings will be as follows:

Tuesday, April 13, 9:30 a.m.

Meetings of standing committees in Myrtle Room and Room 151, Waldorf-Astoria.

First General Session

Wednesday, April 14, 9:30 a.m., Myrtle Room

Business meeting.

Appointment of committee to nominate officers to serve during the ensuing year.

The reports of committees will be received in the following order:

Abstracts of Literature—Ross Campbell, chairman.

Bibliography—Henry E. Surface, chairman.

Groundwood—William A. Kelly, chairman.

Heat, Light and Power—Edward P. Gleason, chairman.

Paper Testing—Frederick C. Clark, chairman.

Pulp and Paper Machinery—George R. Wyman, chairman.

Soda Pulp—Martin L. Griffin, chairman.

Standard Methods of Testing Materials—E. C. Tucker, chairman.

Sulphate Pulp—Olai Bache-Wiig, chairman.

Sulphite Pulp—Herbert G. Spear, chairman.

Vocational Education—George E. Williamson, chairman.

Second General Session

Wednesday, 2 p.m., Myrtle Room

Reading and discussion of special papers:

Some Further Mill Trials on the Pulping of Second Cut Cotton Linters, by Otto Kress and Sidney D. Wells.

Testing Tearing Strength of Paper With the Elmendorf Tearing Tester, by Armin Elmendorf.

Fuel From Sulphite Waste Liquor, by George Barsky and Ralph H. McKee.

Grinding Woodpulp Efficiently, by A. F. Meyer.

Advantages of Liquid Sulphur Dioxide for Sulphite Pulp Manufacture, by Vance P. Edwardes.

3:30 p.m., Room 151

Symposium on Rag Selection and Cooking. E. C. Tucker, chairman:

1. Selection of rags and their standardization.

2. Cooking of rags: (*a*) Reasons for cooking and objects accomplished; (*b*) the cooking liquor; (*c*) the rotary boiler and drive, with special reference to any recent improvement, power consumption, etc.; (*d*) the factors of time and pressure and how cooking is influenced by them; (*e*) the washing of rags in the boiler and their handling from boiler to washer.

Wednesday Evening, April 14

Annual banquet at Hotel Astor; reception at 7 p.m., dinner at 7.30 p.m.

Guests and speakers: Raymond S. Hatch, president; Judge Charles F. Moore, toastmaster; Joseph W. Fordney, chairman of the Ways and Means Committee, House of Representatives; Prof. William H. Walker, Massachusetts Institute of Technology; Prof. Charles Baskerville, College of the City of New York; George Carruthers, president of the Interlake Tissue Mills, Ltd., Toronto, Canada; Henry W. Stokes, president of the York Haven Paper Co., York Haven, Pa.; John Stadler, Belgo-Canadian Pulp & Paper Co., Ltd., Shawinigan Falls, Canada; John E. Alexander, Nekoosa-Edwards Paper Co., Port Edwards, Wis.; Evan Davies, New York; Howard S. Neiman, New York.

Third General Session

Thursday, April 15, 2 p.m., Myrtle Room

A short session will be held prior to recessing for attendance on the general meeting of the American Paper and Pulp Association in the Astor Gallery.

Nomination and election of officers.

Fourth General Session

Thursday, April 15, 2 p.m., Myrtle Room

Reading and discussion of scientific papers:

Possibilities of Developing a More Efficient Method of Extracting the Soda Salts From Black Ash, by George M. Trostel.

Improved Equipment for the Sulphite Mills, by E. R. Barker. This paper will describe a new type of limestone acid system; a new apparatus for automatic melted sulphur feed; an automatic alarm to show sublimed sulphur; a device for regulating the strength of acid in Jenssen towers, and a system for controlling automatically the strength of acids from milk of lime systems.

Methods of Cooking Control, by W. E. Byron Baker.

Limestone Analysis and Evaluation for Bisulphite Liquor Manufacture, by W. E. Byron Baker.

Sectional Individual Motor Drive for Paper Machines, by Stephen A. Staege.

The Application of Pragmatic Philosophy to the Papermaking Industry, by John W. Brassington.

Some New Methods of Waste Sulphite Liquor Recovery, by Walter H. Dickerson.

2 p.m., Room 151

Symposium on the extent to which the jordan can replace the beating engine in the production of paper. The discussion will be led by W. L. Nixon, of the Chemical Paper Manufacturing Co., and Max Zimmerman, of the Charles Boldt Paper Mills, will contribute a special paper on the subject.

A symposium is planned for the discussion of black liquor recovery with special regard to the most durable method of lining the smelters used in the sulphate recovery process. The discussion will be led by G. F. Enderlein, of the Brompton Pulp & Paper Co., Ltd., East Angus, Que., and R. M. Radsch, of the Thilmany Pulp & Paper Co., Kaukauna, Wis.

Proposed Tariff on Antimony Compounds

New tariff duties on antimony and antimony salts are proposed in a bill just introduced by Representative Watson of Pennsylvania. Antimony as regulus or metal and matte containing antimony, but not containing more than 10 per cent of lead, is to be dutiable at 10 per cent ad valorem. His bill also provides for a 25 per cent ad valorem duty on antimony oxide and a duty of 7c. per lb. and 45 per cent ad valorem on antimony salts, titanium salts, hydrosulphites, sulphoxylates and artificial bases.

Meeting of the California Section of the American Chemical Society

At the regular meeting of the California Section of the American Chemical Society held Friday, March 26, at the Engineers' Club, San Francisco, two interesting papers were presented. The first, by Dr. L. H. Duschak of the United States Bureau of Mines, on "The Chemical Basis for the Volatilization Process as Applied to Silver Ores," and the second, by Dr. W. H. Rodebush, Fellow of the National Research Council, on "Industrial Alcohol in the Industries."

Dr. Duschak reported experiments conducted at the Bureau of Mines Station in determining the vapor pressure of silver chloride at high temperatures from 980 to 1,140 deg. C. Vapor pressure of silver and of silver sulphate were also studied, as well as the possible formation of silver silicate. The experiments showed that there was no evidence of the formation of silver silicate under furnace conditions as had previously been indicated by some investigators. Investigation showed that the presence of oxygen and water vapor was necessary for a satisfacory volatilization and also that it was necessary to have an excess of chloridizing agents present to produce what Dr. Duschak termed "protective chlorination," in order to prevent the reduction of the chloride formed to the oxide or to the metal.

Dr. Rodebush reviewed the sources of supply of industrial alcohol, together with its use in the arts. He suggested the possible development of agriculture in the tropics for the production of sugar-bearing plants as a source of future supply. He reviewed the industrial possibilities of water-free alcohol and the production of ethylene-glycol and of ethyl acetate from alcohol and the use of these in industry. Ethylene is a more satisfactory substance than acetylene for use in welding. Attention was called to the fact that ethyl acetate is being used extensively as a solvent.

Cleveland Section Meeting, A. C. S.

At the March meeting of the Cleveland Section, American Chemical Society, held March 19, Dr. Charles L. Parsons gave an extremely interesting illustrated lecture on "Nitrogen Fixation." Before commencing his talk Dr. Parsons outlined the aims of the Society and told how it had become a powerful force in national affairs during the past three or four years. He cited, as an instance, the recent establishment by Congress of the Chemical Warfare Service as a separate corps against the wishes of the General Staff.

In his lecture he outlined the various processes of nitrogen fixation that held commercial possibilities in this country and described some of the plants that had been erected during the war, especially the ones at Muscle Shoals and at the Solvay plant at Syracuse. Dr. Parsons expressed the opinion that the Haber and the sodium cyanide processes seemed to offer the greatest possibilities for future development and that with the development the farmers should be educated to the use of the various nitrogenous fertilizers.

Chemical Warfare Service Stops Recruiting

No enlistments are being accepted for the Chemical Warfare Service, the Adjutant General of the Army announces, "as this branch is filled by men who are securing advanced instruction in chemistry."

Protection for Trademarks in Foreign Countries

Legislation which will bring about much needed protection to American trademarks and commercial names abroad has been approved finally by both houses of Congress and is before the President for his signature. It is expected that the President will sign the measure.

The legislation referred to is the ratification of the Buenos Aires convention, which allows American interests to file their trademarks and commercial names in an international bureau at Havana, thereby precluding separate registration in any of the South American republics.

The Latin-American countries already have ratified the convention. The bill also carried an amendment to the trademark act of Feb. 20, 1905, which adds to that law the following words:

> And if any person or corporation shall have so registered a mark upon the ground of said use for ten years preceding Feb. 20, 1905, as to certain articles or classes of articles to which said mark shall have been applied for said period, and shall have thereafter and subsequently extended his business so as to include other articles not manufactured by said applicant for ten years next preceding Feb. 20, 1905, nothing herein shall prevent the registration of said trademark in the additional classes to which said new additional articles manufactured by said person or corporation shall apply, after said trademark has been used on said article in interstate or foreign commerce or with the Indian tribes for at least one year, provided another person or corporation has not adopted and used previously to its adoption and use by the proposed registrant, and for more than one year such trademark or one so similar as to be likely to deceive in such additional class or classes.

Chemical Engineering at University of Nebraska

The department of chemistry of the University of Nebraska has introduced some new courses in practical chemistry, which have been working out very successfully. These courses were opened last September. For some years this department was not in position to offer technological chemical courses, because of lack of facilities. Now the department is housed in a very fine new laboratory and the chairman of the chemistry faculty, Dr. F. W. Upson, set about arranging for courses devoted to chemical engineering subjects. The department has also put in a course in "Oil and Gas" which is primarily for geologists. This work is in charge of Associate Professor C. J. Frankforter. Mr. Frankforter returned to the department last September, after having served twenty-two months in the Army.

Chemistry of the Earth's Crust

In an address before the Geological Society of Washington on March 24, Dr. H. S. Washington presented a recalculation of the composition of the earth's crust and the density of the earth over different areas. A very striking relationship was pointed out for the first time by Dr. Washington between the average density of the earth and the elevation above sea level. Several charts showing the relationship for both northern and southern hemispheres give almost complete agreement between the average analyses and the altitude figures. A correlation with the variation of density as measured by the pendulum method by Bowie was also given.

A new classification of the elements in the periodic system was presented, showing a systematic relationship between the elements which occur mainly in minerals and those which occur in rocks.

Civil Service Examinations

The following examinations are announced by the Civil Service Commission:

Assistant Examiner, Patent Office.—Examinations will be held April 7 to 9, May 5 to 7 and June 9 to 11 at places specified in Form 1237. Entrance salary, $1,500 a year, with temporary increase of $240 a year.

Mold Maker (Optical Glass or Ceramics).—Two vacancies exist in the Bureau of Standards; one in the position of mold maker, optical glass, at $1,680 a year in Washington, D. C., the other in the position of mold maker, ceramics, at $1,380 a year for duty in Pittsburgh, Pa. Apply on Form 1312 before April 20.

Petroleum Engineer and Assistant Petroleum Engineer (Oil and Gas Production).—Salaries, $3,000 to $4,500 and $2,100 to $3,000 a year, respectively. The closing date for receipt of applications (Form 2118) has been postponed from March 16 to April 27.

Laboratory Assistant.—Vacancies in Bureau of Construction and Repair, Navy Department, at $5.20 per day and at the U. S. Navy Yard, Washington, at $6 per day will be filled from examinations held at the usual places April 28 and 29, June 9 and 10 and July 21 and 22.

Mechanician and Laboratory Assistant.—For duty at Berkeley (Cal.) Station of Bureau of Mines at $5.25 per day. April 28 and 29, 1920.

Physicist.—Applications will be received until further notice for positions in Bureau of Standards (assistant physicist, $1,400 to $1,800 a year; associate physicist, $2,000 to $2,800 a year) and in the Signal Service of the War Department at $1,500 to $1,800 a year.

Laboratory Assistant.—Applications will be received until further notice for position in Bureau of Standards at $1,200 to $1,380 a year.

Technologist.—Positions of associate technologist, $2,000 to $2,800 a year, and assistant technologist, $1,400 to $1,800 a year, in the Bureau of Standards will be filled from this examination. Applications will be received until further notice. Applicants must qualify in rubber, leather, paper, textile, oil or general technology.

In all the positions mentioned, appointees at annual compensation of $2,500 or less, whose services are satisfactory, may be allowed the temporary increase of $20 per month granted by Congress.

Dr. Whitney to Receive Chandler Medal

At a meeting to be held in Havemeyer Hall, Columbia University, at 8:15 p.m. on April 27, the Chandler medal will be presented to Willis Rodney Whitney, director of the research laboratory of the General Electric Co. Dr. Whitney will speak on "The Littlest Things of Chemistry."

The Charles Frederick Chandler Foundation was established in 1910 by friends of Prof. Chandler. The income from this fund is used to provide a lecture by an eminent chemist and to provide a medal to be presented to the lecturer in further recognition of his achievements in science. Previous lecturers on this foundation were Dr. L. H. Baekeland and Dr. W. F. Hillebrand.

Navy Releases Sodium Nitrate for Fertilizers

To assist in relieving the shortage of fertilizing materials the Secretary of the Navy has authorized the sale of 9,925 tons of its surplus of sodium nitrate.

No Liquidation of American Property in Germany

From the first issue of *Transatlantic Trade*, the official organ of the American Association of Commerce and Trade in Berlin, we quote the following note relative to the way in which Germany handled American property during the war:

"There have been so many false reports circulated in the United States as to what happened to American property in Germany during the war that a statement of actual facts seems necessary. American commercial interests were neither liquidated nor sold. Personal and household property of our citizens underwent no change whatever; today American citizens are in full possession of their property. Former members of the American colony, now in the United States, will be glad to learn that their property is intact; much of such property was stored in warehouses at the beginning of the war in 1917. In several cases the storage rent has not been paid, but the German agencies to whom it was entrusted are still carrying this property pending claims of the rightful owner. American business houses in Germany were put under a controller at a salary in keeping with the firm's financial capacity. The principal functions of this controller were to watch the company's finances, and to exercise a general control over the undertaking. His instructions prevented him from injuring the American features of the undertaking.

"In several cases the action of the controller has given rise to criticism. Reference is made to those American firms with headquarters in Berlin and a large network of agencies scattered over the country. With importation of goods cut off, it seemed advisable to the controller, in the interests of the company, to close up these agencies in other cities which involved a large expense in office and shop rent and salaries. This act has been looked upon by the head offices in the United States as a partial liquidation, but the controller defends the act by stating that it was in the company's interests. With the head office intact; he claimed that agencies could be reopened after the war when goods were available: German firms were doing the same."

Freight Rates on Sodium Nitrate

On complaint of the General Chemical Co., the Interstate Commerce Commission has handed down an important decision reducing the rates which have been charged on sodium nitrate imported from Chile, from north Atlantic ports to points in the Middle West. The Commission prescribes rates which are to govern in the future, as follows: New York to Hegewisch (a Chicago rate point) 33c. per 100 lb.; New York to Willow, Ohio, 71 per cent of the Hegewisch rate; Philadelphia and Baltimore to Hegewisch and Willow, and from Baltimore to Ivorydale, 100, 71 and 87 per cent, respectively, of the New York-Hegewisch rate. These rates apply to carload lots and do not include the regular port differentials.

Idaho Phosphate Rock for the Orient

A recent development in the utilization of the phosphate deposits of the West is to be noted in a contract for the shipment of 35,000 tons to Japan. The rock will be mined at Paris, Idaho, and shipped via Portland, Ore. This is to be considered in the light of a preliminary shipment and it is estimated by the Portland Chamber of Commerce that about 300,000 tons of the rock will be thus exported from that port this year.

Engineering and Accident Prevention

For the purpose of bringing the safety movement and the engineering world more closely together, the Engineering Section of the National Safety Council has called a conference of all persons interested in engineering and accident prevention, to be held at the Engineering Societies Building in New York City, April 27. The morning session will first take up the relationship of safety and engineering efficiency—the question whether, apart from its human values, safe operation of a factory or a railroad is in truth inseparably connected with efficient operation. If this question can be answered in the affirmative, the answer will prove conclusively that safety is worthy of greater attention from engineers and that it deserves a place in the curriculum of engineering colleges. This topic—safety education in technical schools—is the next subject on the program. The afternoon session will be devoted to safety standards: first, the present movement for uniform standards; second, the National Safety Council's part in this movement.

Patent Royalties for Government Employees

Government employees are to receive a portion of any royalties which may accrue from patents which may be made of discoveries or inventions made or developed on Government time, according to the provisions of a bill which just has passed the Senate. The Federal Trade Commission is assigned the duty of administering the patents for the benefit of the public. The President is to fix the percentage which is to be allowed the employees.

Water-Power Bill Delayed

Meetings of the conferees on the water-power bill again are being held, but little progress is being made in adjusting the differences between the bills as passed by the Senate and by the House. Some fear protracted delay before a compromise can be agreed upon.

Book Reviews

INORGANIC CHEMICAL SYNONYMS. By *Elton R. Darling, Ph.D.*, in charge of industrial chemistry department, Newark Technical School. 100 pp. New York: D. Van Nostrand Co. Price, $1.

In the commercial world, chemical products are frequently known by names which have no apparent connection with scientific nomenclature. Furthermore, these colloquialisms vary according to geographical location, so that a single chemical may be represented by as many as twenty different terms. Most chemists will recall instances in which a great deal of time and effort was expended in search of the meaning of some strange new compound, only to find that it was an old laboratory friend masquerading under a trade name.

In this book, the author has gathered together over seven hundred synonyms for one hundred and twenty compounds of the following elements: Aluminum, antimony, arsenic, barium, bismuth, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, silver, sodium, zinc, hydrogen. A separate section is devoted to each element in the order given, with a few introductory paragraphs giving the physical properties and a brief review of the history of the element. Under iron, as an example, we find that ferric oxide has the following synonyms: Ferri oxidum, ferri sesquioxidum, ferri rubigo, rubigo, ferri peroxidum, ferri oxidum rubrum, peroxide of iron, red oxide of iron, iron rust, sesquioxide of iron, crocus ferri, crocus martis, ferrugo, polishing crocus, jewelers' rouge, venetian red, stone red, purple oxide, scarlet red.

A miscellaneous section contains eighty additional synonyms covering compounds not included in other sections. An excellent alphabetically-arranged cross-index enables one to identify quickly names which do not indicate the true chemical nature of the compound. The value of the book for reference work is increased by the inclusion of tables giving atomic weights, dates of discovery of the elements, occurrence of the metals in nature, temperature interconversions, comparison of specific gravity and degrees Twaddell and Baumé, weights and measures and conversion factors.

A few errors will be noted, such as listing barytes as a synonym of barium oxide, but these will undoubtedly be corrected at the first opportunity. As a time-saver, the book deserves the attention of every chemist in contact with the field of industrial chemistry.

ALAN G. WIKOFF.

Personal

Dr. HENRY ARNSTEIN, formerly technical director of the Cereal Products Refining Co. of San Francisco, has recently opened offices at 573 Twenty-second Ave., San Francisco. Dr. Arnstein has specialized in the manufacture of compressed yeast, maltose, alcohol, fats, vegetable oils and other food products and will enter consulting practice along these lines.

E. M. BISSONETTE, formerly with E. I. du Pont de Nemours & Co., Deepwater, N. J., is now with the Atlantic Refining Co., Pittsburgh, Pa.

F. W. BROWN recently resigned his position as sulphite superintendent of the Cascade Mill, Berlin, N. H., to accept the position of general manager of the bleached sulphite pulp plant of the Fraser Cos., Ltd., Edmundston, N. B.

GEORGE N. FISHER, formerly associated with the Certain-teed Products Corp., Niagara Falls, is now connected with the General Chemical Co., East St. Louis, Ill., as chemist.

F. C. FREEMAN, chief engineer for the Providence Gas Co., Providence, R. I., recently gave an illustrated lecture before the Providence Engineering Society on the manufacture of gas.

JOHN S. HARRIS, formerly of Klondike, Ariz., is now employed in the chemical department of the Empire Gas & Fuel Co., El Dorado, Kan.

E. J. HORWOOD, works manager for the Broken Hill Proprietary at Broken Hill, has been transferred to the Melbourne office of the company.

Dr. EDWARD H. HUME, head of the Yale University movement in China, addressed the Chicago Foreign Trade Club last week on the organization of the China Society of America.

HENRY N. LYONS, formerly with the Hercules Power Co., is now chief chemist with the Columbia Chemical Co., Barberton, Ohio.

Prof. ELIHU THOMSON, Swampscott, Mass., chief consulting engineer, General Electric Co., Lynn, Mass., has been appointed acting head of the Massachusetts Institute of Technology until a successor is chosen for the place, which was made vacant by the death of Richard Maclaurin.

HENRY LANE WILSON, former Ambassador to Mexico, spoke before the Detroit Chamber of Commerce on March 23, on business conditions in Mexico.

H. W. YOUNG, research chemist for the gas department of the Midwest Refining Co., has returned after an extended tour of the East, collecting information to be used in equipping an experimental laboratory at Salt Creek, Wyo.

Obituary

JOHN JEPPSON, superintendent and one of the founders of the Norton Co., Worcester, Mass., died in the Plaza Hotel, Havana, Cuba, Friday night, March 26, after an illness of two weeks. Mr. Jeppson's sickness dated from an attack of acute indigestion, from which he recovered sufficiently to reassure his relatives as to his condition, and the news of his death, received by Charles L. Allen, treasurer and general manager of the Norton Co., in a dispatch from George N. Jeppson, Mr. Jeppson's son, came as a surprise and shock to his thousands of Worcester friends.

Mr. Jeppson was born on a farm near Hoganas, Sweden, July 1, 1844, the son of Godman and Bengta (Person) Jeppson, and was seventy-five years, eight months and twenty-five days old. His remarkable career in Worcester began April 29, 1869, four days after he landed in New York, a poor Swedish immigrant.

Current Market Reports

The Non-Ferrous Metal Market

New York, April 5, 1920.—The copper market is still steady. March exports totaled 13,100 tons. For May delivery the price is 19.25c. There has been no movement in the price of nickel for a number of weeks, but silver has been fluctuating and is now $1.26½, against $1.23½ last week. Lead and zinc are steady both here and in East St. Louis. Tin has advanced a cent, as have scrap metals. Mercury is up $8 over last week.

	Cents per Lb.
Copper, electrolytic	19.00
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	10.50@10.75
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	62.50
Lead, New York, spot	8.87½
Lead, E. St. Louis, spot	8.60
Zinc, spot, New York	9.00
Zinc, spot, E. St. Louis	8.60

OTHER METALS

Silver	oz.	$1.26½
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f.o.b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	103.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	23.50@24.50
Aluminum, sheet scrap	23.50@24.50
Aluminum clippings	27.00@28.00
Copper, heavy machinery comp	16.00@16.50
Copper, heavy and wire	15.75@16.25
Copper, light and bottoms	14.50@15.00
Copper, heavy cut and crucible	16.50@17.25
Brass, heavy	10.00@10.50
Brass, casting	8.50@9.00
Brass, light	10.00@10.25
No. 1 clean brass turnings	13.75@14.25
No. 1 comp. turnings	11¼@11½
Lead, tea	5½@5½
Lead, heavy	7@7½
Zinc, scrap	4½@4½

The Iron and Steel Market

Pittsburgh, Pa., April 2, 1920.

The iron and steel market has become still quieter, and may almost be described by the term stagnant. The situation does not necessarily reflect any loss in the fundamental strength of the iron and steel position, though of course the extreme conservatism of banking interests at this time and the fear in some quarters that there will be an industrial depression in the near future might be contributing causes. The quietness in the iron and steel market is rather to be ascribed to the technical position of the market, through its having undertaken an advance which it could not sustain. The fancy prices recently paid for prompt deliveries of steel products, including not only sheets and plates but also several other descriptions of steel, are passing and indeed have already passed except for a very limited turnover. The higher prices being charged by large independents over Steel Corporation prices also have to go, though the complete elimination of these premiums may not be until quite a while in the future. With the steel market in process of readjustment buyers are naturally indisposed to take hold.

CAUSES OF STEEL MARKET DULLNESS

In the foregoing reference to the dullness in the steel market reference was made to two causes as if they were totally separate and distinct, but that, perhaps, is not the case. Reference was made to the general industrial and financial situation, on the one hand, and to the technical position of the steel market itself on the other. In a sense, however, the latter is a replica on a small scale of the former. The financiers and others who hold that there must be a readjustment in values and credits, and that there may be a mild industrial depression as a process of readjustment, maintain that prices are too high, that there is such inflation that sound business on a large scale cannot be conducted. If that is the general or average situation in business, the steel situation is the same thing in its narrower sphere. Steel prices started to advance above the Industrial Board price schedule of March, 1919, except that the United States Steel Corporation elected to continue selling at those prices. Many independent steel producers predicted a "runaway market" in steel, and the runaway actually started. Perhaps the proximate cause of the arrest of the runaway market was a production larger than had been expected by those who, actuated by their fears of a steel famine, paid fancy prices for prompt deliveries to eke out their contract deliveries, but a runaway would have been prevented from going far, even with smaller production, by a large amount of latent demand being held back from actual expression. Neither the railroads nor investment buyers generally would invest in steel at prices obviously affording the producers an inordinate profit after paying very high wages and buying supplies at extremely high levels.

Thus the steel market requires a readjustment because it had started out on the road of inflation, but what the bankers assert is that the whole country is on an inflated basis and all commercial operations will have to be adjusted to a more moderate, and therefore safer, level. Accordingly, whether one attributes the present dullness in the steel market to there having begun a readjustment in business generally, or to there having begun a readjustment in steel prices, in either case the matter rests upon the same economic principle, that successful business cannot long be conducted on an inflated basis. It is pertinent to observe another connection, that the Steel Corporation has steadfastly refused to participate in the advance in steel prices, adhering to the Industrial Board schedule, and that the policies of the Steel Corporation are, in the last analysis, directed largely by financial interests.

RAILROAD BUYING

When inquiries for freight cars began to appear in volume at the beginning of March, when the railroad lines were returned to their owners, it was predicted that car buying on this movement would involve not less than 50,000 cars and might run to 100,000 cars. Now it appears doubtful

whether even the lower figure will be attained. The chief difficulty mentioned is that of financing, the railroads offering payment largely in notes, and in some cases proposing to pay only 25 per cent in cash. Undoubtedly another difficulty is that the railroads feel that prices are too high, since the car companies could secure but little steel for early deliveries at the Steel Corporation prices. There is scarcely any railroad inquiry for bridges and structural material generally.

Steel Prices and Sales

The large independent steel companies have not formally opened their order books for third quarter deliveries of such materials as bars, shapes and plates, but may do so shortly. It appears that their customers prefer that the opening should occur later, preferring not to be forced to commit themselves just at this time. Some business has been done, however. Mills have been stating that they do not expect to set their third quarter prices at above 3c. for bars, 3.10c. for shapes and 3.25c. for plates. The Steel Corporation continues to sell in most of its lines, but transactions have been lighter of late, and the corporation's unfilled tonnage statement may show a decrease for March, after heavy increases in preceding months.

Open Coke Market

In one branch of the general market there have been spectacular performances in the past week, the Connellsville coke market. Predictions have been made that when Government price limits, $6 for furnace coke and $7 for foundry, should be removed the market would advance to $9 or thereabout for furnace coke. The actual removal of the restrictions became actually effective at the end of March, but before that time transactions began, for shipment and invoicing April 1 and later. The initial sales were at $9, a few prompt lots going at this figure as well as a fair sized tonnage for the month of April and a small monthly tonnage for the remainder of the year. Then the market began advancing sharply from this level, by 50c or $1 a day, and in the past two or three days it has stood at $11 to $12 for furnace and at $13 to $14 for foundry coke per net ton at ovens. Coke operators seemed to feel that the price should be the same whatever the delivery, whether April, second quarter or balance of year, but at such high levels furnaces became reluctant to commit themselves for more than the month of April.

Nearly all the April business has now been done. The turnover has been chiefly in coke that was released by the expiration of first quarter contracts or understandings between producer and consumer, good for the period of Government control, that coke would be furnished and invoiced at the Government price. As contract deliveries had been somewhat under requirements, the termination of these contracts and understandings operated to create larger uncovered consumption than unsold production.

The advance in coke seems to have had a stiffening effect upon the attitude of blast furnaces in the matter of pig-iron prices, which are now quite firmly held. Pig-iron consumers, however, are not in the market to any extent.

Chemical and Allied Industrial Markets

New York, April 5, 1920.

There has been no change in the general condition of the heavy chemical market during the past week. Spot offerings are practically unobtainable and there is very little material to be had on future delivery. Prices have strengthened and where there has been no actual rise quotations are firmer at the previous levels. The shipment of supplies from the West is still being hampered by transportation difficulties.

General Chemicals

Barium chloride still remains in a nominal position. Spot material is practically unobtainable and producers are working to fill back contracts. The quotation of $140@$150 per ton still holds. *Potassium bichromate* is firmer at 36@37c. per lb. than at the previous quotation of 32@33c. There is very little material available and producers are reported well sold up for the next few months. *Chloroform* came up slightly, being listed at 29@30c., against 28c. of last week. The usual business is being done, with nothing of particular interest in view. *Alcohol*, wood, has jumped still higher, quotations ranging from $2.35@$3.50 per gal. according to the proof. *Caustic potash* is practically unobtainable, the present listing being 28@29c. per lb. Supplies on *sal soda* are still tighter, which has affected the price, it being listed at $22@$26 per ton, against $21@$22 of last week.

Coal-Tar Products

The already reported shortage in all branches in this market still holds. Crude material is especially short and this is holding up production to such an extent that the spot market is at a standstill. There is no scarcity of buyers who are anxious to obtain material at most any price. *Aniline oil* has tightened up slightly, being listed at 34@45c. per lb. *Dimethylaniline* is still off the market, although some small quantities have changed hands at $1.50 per lb.

Naval Stores

This market remains in the same position in which it was last week. Rosins are still scarce, while turpentine is not to be had in the New York market at any price, but $2.36 per gal. is the nominal quotation of the week.

Crude Rubber

This market has been at a standstill during the past few weeks. There are several reasons for this condition, the principal one being fluctuating foreign exchange, as manufacturers will not go in the market on a speculation basis. Other contributing causes are the present condition of the spot market in relation to future delivery and the difficulty on the part of the tire manufacturers to obtain fabric, which has limited the buying of rubber. During the war the Government cut importations of crude rubber in half, which allowed large quantities to accumulate, and this material is now being offered on the spot market, causing future offerings to be turned down by the buyer for the more favorable spot price. The extreme tire fabric shortage is also a large factor in the present depression, as manufacturers will not buy the rubber when their output is being limited by the small quantity of fabric being received. It is the opinion of those doing business in this market that a firm rising exchange will go a long way toward putting this market back in its former position.

Ferro-Alloys

Ferromanganese continues upward with no relief in sight. Car shortage and labor trouble at the docks, combined with the extreme shortage of supplies are accountable for the increasing market price on this item. Quotations on English material for prompt shipment are $200 per ton and for last half $175@$200 is being asked, with no actual offers to be found even at these prices. Domestic is listed $235@$240 prompt delivery and $200@$220 for last half.

Spiegeleisen remains firm, with business being transacted at prices ranging from $60@$65 per ton.

Miscellaneous

The barytes market is at a standstill, as there is very little material to be obtained. Demand so far exceeds output that producers have warned their selling representatives not to take any more contracts without first consulting the works. No price is being quoted on contract goods, all goods being sold at current price at time of delivery. The spot market is also practically bare of this material and as high as $40 per ton is being asked for white floated, while the off-color grade is listed at $25@$30 per ton.

Tungsten is firmer under the influence of pending legisiation. Although there has not been any larger business than usual, *wolframite* is firmer at $6.50@$7.50 per unit than it was last week.

Fullers earth remains firm at $25@$30 for domestic and $35@$40 for foreign, with very little material available at these prices.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	..–.....	$0.60 – $0.65
Acetone	lb.	$0.13 –$0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	2.75 – 3.00	3.25 – 3.50
Acetic, 56 per cent	cwt.	6.00 – 6.50	7.00 – 7.50
Acetic, glacial, 99½ per cent. carboy	cwt.	12.00 –14.00	15.00 – 15.50
Boric, crystals	lb.	.14½– .15½	.15½– .16½
Boric, powder	lb.	.14½– .15	.15 – .16
Citric	lb.	.85 – .86	1.19 – 1.25
Hydrochloric	lb.	.08 –.....	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –.....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .06	.05½– .07
Molybdic, C. P	lb.	..–.....	4.25 – 5.00
Nitric, 40 deg	lb.	.06 – .07	.07½– .08½
Nitric, 42 deg	lb.	.06½– .07½	.08 – .09½
Oxalic, crystals	lb.	.35 – .42	.43 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –.....	..–.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	17.50 –22.00	..–.....
Sulphuric, 60 deg., drums	ton	..–.....	..–.....
Sulphuric, 66 deg., tank cars	ton	22.00 –25.00	..–.....
Sulphuric, 66 deg., drums	ton	..–.....	..–.....
Sulphuric, 66 deg., carboys	ton	..–.....	..–.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –30.00	32.00 –.....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	32.00 –.....	34.00 –.....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	35.00 –.....	40.00 –.....
Tannic, U. S. P	lb.	..–.....	1.35 – 1.45
Tannic (tech.)	lb.	..–.....	.60 – .80
Tartaric, crystals	lb.	..–.....	.69 – .74
Tungstic, per lb. of WO	lb.	..–.....	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.35 – 3.50	..–.....
Alcohol, denatured, 188 proof (nominal)	gal.	..–.....	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	..–.....	.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05¼– .06
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾– .02	.02½– .03½
Aluminum sulphate, iron free	lb.	.02½– .03	.03¼– .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾– .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15 – .15½	.16 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	..–.....
Ammonium sulphate	lb.	.05 –.....	.06 –.....
Amylacetate	gal.	..–.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	..–.....	.10½– .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..–.....
Barium chloride (nominal)	ton	125.00–135.00	140.00 –150.00
Barium dioxide (peroxide)	lb.	.23 – .27	.28 – .30
Barium nitrate	lb.	.17 – .19	.20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½– .06
Bleaching powder (see calcium hypochlorite)		..–.....	..–.....
Blue vitriol (see copper sulphate)		..–.....	..–.....
Borax (see sodium borate)		..–.....	..–.....
Brimstone (see sulphur, roll)		..–.....	..–.....
Bromine	lb.	.85 – .90	..–.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 –.....
Calcium carbide	lb.	..–.....	.04¾ .05
Calcium chloride, fused, lump	ton	20.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½– .01¾	.02 – .02½
Calcium hypochlorite(bleaching powder)	cwt.	..–.....	4.00 – 4.50
Calcium peroxide	lb.	..–.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..–.....	.75 – .80
Calcium sulphate, pure	lb.	..–.....	.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.10½– .11	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..–.....	.80 – 1.05
Caustic potash (see potassium hydroxide)		..–.....	..–.....
Caustic soda (see sodium hydroxide)		..–.....	..–.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.29 – .30	.31 – .32
Cobalt oxide	lb.	..–.....	2.00 – 2.05
Copperas (see iron sulphate)		..–.....	..–.....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	..–.....	.65 – .70
Copper sulphate, crystals	lb.	.08¾– .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		..–.....	..–.....
Epsom salt (see magnesium sulphate)		..–.....	..–.....
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)		..–.....	..–.....
Glycerine	lb.	..–.....	.24½– .26
Iodine, resublimed	lb.	..–.....	4.10 – 4.30
Iron oxide, red	lb.	..–.....	.03 – .20
Iron sulphate (copperas)	cwt.	1.20 –.....	1.50 – 2.00
Lead acetate, normal	lb.	.12 – .13	.14 – .23
Lead arsenate (paste)	lb.	..–.....	.13 – .17
Lead nitrate, crystals	lb.	..–.....	.70 – .90
Litharge	lb.	.14 – .15	.15½– .16
Lithium carbonate	lb.	..–.....	1.50 –.....
Magnesium carbonate, technical	lb.	..–.....	.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	3.40 – 3.55	3.60 – 3.75
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –.....	.15 –.....
Nickel salt, single	lb.	.16 – .17	.17½–.....
Phosgene (see carbonyl chloride)		..–.....	..–.....
Phosphorus, red	lb.	..–.....	.60 – .65
Phosphorus, yellow	lb.	..–.....	.35 – .37
Potassium bichromate	lb.	.36 – .37	.38 – .40
Potassium bitartrate (cream of Tartar)	lb.	..–.....	.56 – .60
Potassium bromide, granular	lb.	..–.....	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –.....	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb.	.15 – .20	.21 –.....
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	..–.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –.....	.21 –.....
Potassium permanganate	lb.	..–.....	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	.34 – .36	.38 – .40
Potassium sulphate	ton	$225.00 –.....	..–.....
Rochelle salts (see sodium potas. tartrate)		..–.....	..–.....
Salammoniac (see ammonium chloride)		..–.....	..–.....
Sal soda (see sodium carbonate)		..–.....	..–.....
Salt cake	ton	22.00 –26.00	..–.....
Silver cyanide (nominal)	oz.	..–.....	1.25 –.....
Silver nitrate (nominal)	oz.	..–.....	.77 – 82¾
Soda ash, light	100 lb.	..–.....	3.50 – 3.60
Soda ash, dense	100 lb.	2.70 – 2.75	3.55 – 3.65
Sodium acetate	lb.	.06¾– .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –.....	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.05½– .06½	.07 – .07½
Sodium borate (borax)	lb.	.08½– .08¾	.09 – .09½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 –.....	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –.....	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	..–.....	6.75 – 7.00
Sodium hyposulphite	lb.	..–.....	.03¾ .04
Sodium molybdate	lb.	2.50 –.....	3.25 –.....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	..–.....	.25 – .30
Sodium peroxide, powdered	lb.	..–.....	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾– .04½	.04½– .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .2z	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½– .02	.02 – .0¾
Sodium silicate, solution (60 deg.)	lb.	.02¼– .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.40	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	..–.....	.05 – .06
Sodium sulphite, crystals	lb.	.03½–.....	.04 – .06
Strontium nitrate, crystals	lb.	.25 –.....	.28 –.....
Sulphur chloride	lb.	.05¾–.....	.06 –.....
Sulphur, crude	ton	22.00 –.....	..–.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –.....	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –.....	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –.....	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½–.....	.46 – .50
Tin oxide	lb.	.50 – .60	.65 –.....
Zinc carbonate, precipitate	lb.	..–.....	.19 – .20
Zinc chloride, gran.	lb.	.13 –.....	.13½– .15
Zinc cyanide	lb.	.49 –.....	.50 – .60
Zinc dust	lb.	.11¾– .12½	.13 – .15
Zinc oxide, U. S. P.	lb.	..–.....	.19 – .21
Zinc sulphate	lb.	.03½– .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.48
Anthracine, 80% in drums (100 lb.)	lb.	.75 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.35
Benzidine, sulphate	lb.	1.00 —	1.15
Benzoic acid, U.S.P.	lb.	.90 —	1.10
Benzoate of soda, U.S.P.	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	.50 —	.65
Beta naphthol, sublimed	lb.	.70 —	.90
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.70
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline (nominal)	lb.	.95 —	1.50
Dinitrobenzol	lb.	.26 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.32 —	.36
Dinitrotoluol	lb.	.38 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.55 —	.65
H-acid (nominal)	lb.	1.75 —	1.90
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline crushed, in bbls. (250 lb.)	lb.	.08 —	.09
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.08½ —	.10
Naphthionic acid, crude	lb.	.70 —	.80
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.30 —	.35
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.12 —	.18
Paranitraniline	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.15 —	3.00
Paratoluidine	lb.	1.75 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.45 —	.50
Salicylic acid, U. S. P.	lb.	.55 —	.60
Salol	lb.	.90 —	1.00

Solvent naphtha, water-white, in drums, 100 gal..	gal.	$0.25	—	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dar\	lb.	$0.39	—	$0.40
Beeswax, refined, light	lb.	.40	—	.41
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1, (nominal)	lb.	.80	—	.88
Carnauba, No. 2, regular (nominal)	lb.	.60	—	.70
Carnauba, No. 3, North Country (nominal)...†	lb.	.43	—	.45
Japan	lb.	.17	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.11
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.11	—	.11¼
Paraffine waxes, refined, 133-135 m.p.	lb.	.12	—	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½	—	.14
Stearic acid, single pressed	lb.	.26	—	.27
Stearic acid, double pressed	lb.	.32	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	...
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.47
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.060	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.95	—	$19.50
Rosin E-I	280 lb.	19.75	—	20.00
Rosin K-N	280 lb.	20.25	—	20.50
Rosin W. G.-W. W.	280 lb.	22.00	—	22.50
Wood rosin, bbl.	280 lb.	15.50	—	17.50
Spirits of turpentine	gal.	.	—	2.35
Wood turpentine, steam dist.	gal.	.	—	2.25
Wood turpentine, dest. dist.	gal.	.	—	2.10
Fine tar pitch, bbl.	200 lb.	8.40	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.92	—	.95
Rosin oil, second run	gal.	.94	—	.97
Rosin oil, third run	gal.	1.12	—	1.15
Rosin oil, fourth run	gal.	1.17	—	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

ara—Upriver fine	lb.	$0.40½	—	$0.42
Upriver coarse	lb.	.30½	—	.32
Upriver caucho ball	lb.	.32½	—	.33
Plantation—First latex crepe	lb.	.47½	—	.48½
Ribbed smoked sheets	lb.	.47	—	.48
Brown crepe, thin, clean	lb.	.45	—	..
Amber crepe No. 1	lb.	.46	—	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.23
China wood oil, in bbls.	lb.	.24½	—	.25½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.19	—	.19½
Cocoanut oil, Cochin grade, in bbls.	lb.	.20½	—	.23
Corn oil, crude, in bbls.	lb.	.17½	—	.19
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½	—	.18
Cottonseed oil, summer yellow	lb.	.19½	—	.20½
Cottonseed oil, winter yellow	lb.	.22	—	.24½
Linseed oil, raw, car lots	gal.	1.74	—	
Linseed oil, raw, tank cars	gal.	1.67	—	
Linseed oil, boiled, car lots	gal.	1.77	—	
Olive oil, commercial	gal	2.50	—	3.00
Palm, Lagos	lb.	.16	—	.16½
Palm, bright red	lb.	.15½	—	.17½
Palm, Niger	lb.	.15	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½	—	.22
Peanut oil, refined, in bbls.	lb.	.27	—	.28
Rapeseed oil, refined in bbls.	gal	1.70	—	1.78
Rapeseed oil, blown, in bbls.	gal.	1.80	—	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19	—	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.19¼	—	.20

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.30	—	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	.....	—	$40.00
Barytes, off color	ton	$20.00	—	25.00
Blanc fixe, dry	lb.	.04½	—	.05½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.....	—	
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar (nominal)	ton	13.50	—	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00	—	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	52.00	—	57.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	.07½
Graphite, crucible, 86% carbon content	lb.	.....	—	.08
Graphite, crucible, 87% carbon content	lb.	.....	—	.08
Graphite, crucible, 88% carbon content	lb.	.....	—	.09
Graphite, crucible, 89% carbon content	lb.	.....	—	.09½
Graphite, crucible, 90% carbon content	lb.	.....	—	.10
Graphite, crucible, 91% carbon content	lb.	.....	—	.10½
Graphite, crucible, 92% carbon content	lb.	.....	—	.11
Graphite, crucible, plus 92%	lb.	.....	—	.12½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	...
Shellac, orange, fine nominal	lb.	1.45	—	...
Shellac, orange, superfine	lb.	1.60	—	1.65
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	20.00	—	60.00
Talc, imported	ton	60.00	—	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.22
Ferro-manganese, 70-80% Mn.	gross ton	180.00	—	240.00
Spiegeleisen, 16-20% Mn.	gross ton	60.00	—	65.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25	—	2.75
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	200.00
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	.90	—	1.10
Ferro-uranium, 35-50% of U	lb.	7.00	—	...
Ferro-vanadium, 30-40% per lb. of contained V....	lb.	6.50	—	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70	—	$0.85
Chrome ore, 48% and over	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00	—	
*Coke, furnace, f.o.b. ovens	net ton	6.00	—	
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00	—	30.00
Manganese ore, 45% Mn and over	unit	75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	6.00	—	...
Pyrites, foreign, lump	unit	17	—	...
Pyrites, foreign, fine	unit	17	—	...
Pyrites, domestic, fine	unit	16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	...
Rutile, 95% TiO_2	lb.	.11	—	...
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	...
Monazite, per unit of ThO_2	unit	42.00	—	...

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage, 25c. for 19 to 24 gage, for galvanized corrugated sheets, add 10c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

LOS ANGELES — King W. Vidor has awarded the contract for the construction of seven 1- and 2-story picture-producing buildings on Santa Monica Blvd., to the Milwaukee Bldg. Co., 316 Wright & Callender Bldg. Estimated cost, $100,000.

Connecticut

MIDDLETOWN—The Standard Oil Co., 26 B'way, New York City, plans to build an oil plant along the Connecticut River. Estimated cost, $100,000.

Illinois

CHICAGO—Shea, Smith & Co., 322 Federal St., manufacturing stationers, plan to build a 5-story steel and concrete factory at Congress St. and Ashland Blvd. Estimated cost, $600,000.

CHICAGO—The Vulcan Louisville Smelting Co., 208 South La Salle St., plans to rebuild a part of the North Chicago plant which was recently destroyed by fire. Estimated cost, $400,000.

Indiana

EVANSVILLE — Clifford Shopbell, 707 Furniture Bldg., will receive bids for the construction of a 2-story, 80 x 150-ft. factory for the Liquid Carbonic Co., Heidelback Ave. and Indiana St. Estimated cost, $30,000. Noted March 3.

Kansas

PROTECTION—The city is receiving bids for the construction of a disposal plant. Filter equipment will be installed in same. Estimated cost, $50,000. W. B. Rollins & Co., 209 Railway Exch. Bldg., Kansas City, Mo., engr.

Louisiana

NEW IBERIA—The United Fiber & Products Co. has purchased the mill of the Sugar Cane By-Products Co. and will install new machinery in same. The mill will have a daily capacity of 15 tons newsprint paper. W. T. Larkin, 1520 Fidelity Bldg., Baltimore, Md., pres. F. Logan, 467 C St., N. W., Washington, D. C., engr.

Maryland

BALTIMORE—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of eight 1-story, 25 x 100-ft. acetylene plants. Estimated cost, $75,000.

LANSDOWNE—The Natl. Steel Rolling Co, 203 Keyser Bldg., Baltimore, has purchased the plant of the Schuylkill Haven Rolling Mill Co., Schuylkill Haven, Pa., and plans to build a subsidiary plant near here. The plant will be an oil and electric steel reclaiming bar mill and will have an annual capacity of 9,000 tons. Estimated cost, $100,000.

Massachusetts

FITCHBURG—Croker, Burbank & Co., 549 Westminister St., has awarded the contract for the construction of a 2-story, 46x300-ft. machine shop, 1-story, 54x100-ft. spinning shop and a 2-story, 130x130-ft. header shop, to E. J. Cross Co., 82 Foster St., Worcester. Estimated cost $400,000.

Michigan

NORTHVILLE — The Detroit Bd. of Health, 233 St. Antoine St., Detroit, received bids for the construction of a 2-story, 28x26-ft. laboratory, in connection with the group of buildings to be constructed at the proposed Detroit Municipal Tuberculosis Sanitarium, from John Finn & Co., 234 East Fort St., Detroit, $29,375; George A. Fuller Co., 540 Penobscot Bldg., Detroit, $30,700. Noted Feb. 26.

Missouri

ST. LOUIS—The Amer. Bakers' Machine Co., 2121 North 9th St., plans to build a factory and office building on Kingshighway and McRee Ave. Estimated cost, $110,000.

ST. LOUIS—The Skinner Bros. Mfg. Co., 10th and Tyler Sts., builders of industrial heaters and blow piping systems, is building a factory at Lunt and Vandeventer Ave. Estimated cost, $250,000.

New Jersey

NEWARK—The Seaboard Chemical Co., Blanchard St., has awarded the contract for the construction of a wood alcohol plant, to Edward M. Waldron, Inc., 665 Broad St. Estimated cost, $40,000. The company will be in the market for chemicals for the manufacture of wood alcohol.

PLEASANTVILLE—The Common Council, City Hall, will receive bids until April 19 for the construction of a sewage screening plant, etc.

TRENTON—The Kelso Mfg. Co., asbestos manufacturer, 58 Market St., plans to construct a factory addition on Market St.

New York

BROOKLYN—Fred A. Phelps, archt., Union Bldg., Newark, N. J., will receive bids until April 24 for the construction of a 4-story, 55x175-ft. paint factory at Hamilton and Smith Sts., for Devoe Reynolds, 460 Smith St., and will be in the market for chemicals for the manufacture of paint. Noted March 17.

BUFFALO—The Hewitt Rubber Co., Kensington Ave., plans to build a 2-story brick addition to present plant. Estimated cost, $25,000.

New Mexico

LORDSBURG—The Great Eagle Mine is in the market for crushing machinery, etc. J. W. Cauthen, supt.

Ohio

ASHLAND—The city has awarded the contract for the furnishing and installing of filter equipment for the proposed 1-story filtration plant, to the Amer. Water Softener Co., 1011 Chestnut St., Philadelphia, Pa., at $34,000. Noted March 31.

CINCINNATI—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of a few 1-story, 25 x 100-ft. acetylene plants. Estimated cost, $75,000.

CLEVELAND—The Cleveland Steel Co., Rockefeller Bld., plans to build a 1-story steel plant on West 117th St. and the Big Four R.R. Estimated cost, $350,000. C. J. Jones, mgr. A. S. McKee Co., Rockefeller Bldg., engr.

ELYRIA — H. A. Beck, Dir. of Pub. Servc., City Hall, will receive bids until April 26 for the furnishing and installing filter plant equipment.

DOVER—The Dover Mfg. Co., c/o Poe Eng. Co., archt. and engr., Rockefeller Bldg., Cleveland, O., plans to build a 3-story, 80x200-ft. factory. Estimated cost, $100,000.

Pennsylvania

PHILADELPHIA—The Presto-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of a few 1-story, 25x100 ft. acetylene plants. Estimated cost, $80,000.

South Dakota

MOBRIDGE—The city had plans prepared for the improvement of the waterworks system, taking water supply from the Missouri River, with filtration. Estimated cost, $175,000.

Texas

TEMPLE—The Southland Oil Co. is rebuilding its cotton seed-crushing plant. E. A. Dill, engr. Estimated cost, $60,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive at St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9 and 10. Headquarters will be at the Copley-Plaza Hotel.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Romance of Leather Making," Tuesday, April 13, at 4 p.m., E. A. Brand (*Lantern*); "Water Supply and Drainage in War Cantonments." Wednesday, April 21, at 4 p.m., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE ELECTRIC FURNACE ASSOCIATION will hold a meeting in Boston, April 8 to 10, together with the American Institute of Electrical Engineers and the American Electrochemical Society. The subject is "Electrically Produced Alloys and Power for Electrochemical Purposes." Headquarters will be at the Copley-Plaza Hotel.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E., will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INTERNATIONAL MINING CONVENTION will be held in Seattle April 7 to 10.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept, 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NATIONAL SAFETY COUNCIL, Engineering Section, will hold its spring conference in the Engineering Societies Building, New York City, on April 27.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, April 14, 1920 *Number* 15

Patent Royalties For Government Employees

THE report that Government employees are to receive a portion of royalties which may accrue from patents on inventions made or developed within Government time is worthy of note. Under the bill, which, as reported in our last issue, has passed the Senate, the Federal Trade Commission is to administer the patents and the President is to fix the percentage of royalties allowed to employed inventors. We take it that examiners in the Patent Office are not to participate in this privilege for the reason that a type of man that has thus far been pretty well avoided would be encouraged to enter that occupation. The temptation to file claims that would establish profitable interferences would invite the wrong men to come in as examiners.

Teaching and Government service appeal to some men of the very first rank. It is known beforehand that these occupations do not lead to wealth, as do occasional opportunities in industry. On the other hand, except in institutions of learning that suffer from the control of politics, a kind of academic freedom is provided, the annoynace of hasty and slipshod performances to beat a rival concern are avoided, the pay is regular, the domicile of a person so employed is likely to be in a pleasant place and there is a dignity attached to either calling that is at once agreeable and distinguished.

The Bureaus of Mines and of Chemistry are places where the value of such privileges may speedily develop. Many patents have emanated from these bureaus and have been assigned to the Government for the public welfare.

Whether or not the inventor should have any participation or share in the proceeds of his work done on Government time is a question of expediency rather than of ethics. The purpose of corporate research is for the benefit of the corporation, and this holds true for the people as well as for stockholders. But in industry a man is supposed to be able to look after himself, whereas in Government service he has no voice in making rules or contracts. He can accept or decline, but he cannot negotiate. We should like to see Dr. COTTRELL, for instance, made rich in spite of himself; for anyone who contributes as much as he has to human welfare and industrial progress is entitled to it. In England he would have been Sir FREDERICK long ago, while in Germany in the old days he would have been a real, simon-pure, genuine privy councillor "mit dem Prefix Excellenz" and probably ennobled into the bargain. It is men of this type, however, who are not even interested in the emoluments of office. They have a sane view of life, welcoming the luxuries of civilization but with no desire whatever for plutocratic luxuries. They do not want to keep their eyes at the point of strain to catch opportunities on the fly or to scrap with contemporaries for control or advantage. And the reward proposed is unlikely to be opulent. It is hardly enough of a bait to lure into the Government service shifty persons whose desire for profit is a constant hazard to character and who prefer dollars to a clear conscience.

Another point in its favor is that it will constitute an ever-present premium on the application of pure science to the use and benefit of society. Incentives of this sort have great potential value.

There may be serious objections to the proposal, but at present writing we are impressed with its advantages.

The Soviets At Work

UNDER the title, "The Soviets at Work," LENIN has recently made a statement that should be brought to the attention of every American. It deserves quotation in full:

"The bolshevists have destroyed capitalism, nationalized industry and formed workers' soviets. But Russia is still far from communism and a socialistic soviet republic.

"What the bolshevists have done so far was the easiest part. It was the destructive part. It required only force and decrees. The hardest part is still before them. Bolshevism will fail unless it can rebuild Russian industries and get maximum production.

"This cannot be accomplished under the original plan of bolshevism. The workers' soviets don't know how to run the factories and keep order. And the workers aren't yet willing to work for the same rate of pay for different kinds of work. The machine worker still wants more than the man with a pick; and the brain worker still wants more than the machine worker. Russia will not have communism until human nature is changed and each man is willing to work for the good of all instead of for personal gain.

"It will take years to change human nature by education and to teach workers to run factories by soviet methods. But in the meantime industry must be recognized and maximum output by both factory and the individual worker maintained.

"The only course before the bolshevist leaders is to take a step backward from the soviet state—to return to the old order. They must call in bourgeois experts at large salaries to run the factories. They must adopt the factory methods of capitalistic America.

"And the bolshevist leaders must go back still further. They must place the workers under iron discipline. They must make the hundreds and thousands of workers in each factory subject to the will of one man—the

bourgeois manager. The workers must be compelled to work their hardest."

Thinking men by the thousands have said that with an ideal human family socialism would be a most desirable system. LENIN, the proponent of Russian communism, from the depths of his terrible experience, approves those views.

If we could get a knowledge of what is transpiring in Russia into the minds of our loose-thinking elements it would lead them to improve what we have rather than advocate the Russian system—and to court the inevitable Russian chaos.

The Rule and Its Exceptions On the Properties of Lubricants

IF THERE is any actual rule for grading lubricants, a statement of it would embody the following five general principles: Purity, freedom from acid or corrosives, maximum adhesion to the surfaces to be lubricated, minimum internal cohesion or resistance to shear and stability under conditions of use. About a dozen laboratory tests have been devised to determine whether or not a given lubricant conforms to all of these specified properties. The application of this series of tests, however, has been to give a convenient means for comparing the qualities of an unknown lubricant with those that are found in lubricants that have proved most satisfactory after many years of actual use. Exceptions to indications of these tests have been found, so a knowledge of when the rule does not apply is of paramount importance to the rule itself.

The "germ" process recently introduced in England apparently is a good case for discussion. In this process mineral oils are compounded with from one to two per cent of rape-oil fatty acids, and the same reduction in the coefficient of friction is obtained as with twenty per cent of the neutral glycerides. From time immemorial, neutral rape-oil has been specified, so as to meet an acid test, which was actually designed to prevent the sale of refined lubricants from which the last traces of sulphuric acid had not been removed.

It is possible that the term acid will gradually come to have the qualification of "mineral" applied to it. At the same time, it may be expected that instead of removing all the unsaturated hydrocarbons, the lubricant refiner of the future may be a sort of synthetic chemist and make his anti-friction fatty acids right in the oil by adding carboxyl groups on to the open double bonds instead of sulphonating and removing them.

How They Do It Out in Kansas

GOVERNOR HENRY ALLEN recently addressed the Chicago Chamber of Commerce on the operation of the new industrial law in his state for preventing strikes. A special session of the Legislature was called during the coal strike last winter and a law was passed which would make it impossible for the recurrence of such wasteful events in the industries. The court which has been established is a court neither of arbitration nor of conciliation, but a court of justice operating as the chief representative of the State Government.

The law has not been exactly popular with a certain section of the labor element that has seemed inclined lately to run amuck.

However, a recent example of how the law functions is best described in Mr. Allen's own words:

> The other day there came to me a man representing the Maintenance of Way Railroad Craft in Kansas. He had just received from his national officer at Detroit orders to call out on strike the men who work in the maintenance-of-way crafts of the railroad organizations. He had also received orders to pass the word along as rapidly as he could. Now this man knew about this law, and he came to me and handed me the telegram, and said, "Governor, what will happen to me if I pass the word along to my locals?" I said, "Sit down, and we will read this law for a minute."
>
> I ran my finger underneath the lines that provided the penalty, and I read that to him, and in a moment I heard him swallowing his epiglottis, and he said, "Why, you could fine me $1,000, couldn't you, because I am the head of this organization?" "Well," I said, "read these other lines." "Why," he said, "you could put me in the penitentiary for a year," and I said, "Yes. Since you have come to me and have taken the trouble to consult me about the law on the matter, I am inclined to think that I would give you both barrels."

Looking backward over several decades, we may recall that other things have originated in Kansas which later became successful national measures dealing with difficult situations.

May the nation continue to look westward for future inspiration?

The Muscle Shoals Plant Should Be Operated

EDITORIALLY we have already commented upon the proposal of the War Department to operate the Muscle Shoals nitrogen fixation plants and expressed the opinion that the proposals of the War Department to this effect were sound. The criticism of this plan made before the Senate Agricultural Committee last week, as reported elsewhere in this issue, has not changed our general conclusions, although the additional light which has been thrown upon this subject is very interesting indeed.

It seems that there are several important reasons why the Government cyanamide plant at Muscle Shoals should be operated.

First, we believe that the nitrogen-using industries of this country can absorb the output of ammonia, nitrates and other forms of nitrogen available without being affected materially by the output of this small plant. Its output will form only a few percent of the total available nitrogen needed in this country and this certainly is not sufficient to materially affect our nitrogen markets.

Second, we believe that the War Department can best keep in touch with nitrogen fixation conditions and can gain most valuable experience only if it retains active interest and participation in some phase of these industries. The continuance of the Muscle Shoals plant and the investigations which will accompany this plant operation should give the Ordnance Department extremely valuable experience which will be much needed in case this country should ever again be confronted with serious war conditions.

Third, we believe that the losses to the Government will be less if it continues to operate this plant (at least for the near future) than if the plant is allowed to lie idle or is sold to any private interest either immediately or in the near future.

Fourth, we believe that the American chemist has sufficiently developed the art of converting cyanamide

into ammonia, and by oxidation of this ammonia into nitrates, to justify considering the product of this plant as available either as a substitute for ammonium sulphate or as a substitute for Chilean nitrate. Ammonia and nitrates are somewhat interchangeable, for the present state of knowledge makes it readily possible to convert ammonia into nitrate at costs that are not by any means prohibitive—especially in periods of emergency. The conclusion that there is a surplus ammonia capacity in this country which can do nothing to eliminate the need for importing Chilean nitrate is therefore not correct.

No policy, such as may have been proposed by some Government representatives, should be adopted permitting some Bureau to enter into the fertilizer market in competition with the American Cyanamid Company or other similar interests. General Government operation of manufacturing plants is not desirable where industries stand ready to care for the supply of needed materials. Any evident injustice against corporate interests that have co-operated with the Government in the development of their plants or processes during the war period should be certainly vigorously opposed. If the patents and the contracts under which the Muscle Shoals plant was constructed and operated are as satisfactory as the private interests seem to believe them to be, we see no reason why an observance of these contracts and patent rights will not amply protect individuals against Government interference except that in the field of ammonia resources or possibly in the field of nitrate supply the product of the Government's effort may for a brief period seem to be competing tonnage. However, this competition will not be either serious or long continued and we reiterate, therefore, that we still believe reasons entirely different from the commercial aspects of the matter fully justify continuance of the plan proposed for operation of this plant.

The Tonnage Output Of the Steel Industry

IT IS a good motto, and a useful one, that "obstacles were made to be overcome." The steel industry is now showing, in its tonnage outputs, the results of having learned fresh lessons during the war in overcoming obstacles. It is not long ago that what appeared to be a gloomy view of the future tonnage output of the industry was being taken by some classes of officials in steel companies, particularly in sales departments, but the actual tonnage outputs being made indicate that the steel industry is already on a fair road toward functioning better than ever, and producing a total output larger than it had been supposed capable of producing even under favorable physical conditions.

During the war there was much evidence of the steel industry straining itself to the utmost to produce a maximum of steel, and in the forms requisite for prosecuting the war, but when statistics were gathered of actual outputs they were, in the main, quite disappointing. Evidently there were few plants that produced as much steel in either 1917 or 1918 as in 1916, unless they had added to their facilities, and this made it appear that the steel producers, however desirous they were of bringing about the best results possible, were failing in their effort. There were very great difficulties, however, production being impeded at almost every step, not only by the transportation difficulties, which were notorious, but by many other things. There is good reason to infer that if the managers, superintendents and others directly responsible for mill and furnace operations had exerted themselves no more during American participation in the war than they had in 1916 the tonnage outputs of 1917 and 1918 would have been much less than they were. It is not alone the total tonnages of the two years that are to be considered, but also the difficulties under which those tonnages were produced.

A difficulty or obstacle overcome makes it possible to accomplish still more the next time there is a test. This is no new experience for the American steel trade. The market has been subject to its ups and downs. The trade had "either a chill or a fever," as was remarked by the late JAMES M. SWANK nearly a third of a century ago, while later ANDREW CARNEGIE observed that the steel industry was "either a prince or a pauper." There have been alternations whereby in one period, perhaps for a few months or perhaps for a couple of years, mills and furnaces would be strained to produce maximum tonnage, while in an intervening period there would be an insufficiency of orders, with specifications inconvenient for efficient rolling at that. At the average plant it has been the experience that almost month after month during a period of activity new tonnage records would be made, while from one period of activity to the next a great deal would be gained. It should not be surprising, therefore, if after the strenuous times of the war, forcing the devising of new expedients, the steel mills should be found now able to function better than they did in 1916. The actual capacity, measured in terms of trains of rolls and number of open-hearth furnaces of given dimensions, has of course greatly increased. In terms of steel ingots the increase in nominal capacity from the beginning of 1915 to the present time has been estimated at fully 40 per cent, only a relatively small portion of this capacity having been effective in 1916, the year that bears the palm of the past four for tonnage output in steel ingots proportionate to rated capacity.

Aggregate tonnages are not yet record breaking by any means, for there are transportation difficulties in the way, but individual cases show record-breaking outputs. A conspicuous case is that of the National Tube Company, furnishing no insignificant illustration since the company produces about 4 per cent of all the finished steel of the country. This company had a larger production in March, by a very comfortable margin, than in any previous month in its entire history.

The steel industry has been a leader in many respects, illustrating what can be accomplished by courage in adopting heavy machinery and trying new devices and methods. With the world at large, including the United States, suffering economically from inefficiency and what amounts to laziness, the steel industry of the United States will help the world if it sets an example now of producing steel at a greater rate than it had been assumed capable of, judging by past performance. By taking account of production in past periods of activity and allowing for new construction meanwhile, the steel ingot-producing capacity has been estimated in recent months at not over about 50,000,000 tons per annum, but it seems quite probable that in the near future a rate of output nearer 55,000,000 tons will actually be shown.

Readers' Views and Comments

Reversing the In and Out Ratio of the Chemical Engineers

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with interest your editorial in your issue of Feb. 18, but cannot agree with your point of view. In fact, I believe that the other side of the shield looks entirely different. The American Institute of Chemical Engineers was organized after a preliminary campaign of a year by a committee of five, of which the writer was a member. A list of 700 names of chemists scattered over the United States was prepared as being possible members of the new society. Correspondence with this list was carried on for a year with the object of learning if there was a demand for the organization of the new society. A meeting was held in New York at which the question was discussed, after which a mail vote was taken.

As this was favorable by a large majority, the committee drafted a constitution and effected organization at Philadelphia, June 22, 1908, with forty charter members. During the year sixty more of the 700 joined the organization. Many of the 700 were found on investigation to be qualified by reputation only; others decided not to join the society. The society continued to grow steadily and now has a membership of 357.

You state in your editorial that there are "six outs" to "one in," which would mean that there are 2,500 chemical engineers in the United States who would be eligible for membership in the American Institute of Chemical Engineers. You also state that the "one in" has done nothing to reverse the ratio of membership.

I cannot agree with either of these statements. The Institute has met in various large centers of chemical industry, where many of the "six outs" must reside in order to gain a livelihood by this profession. Before each meeting the local committee has carefully gone over the list of chemists and engineers residing in the section and made a list of the men who could qualify for membership. These men have been invited to apply for membership and generally have done so and been elected.

In this manner a search has been made by a group of local chemical engineers for members in the following centers: Chicago, St. Louis, Cleveland, Detroit, Buffalo, Troy, Boston, Savannah, Los Angeles, San Francisco, Washington, Baltimore, Philadelphia and New York. Undoubtedly younger men are continually coming forward and men in out-of-the-way places are overlooked, but it seems unlikely that six men could have been overlooked for every one who was found. Members of the society are also constantly sending in names or inducing their friends to apply for membership.

The membership of the society will no doubt keep increasing as the ever-growing number of graduates of the chemical courses of our universities and technical schools gain experience and rise into positions of responsibility or demonstrate their ability, but I doubt if a very large and sudden increase in membership is possible unless the standards of membership are lowered.

There is no probability that the present membership will consent to the lowering of the professional or ethical requirements for membership. The society will be of the greatest service to the chemical industry and our country by locating the "outs" who meet the standards of the society and making them desire to become "ins." With its present membership the society can hold very successful meetings and meet all its financial obligations. Nevertheless, it is making an earnest effort to reach all who can qualify.

Another possible method of quickly increasing its membership is to offer another grade of membership such as that of associate membership for those who cannot meet all the professional requirements of education and experience, but who conform to the requirements of the code of ethics. This was considered some years ago, but at that time was not considered advisable.

In this letter I am expressing my personal view of the situation, which does not necessarily reflect the view of the American Institute of Chemical Engineers as a body, as there are quite a number of members of the Institute who have expressed views along the lines of your editorial. J. C. OLSEN.

Brooklyn, N. Y.

Acid Fumes on Riverside Drive

To the Editor of Chemical & Metallurgical Engineering

SIR:—Your amusing comment on "Acid Fumes on Riverside Drive" should be taken in good part by residents on or near the Drive, but I wish to add my plea that something effective be done about it. Being a chemist myself and familiar with all sorts of odors, I am compelled to say they are horrible.

It may be all very well to pass facetious remarks about these assorted odors, and good-humoredly "pass the buck" as to who is to blame, as well as to comment that it is too bad about the "pampered rich" in this section—including several less pampered ones. The point would seem to be that chemistry is a science to alleviate the disagreeable in life as far as possible, rather than to add to it.

I confess that, though living a short distance away from the Drive, only the other night, having just retired, I unexpectedly inhaled several lungfuls of these "delightful odors"—or such as one may cultivate himself to so recognize, as your editorial expresses it—and I enjoyed it and felt impelled to draw deep thrilling drafts of it, as much as most people enjoy breathing sewer gases and those from defective flues. I can heartily recommend the experiment to you.

Incidentally, it may also be beneficial to terraces on Riverside Park to be sprayed with a solution of sulphuric acid 1 : 6,000, which on evaporation would become concentrated to some extent and promote a healthy growth to grass-seedlings. H. S. MUDGE.

New York City.

The Elastic Development of Steel

Description of a Research Undertaken to Salvage a Large Number of Unsatisfactory Bayonet Blades, Which Developed the Fact That Unusually High Strengths Could Be Produced in Medium and High Carbon Steels by High Drawing After Quenching

BY SIDNEY CORNELL

MILITARY men in the Ordnance Departments of the United States and the Allied nations devised tests for semi-finished and finished munition parts that were often unnecessarily and unusually severe, many times representing no strain to which the part would be subjected in actual service. Contracts were taken by our manufacturers with full knowledge of these requirements as specified and stated, but often without knowledge as to what it meant to meet such required tests, and financial losses resulted which will be remembered for a long time. It seems that a more thorough knowledge of the useful strength of metal generally, rather than laboratory tests for condition, might be of immense service in industry and of continual value in the manufacture of commercial goods. Viewed in this light the severe requirements of governments for their war tools can be taken as beneficial, for tests were conducted that commercially never would have been attempted, in order to develop properties in metal parts so as to pass such tests.

Maximum Strength Not at Highest Hardness

Ordinarily the full strength of steel is supposed to be developed at the proper hardening temperature without let-down of the temper. It is also generally assumed that each let-down, or draw, after that hardening weakens the steel, in the sense that it is then not as strong as in the hardened condition.

This view is erroneous, as was discovered by the writer in exhaustive tests made on finished, semi-finished and raw stock required for the manufacture of rifle parts. The useful strength of steel is proportional to the elastic limit of that steel, and inasmuch as this property is susceptible to heat treatment, the most resilient steel can be defined as one that fills the greatest usefulness. The greatest elastic limit, and incidentally also the maximum tensile strength, is not obtainable in steel when hardened only, but is found in the hardened steel when drawn at a more or less closely limited drawing temperature.

Flexure Tests for Bayonets

The English Government required a flexure test for bayonet blades—which subsequently was adopted by the United States—that the hardened and drawn bayonet blade be bent axially 2½ in. (63.5 mm.) out of the vertical, and that the blade must restraighten without a kink or long bow in the cutting edge or back visible to the eye. A vertical lever is used to perform this test, and a pressure of approximately 110 lb. (50 kg.) on the end of a bayonet is required to effect the flexure. The vertical foreshortening of the blade to give a maximum bow of 2½ in. amounts to ¾ in. (19.05 mm.). The test was originally conducted by bending both ways, right and left. It was found that a set in one direction would be corrected by a corresponding set in the other direction, yielding a blade at the end that would pass inspection as straight and of satisfactory temper. Finally instructions were given which required the blade to be inspected after each flexure, right or left, yet adhering to the requirements of perfect straightness.

The Remington Arms Union Metallic Cartridge Co. had serious difficulty in 1916 in meeting these and other requirements. English inspectors would reject blades that were too stiff and which required over 120 lb. (55 kg.) on the vertical lever, although stiff bayonets, so called, usually broke in the test. On the other hand, any blade that set, kinked or had a long bow in it after the flexure test was condemned as "soft." Matters progressed so that although the production of machined, hardened and drawn bayonet blades amounted to over 10,000 per day, the acceptance on the part of the English inspectors became less and less until finally no production in bayonets was made. An accumulation of manufactured but not accepted blades finally amounted to over 1,000,000 English bayonets.

Expert heat-treating recommendations from various experts were used during this time, but no satisfactory blades were made. Irregularities in the steel used could not be blamed for the trouble, as satisfactory blades in quantity had been produced from steel of the same composition. Heat treatment obviously was at fault, and the contentions of the English inspectors in calling blades "soft" undoubtedly had a bearing on the methods of attack on the part of the heat treaters in trying to solve the problem. As a matter of fact the term "soft" was not the correct definition of the trouble.

Characteristics of Rejected Bayonets

The heat treatment given the blades was as follows: Harden in a lead bath at 1,500 reg. F. (816 deg. C.), quench in oil, draw temper at 575 deg. F. (302 deg. C.) in a niter bath for 3 min., and quench in water, followed by a straightening operation by hand.

With a million scrap bayonets to reclaim, a thorough investigation was inaugurated. The steel was found to vary considerably in composition; for instance, carbon varied from 0.75 to 0.95 per cent. Other ingredients in the steel were practically constant, chromium varying from 0.33 to 0.37 per cent. As mentioned before, the composition of the steel could not be blamed for the trouble, as bayonets had been made from all lots that were acceptable, and while all heat treatments in reason had been tried, nothing at this stage would yield a bayonet in quantity that would pass English inspection requirements. Among rejected bayonets there were naturally those in all stages of manufacture, as far as the heat treatment was concerned, including those that were hardened only, those that had not been

hardened and those that had been hardened at 1,500 deg. F. and drawn at 575 deg. F. (816 and 302 deg. C.).

Starting with raw stock, various hardening temperatures were tried upon duplicate pieces, determinations being made on the various physical properties of the steel. The working temperature selected was 1,480 deg. F. (804 deg. C.) as the one which produced the best

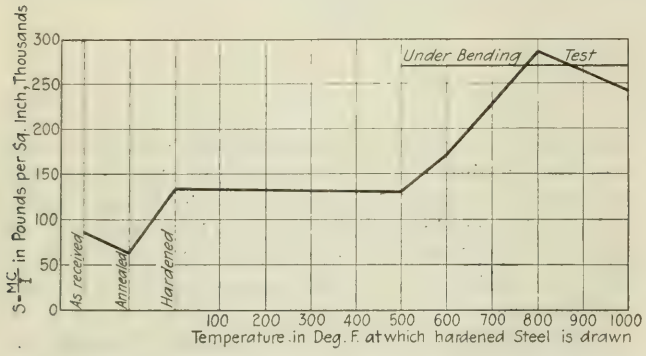


FIG. 1. ELASTIC DEVELOPMENT OF STRENGTH OF BAYONET BLADE STEEL

condition of the hardened steel. This was not radically different from the previous shop practice. To carry the matter further, ultimate tests were made on bars which had been hardened at 1,480 and drawn at various temperatures, and the results plotted. Indications from these tests gave the result that a hardened bar had the greatest elastic limit when drawn at 800 deg. F. (427 deg. C.), very much higher than ordinarily thought reasonable.

A test lot of bayonets that had been rejected as being "soft" and which had been hardened at 1,500 deg. F. (816 deg. C.) and drawn at 575 deg. F. (302 deg. C.) were redrawn at 750 deg. F. (399 deg. C.) and submitted to the English inspectors, who accepted the

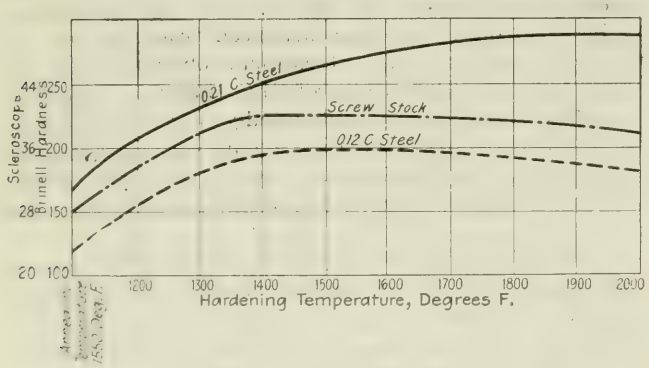


FIG. 2. EFFECT OF HARDENING LOW-CARBON STEELS AT VARIOUS TEMPERATURES

blades. This eventually became known as a "stiffening process." Various precautions in relation to hand straightening were adopted, and on this so-called "stiffening draw" the bayonet department became productive again, the majority of the 1,000,000 rejected bayonets finally being accepted.

A more complete analysis as applied to the strength of the British bayonet blade follows:

When the bayonet is subjected to the ¾-in. flexure test it acts as a column for which the formula is

$$P_c = \frac{IS}{C}$$

P = load, in this case 110 lb.

x = deflection; when foreshortened ¾ in., is 2½ in.

I = moment of inertia about neutral axis.
= 0.0002206 for the average section of the blade.
= 0.0001296 for the weakest section of blade.

C = distance to extreme fiber, average value, 0.114.
= 0.127 at weakest point.

S = extreme fiber stress in lb. per sq.in.

With a blade that met the English requirements of applied load of 110 lb., producing a ¾-in. foreshortening and a 2½-in. deflection in the blade, the maximum value of S is 269,000 lb. (18,912 kg. per sq.cm.).

It was observed that when hardened but not drawn blades were tested they had a tendency to bend slightly before breaking, but that they had no power of recovery. When drawn at 500 deg. F. (260 deg. C.) the recovery after imposing a load was first evident, increasing proportionally up to a maximum of 800 deg. F. (427 deg. C.) and then lessening in intensity.

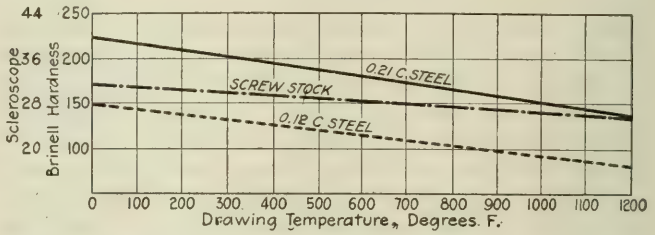


FIG. 3. EFFECT OF ANNEALING HARDEST BARS OF FIG. 2 AT VARIOUS TEMPERATURES

Fig. 1 shows the results of tests on this steel, using duplicate samples for check in all cases, conducted with the object of meeting the theoretical maximum fiber stress under a 110-lb. (50-kg.) load on a bayonet. The maximum elastic limit possible to develop in an extreme fiber by heat treatment is 288,000 lb. per sq.in. (20,200 kg. per sq.cm.), whereas the theoretical elastic limit imposed by the machine is 269,000 lb. per sq.in. Thus there is a leeway of only 18,000 lb., or 6 per cent.

Principal data regarding the bayonet steel follow:

Average Analysis: Carbon, 0.86; manganese, 0.33; silicon, 0.24; phosphorus, 0.017; sulphur, 0.013; chromium, 0.37.

Average Physical Properties: Tensile strength, 97,000; elastic limit, 80,000; elongation, 27 per cent; reduction, 60 per cent.

Ar = 1,260 deg. F.; Ac = 1,335 deg. F.

Standardized Heat Treatment: Pack anneal at 1,550 deg. F. for 22 hr.; lead hardening at 1,500 deg. F. for 4 min.; oil quench; niter draw from 575 deg. F. for 3 min.; first straightening in lead to straw color; second straightening in lead to blue color; stiffening in niter at 750 deg. for 2½ min.; water quench.

Following the important practical results obtained by elastic development in bayonet steel, equally important results were obtained through a similar study of the properties of the various grades of steel used in the manufacture of rifle components. The steels for this use were classified into seven grades, but elastic developments were not made on the first three grades, these being low-carbon material. However, hardening tests were made, and effects of drawing at different ranges were recorded in Brinell hardness with enlightening results.

Fig. 2 shows effect of hardening Grade 1 steel at different temperatures, and Fig. 3 the Brinell hardness after the hardened material had been drawn.

The analysis and physical properties of this grade follow:

C	0.12	Tensile strength	53,800
Mn	0.34	Elastic limit	35,900
Si	0.05	Elongation, per cent	33
S	0.027	Reduction, per cent	71
P	0.013		

Examination of the dotted lines shows the evident fact that quenching from an increasingly higher temperature increases the Brinell hardness of even a 12-point steel up to a flat maximum somewhere between 1,500 to 1,700 deg. F. (800 to 940 deg. C.), above which the hardness is less than after a lower quenching. Taking bars which had received their maximum hardness, annealing at progressively higher temperatures reduces the Brinell hardness in a linear ratio.

Grade 2 steel (screw stock) had the following chemical analysis and physical properties:

C	0.15	Tensile strength	62,200
Mn	0.65	Elastic limit	42,300
Si	0.026	Elongation, per cent	29
S	0.104	Reduction, per cent	61
P	0.081		

Its Brinell hardness after a series of quenchings and systematic drawings is plotted in Figs. 2 and 3 in dot and dash. The characteristics of the curves are exactly similar to those of soft-low-sulphur steel, (Grade 1).

Grade 3 steel of the following analysis was treated in the same manner:

C	0.21	Tensile strength	67,000
Mn	0.45	Elastic limit	48,000
Si	0.11	Elongation, per cent	28
S	0.039	Reduction, per cent	65
P	0.035		

Fig. 2 shows that its hardness, originally higher than the two other steels, increases at a rate which indicates a flat maximum near 2,000 deg. F., where the quenching experiments stopped. However, the effect of drawing such metal after a quenching from

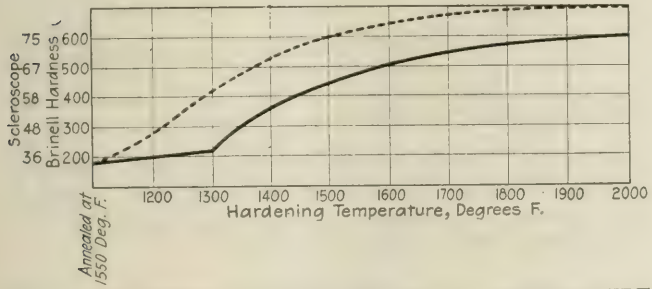

Scleroscope
Brinell Hardness
75 67 58 48 36
600 500 400 300 200
1200 1300 1400 1500 1600 1700 1800 1900 2000
Hardening Temperature, Degrees F.
Annealed at 1550 Deg. F.

FIG. 4. HARDNESS VERSUS HARDENING TEMPERATURE CURVES

Full line represents 35-point carbon steel. Dotted line represents smokeless barrel steel.

1,650 deg. was more pronounced than before, as indicated by a steeper slope of the line representing hardness against drawing temperature.

Determinations of elastic development were made on Grade 4 steel and the grades to follow. The rise in strength under appropriate heat treatment is plainly evident. The properties of Grade 4 in its condition as received is as follows:

C	0.35	Tensile strength	90,300
Mn	1.28	Elastic limit	61,700
Si	0.19	Elongation, per cent	22
S	0.034	Reduction, per cent	64
P	0.054		

Fig. 4 shows in a full line the hardness after annealing at 1,550 deg. C. and after quenching this normalized material from various temperatures. The hardness is shown to rise continually up to the highest temperatures experimented with. Samples after hardening from 1,650 deg. C. were then drawn at various temperatures. Fig. 5 shows the results in a full line. Hardness in this case is a mean line between a higher graph showing scleroscope numbers and a lower graph the Brinell

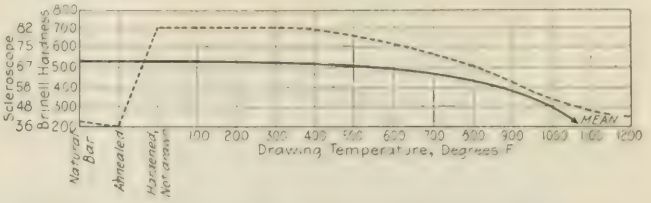


FIG. 5. DECREASE OF HARDNESS UPON DRAWING

Full line represents 35-point carbon steel. Dotted line represents smokeless barrel steel.

numbers. For instance, the scleroscope hardness of the hardened specimen drawn at 600 deg. is 70, while the Brinell number is 480.

A number of transverse specimens were then hardened by oil-quenching from 1,510 deg. F. These were then drawn at various temperatures, tested, and the physical properties under the ordinary slow deflection test determined and plotted as in full lines in Fig. 6. Contrary to the general assumption, reheating even to relatively high temperatures increased the ultimate strength and elastic limit.

Grade 5 steel is the so-called smokeless barrel steel on

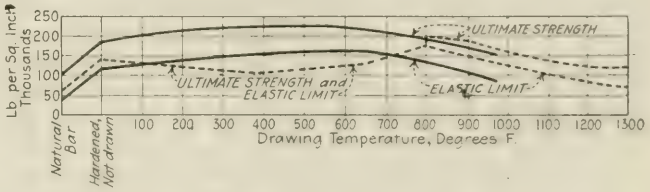

Lb. per Sq. Inch
Thousands
250 200 150 100 50 0
ULTIMATE STRENGTH
ULTIMATE STRENGTH and ELASTIC LIMIT
ELASTIC LIMIT
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
Drawing Temperature, Degrees F.
Natural Bar
Hardened, Not drawn

FIG. 6. ELASTIC DEVELOPMENT FOR STEELS SHOWN IN FIGS. 4 AND 5

Full line represents 35-point carbon steel. Dotted line represents smokeless barrel steel.

which a great deal has been written, and which has caused a great deal of trouble in its fabrication. Its analysis is:

C	0.53	S	0.052
Mn	1.25	P	0.064
Si	0.27		

The physical properties of the steel as received and after routine heat treatment are:

AS RECEIVED

Tensile strength	120,300	Elongation, per cent	16
Elastic limit	73,000	Reduction, per cent	44

HEAT-TREATED BARRELS

Tensile strength	132,400	Elongation, per cent	12
Elastic limit	115,500	Reduction, per cent	48

This steel when hardened from different temperatures gives the results plotted in Fig. 4 in dotted lines, the Brinell and scleroscope being the measures of hardness. A line is traced quite similar to that for Grade 4 steel, but somewhat higher on the hardness scale.

The bar or billet as it came from the rolling mill, after it had been annealed and hardened from the best temperature and then drawn from a series of rising temperatures, gave results shown dotted in Fig. 5. Results again are quite similar to those for steel of the previous grade, shown in full lines. However, when subjected to elastic development, the elastic limit and

ANALYSES AND PHYSICAL PROPERTIES OF STEELS STUDIED

Grade	C	Mn	Si	S Maximum	P Maximum	Tensile Strength	Elastic Limit	Elongation Per Cent	Ac_1 Deg. F.	Ar_1 Deg. F.	B.t.u. at Ar_1
1	0.025–0.15	0.50	—0.05	0.06	0.06	35,000– 50,000		25	1345	1225	4.6
2	0.10 –0.20	Commercially known as Screw Stock			....	Approx. 40,000		..	....	....	....
3	0.20 –0.30	0.50	0.05–0.20	0.05	0.04	40,000– 60,000		20	1340	1248	5.9
4	0.30 –0.40	1.10–1.40	0.15–0.30	0.06	0.06	50,000– 75,000		20	1314	1195	6.4
5	0.50 –0.60	1.00–1.30	0.15–0.25	0.06	0.08	113,800–142,225	Min. 92,450	10	1330	1195	8.9
6	0.60 –0.70	1.10–1.40	0.15–0.30	0.06	0.06	75,000–100,000		15	1355	1215	11.1
7	0.90 –1.00	0.25–0.45	0.10–0.20	0.03	0.025	75,000– 90,000		12	1360	1280	11.7
8*	0.70 –0.80	0.30–0.40	0.10–0.25	0.03	0.03	Approx. 250,000		..	....	....	....

* Commercially known as music wire.

ultimate strength (practically the same value) increase up to a drawing temperature of 800 deg. F., and then decrease. This is shown in Fig. 6 in dotted lines, and its difference from that of Grade 4 is striking.

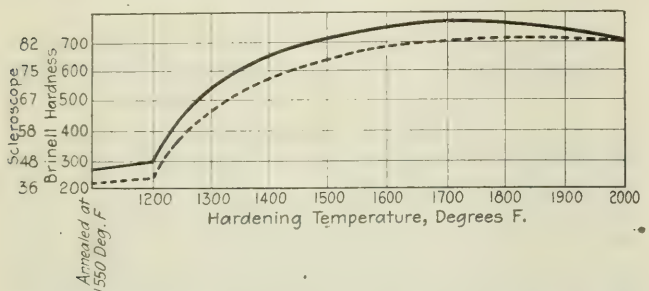


FIG. 7. HARDNESS VERSUS HARDENING TEMPERATURE FOR HIGH-CARBON STEEL

Full line represents Grade 6 (0.60 carbon). Dotted line represents Grade 7 (0.92 carbon).

Grade 6 steel of higher carbon content analyzed:

C	0.60	Tensile strength	109,800
Mn	1.25	Elastic limit	60,300
Si	0.275	Elongation, per cent	17
S	0.037	Reduction, per cent	51
P	0.062		

The effect of hardening is shown in Fig. 7, temperatures up to 2,000 deg. F. being used, and the Brinell and scleroscope the measure.

The effect of drawing at different temperatures is shown in Fig. 8 in full lines. Note that this steel comes nearest to obeying the rules as indicated by various authorities, viz., that the hardened and not

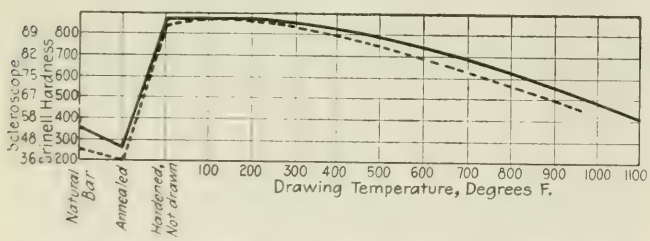


FIG. 8. DECREASE OF HARDNESS UPON DRAWING

Full line represents Grade 6 (0.60 carbon). Dotted line represents Grade 7 (0.92 carbon).

drawn steel is the strongest. However, the measure is Brinell hardness, not elastic limit or tensile strength. That in many cases there is not a constant relation between these properties is shown in Fig. 9. Here the elastic development is clearly shown, this steel reaching a maximum strength when drawn at 800 deg. F.

Grade 7 steel has the following analysis:

C	0.92	Tensile strength	79,700
Mn	0.36	Elastic limit	50,300
Si	0.18	Elongation, per cent	25
S	0.023	Reduction, per cent	55
P	0.022		

The effect of hardening temperature is illustrated in Fig. 7 in dotted lines, the measure again being Brinell and scleroscope.

The effect of drawing temperature is given in Fig. 8, while the elastic development is clearly illustrated in Fig. 9. The ultimate strength increases in a well-defined relationship to the elastic limit; maximum development is attained at approximately 650 deg. F.

It is believed that the foregoing data in relation to the effect of temperatures on the heat treatment of steel will be new to many persons, and it will fill a need in the heat-treatment department of smaller plants where facilities for conducting such an investigation are not at hand. The range of composition of the steels covers from 0.10 to 1 per cent carbon in eight steps, so that properties of any steel as usually met with can be approximated.

The analyses of the steels as given represent averages of not less than twenty-five check analyses conducted on the material as received. The specified chemical re-

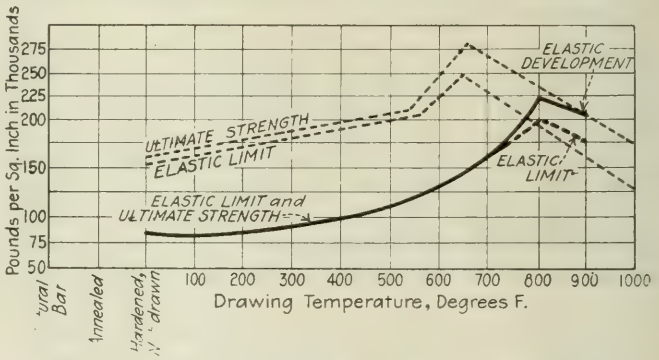


FIG. 9. ELASTIC PROPERTIES OF HARDENED AND DRAWN STEELS

Full line represents Grade 6 (0.60 carbon). Dotted line represents Grade 7 (0.92 carbon).

quirements for the seven grades of steel discussed were as tabulated above, attention also being drawn to the Ac_1 and Ar_1 points as determined, and to the B.t.u. liberation at the Ar_1 point as calculated.

Conclusion

Heat treatment is far from being an exact science. There must be a mass of data in existence in this country the authors of which show a hesitancy toward presenting it to criticism in the technical press. It is suggested that these authors present their data, and that they receive a fair reception on the part of editors. Many articles on heat treatment are remarkable by their similarity, dealing with metallography in particular, and it is thought that the reason for this state of affairs is that all of the men engaged in "heat treating" for a livelihood know that there is no real working treatise on the subject of "heat treatment of steel," and the writers among them are making a start at one that will be complete. Why not publish observed facts, which may bring about discussion and undoubtedly will be a step toward betterment in this art which never can be absolutely scientific?

New York City.

Electric Furnace Smelting of Montana Manganese Ores*

Balance Sheet of 10-Day Electric Furnace Test—Discussion of Slag and Furnace Losses, Together With a Method of Calculating Charges—Description of Electric Furnace Plant at Great Falls

By E. S. BARDWELL
Metallurgist, Anaconda Copper Mining Co.

DURING the year 1918 there was produced in the United States 304,366 long tons of manganese ore containing over 35 per cent manganese[1]. Of this amount, Montana alone produced 199,932 tons, or over 65 per cent of the total tonnage. Practically all of this ore came from the Philipsburg and Butte districts; 127,415 tons from the Philipsburg district, 72,381 tons from the Butte district, with only 136 tons reported as coming from other parts of the state. The armistice caused an immediate curtailment of manganese mining in Montana due to the ability of the Eastern steel plants to secure supplies of manganese ore again from foreign sources.

Prior to 1914 less than 2 per cent of the total high-grade manganese ore used in the United States was mined in this country. The manganese production of the State of Montana in 1918 was greater than the total imports to this country for the year 1911 and would represent a substantial percentage of this country's normal requirements.

In view of these facts, the importance of this potential source of manganese cannot fail to be recognized and a discussion of the problems of smelting these ores in the electric furnace should be of interest.

Character of Ores

The Montana ores are low in phosphorus and iron and admirably suited for the production of 80 per cent ferromanganese.

In the Butte district the Emma mine is the chief producer. The output of this mine during the war reached a maximum of 10,000 tons of rhodocrosite ore a month, the greater part of which was shipped to Eastern consumers.

A typical analysis of this ore would be as follows:

	Per Cent		Per Cent
Moisture	2.61	BaO	0.00
MnO	46.87	CO_2	33.56
FeO	2.68		
SiO_2	6.19		95.70
Al_2O_3	1.18	Undetermined	4.30
CaO	0.00		
MgO	2.61		100.00

The Philipsburg ores differ from those of the Butte district in that they are higher in silica and contain manganese principally in the form of the psilomelane, a hydrated oxide of manganese of more or less indefinite composition.

An average analysis of this ore would be about:

	Per Cent		Per Cent
Moisture	9.73	BaO	
MnO_2	50.10	Loss on ignition	12.80
MnO	3.83		
Fe_2O_3	2.90		99.44
SiO_2	18.07	Undetermined	.56
Al_2O_3	2.01		
CaO			100.00
MgO			

By washing it is possible to reduce the silica content of the Philipsburg ores to at least one-half the percentage stated above, with a corresponding increase in manganese content.[2]

Electric Furnace Plant at Great Falls, Mont.

During 1918 the Anaconda Copper Mining Co. erected at Great Falls, Mont., an electric furnace plant capable of producing ninety tons daily of 80 per cent alloy. The first of five furnaces was started in September. Three furnaces were ready for operation at the time the armistice was signed, shortly after which time operation ceased due to lack of market for the product.

The furnaces consist of an open-top, shallow brick shaft 28 x 14 x 9 ft. (8.5 x 4.3 x 2.7 m.) in outside dimensions. Outer walls are of red building brick with an inner firebrick lining. This shaft has a tamped lining composed of dead-burned magnesite with pitch as a binder. The tamped lining is 3 ft. (91 cm.) in thickness at the bottom of the crucible and is brought up the sides to a point about 18 in. (46 cm.) above the tap-hole level. Cooling pipes are provided in the bottom through which air for cooling the bottom is circulated. Inner dimensions of the crucible at the middle section are 22 x 9 ft. x 6 ft. deep (6.7 x 2.7 x 1.8 m.). The furnaces are operated on 60-cycle, three-phase alternating current. Two 24-in. (61-cm.) round amorphous carbon electrodes are used in a common holder on each phase. Electrodes are spaced 3 ft. (0.91 m.) between centers in the holders and the pairs about 5 ft. (1.52 m.) on centers.

The holders originally provided were discarded on account of mechanical difficulties and a simple holder devised made in two entirely independent halves held together by pins and wedges. A long "fish-tail" cast integral with the holder makes it possible to avoid bringing cables out over the furnace where they will be subjected to the hot gases. Water cooling is brought about by a coil of pipe properly formed and cast in, and water connections for each half are independent. The holder is supported by yokes which serve to keep the chains used for raising and lowering the holders up out of the heat. Winches for raising and lowering the electrodes are placed upon the bridge supporting the holder and electrodes, which bridge is insulated from the furnace superstructure by means of vitrified brick interposed between. No trouble was experienced from failures of insulation during the time the furnaces were operated. The holders themselves were cast in sand molds from phosphor-copper and require practically no machine work. We found the contact surface ample and the holder sufficiently flexible

*Paper presented at the thirty-seventh convention of the American Electrochemical Society, Boston, April 9, 1920.

[1] *Mineral Industry*, vol. 27 (1918), p. 460.

[2] A brief account of concentrating methods employed is given in CHEM. & MET. ENG., vol. 18, p. 625, June 15, 1918.

to take care of the inequalities in size often existing between the two electrodes in the holder. A loosely fitting sheet steel sleeve was provided to slip down over the electrode. This rested on top of the holder and prevented the electrode being eaten away above the holder by the hot gases.

When slipping electrodes the wedges were easily loosened, the holder raised and again clamped. The time required for slipping electrodes was not over 10 min. No attempt was made to protect the electrode exposed between the holder and the charge except to keep the holder as close down to the top of the charge as was feasible.

Substation

The substation, from which electrical energy is supplied to the furnaces, is located immediately back of the furnaces. It received power at 110,000 volts from nearby hydro-electric plants of the Montana Power Co. Two 12,000 k.v.a. General Electric transformers serve to reduce the voltage from 110,000 to 6,600 volts, at which voltage it is delivered to the furnace transformers. Each furnace is equipped with one General Electric polyphase transformer rated at 5,630 k.v.a., provided with taps on the high tension side for 85, 100, 115 and 130 volts. The furnaces were operated with a no-load voltage of 115 volts. The average input under these conditions was 3600 kw. The power factor was about 80 per cent.

The operating panels are arranged in a gallery overlooking the furnaces. Provision is made for either hand or automatic control. The automatic regulators are of the General Electric type originally designed to operate on current. We found it advantageous, however, to keep the voltage on the separate phases balanced rather than the current and the necessary alterations were made in the apparatus to enable us to regulate on the voltage between phases and ground. With this change the automatic control proved highly satisfactory, holding the load constant under all conditions met with in operation with very little attention on the part of the operator.

Charge Mixing

The weighing and mixing division is so arranged that four operators can, in one shift, weigh and mix sufficient charge to keep five furnaces in operation for 24 hr. This would hardly be feasible were the plant treating a large variety of ores, but given a constant supply of ore of a uniform grade, little or no difficulty has been experienced. Mixed charge is delivered by belt conveyors to the mixed charge bin, whence it is taken in boats by traveling crane and dumped into charge hoppers at the furnace.

The charge consists of ore, limerock, coal, coke and iron ore. The only manganese ore treated at Great Falls is the Butte rhodocrosite ore from the Emma mine. The charge treated was as follows:

	Lb.		Lb.
Ore	560	Coke	50
Limerock	99	Iron ore	12
Coal	160		

When the furnaces were first started coal only was used as a reducing agent. We soon found, however, that owing to the fact that the rhodocrosite decrepitates when heated this gave us too compact a charge. Primarily to do away with this difficulty, we substituted for a part of the coal an equivalent amount of blast-furnace coke based, of course, on the relative fixed carbon content of the two materials. With this change the furnace operated very smoothly with only occasional boils. Coke alone was tried, but with this we could not keep the electrodes down in the charge. The proportions of coal and coke indicated above were finally determined upon as being the best under our conditions.

The furnaces are tapped at intervals of about 1½ hr. The slag and metal run into ladles, the slag is skimmed into a slag sluice and the metal cast by machine.

The plant was operated for such a short time and under such adverse conditions that it is impossible to give accurate metallurgical results. The results were on the whole, however, satisfactory. The loss by volatilization was not over 15 per cent and the recovery of manganese in metal between 75 and 80 per cent.

Electric Furnace Test on Montana Ores

Materials

The ore used in the test about to be described consisted of a half and half mixture of ores from the Philipsburg and Butte districts. This material was very carefully bedded, sampled and analyzed. The analysis of the mixture gave results as follows:

	Per Cent		Per Cent
Moisture	5.03	BaO	0.03
MnO_2	23.92	MgO	1.15
MnO	26.37	CO_2	16.67
FeO	1.14	Comb. H_2O	6.43
Fe_2O_3	1.40	Undetermined	2.43
SiO_2	13.48		
Al_2O_3	1.95		100.00
CaO	.....		

Coal was used as a reducing agent. This coal was of the following analysis:

	Per Cent		Per Cent
H_2O	7.82	Al_2O_3	0.73
Fixed carbon	54.43	MgO	0.34
Volatile hydrocarbons	31.73	Undetermined	0.67
FeS_2	1.84		
SiO_2	2.44	Total	100.00

As flux a very pure marble was employed. This contained 55.0 per cent CaO and 43.2 per cent CO_2.

It was necessary to add iron in order to make 70 per cent ferromanganese. The iron was added in the form of turnings which were not analyzed but which for the purpose of the test we assumed to contain 100 per cent iron.

The Furnace

The furnace upon which this test was conducted was of the rectangular open-top type. It consisted of a steel shell 18 ft. x 9 ft. x 8 ft. 8 in. (5.5 x 2.7 x 2 m.) outside dimensions with carbon lining approximately 30 in. (76 cm.) thick at the bottom of the crucible and 18 in. (46 cm.) on the sidewalls. The transformer equipment consisted of 3 single-phase Pittsburgh transformers each rated at 667 k.v.a. and connected Δ/Δ. These transformers were provided with taps for 65, 75 and 85 volts and during the test were operated at no-load voltage of 75 volts. Three 24-in. round amorphous-carbon electrodes were used in water-cooled top holders. Motor-operated winches served to move electrodes up and down, but the furnace was not provided with automatic regulators. The furnace was tapped at intervals of about 1¼ hr. The slag and metal was allowed to flow into sand pits, where it solidified, and was then removed to the yard, where the slag was separated and metal weighed and loaded into cars.

The furnace charge was varied slightly from time to time during the test but was substantially as follows:

	Lb.		Lb.
Ore	500	Limerock	90
Coal	150	Turnings	30

This charge gave us metal containing 70.9 per cent manganese. The coal is, however, too high and the limerock too low for best results. A method for calculating the charge will be given later on.

Balance Sheet

The furnace was operated on the above charge for a period of 274 hr., during which time a total of 501,000 lb. of the ore mixture was smelted, yielding 186,419 lb. of metal containing 70.9 per cent manganese. The slag from the furnace was kept separate from the slag resulting from other furnace operations and was weighed, sampled and analyzed. The complete balance sheet follows:

	Charge	Products		
Ore, 501,000 lb.		Metal	Slag	Gases
Mn	178,096	132,171	4,482	41,443
Fe	8,831	8,831	.....	.....
Si	31,501	15,286	16,215	.....
Al_2O_3	9,790	.....	8,342	.....
BaO	150	.....	925	.....
MgO	5,753	.....	4,313	.....
CO_2	83,517	.....	.....	83,517
H_2O	57,415	.....	.....	57,415
Comb. O_2	115,673	.....	20,588	95,085
Flux, 91,100 lb.				
CaO	50,105	.....	47,162	.....
CO_2	39,355	.....	.....	39,355
Coal, 147,890 lb.				
Fe	1,270	1,270	.....	.....
Si	1,688	.....	659	1,029
Al_2O_3	1,088	.....	.....	.....
MgO	257	.....	.....	.....
C	80,495	9,135	.....	71,360
Volatiles	46,926	.....	.....	46,926
H_2O	11,567	.....	.....	11,567
Iron, 29,796 lb.				
Fe	29,796	19,540	.....	10,256
Totals, 769,786		186,233	102,686	457,953

Metal and slag represent actual analyses.
Only 2.97% unaccounted for by balance sheet.

Analyses of metal and slag were as follows:

Slag	Per Cent	Metal	Per Cent
Mn	4.26	Mn	70.9
SiO_2	34.37	Fe	15.9
Al_2O_3	7.93	Si	8.2
CaO	44.83	C	4.9
MgO	4.10		
BaO	0.88		99.9
	96.37		

Ratio ore to metal	2.68
Per cent total manganese in metal	74.21
Per cent total manganese in slag	2.51
Per cent total manganese in gases	23.28
Per cent of charge accounted for in metal	24.22
Per cent of charge accounted for in slag	13.67
Per cent of charge accounted for in gases	62.11
Pounds slag per ton of metal	1,129
Pounds gas per ton of metal	5,130
Pounds electrode per ton of metal	150
Kilowatt-hours per ton of metal	4,879

Calculation of Theoretical Power Requirement

From our balance sheet it is possible to compute a heat balance of the furnace. In so doing we shall assume:

1. That the slag and metal contain at tapping 600 and 400 calories of heat respectively.

2. That the gases escape from the furnace at temperature of 300 deg. C.

The heat available is principally the heat of oxidation of the carbon plus that furnished by the electrical energy used. The charge gives up to the carbon, as shown by the balance sheet, 95,085 lb. of oxygen. The 71,360 lb. of carbon burned would require 71,360 × (16 ÷ 12) = 95,147 lb. of oxygen to burn to CO or practically all the carbon is burned to CO. Carbon monoxide is capable of reducing manganese dioxide to the monoxide, and it appears probable that a certain amount of reduction takes place in this manner. The balance of the carbon monoxide escapes as such and burns at the top of the charge.

The heat of formation of the slag will be taken as 150 calories per lb. of contained SiO_2 and Al_2O_3. The heat of combustion of carbon with manganese is about 825 calories per lb. of carbon combined, while the heat of formation of manganese silicide is 1,693 calories per lb. of silicon combined.

HEAT AVAILABLE FOR ENTIRE TEST

	Pound Calories
Supplied by electric current	*X*
Oxidation of C to CO = 71,360 × 2,430	173,404,800
Formation of silicate slag = 44,500 × 150	6,675,000
Formation of Mn_3C = 9,135 × 825	7,536,375
Formation of Mn_7Si_2 = 15,286 × 1,693	25,879,198
Total	*X* + 213,495,373

HEAT DISTRIBUTION

	Pound Calories
Reduction of Mn from MnO_2 76,656 × 2,278	174,622,368
Reduction of Mn from MnO 96,969 × 1,653	160,289,757
Reduction of Fe from FeO 4,409 × 1,173	5,171,757
Reduction of Fe from Fe_2O_3 5,692 × 1,746	9,938,232
Reduction of Si from SiO_2 15,286 × 7,000	107,002,000
Calcination of $CaCO_3$ and $MnCO_3$ 122,872 × 1,026	126,066,672
Distillation of volatile from coal 46,926 × 800 (assumed)	37,540,800
Expulsion of moisture 68,982 × 600	41,389,200
Sensible heat in gases*	36,003,000
Sensible heat in slag 105,201 × 600	63,120,600
Sensible heat in metal 186,419 × 400	74,567,600
Total heat energy required	835,711,986

Equating heat input and outgo

$$213{,}495{,}373 + X = 835{,}711{,}986 \text{ lb. cal.}$$
$$X = 622{,}216{,}613 \text{ lb. cal.}$$

But 1 Kw.-hr. = 1,897 lb. cal.

hence required electrical energy, no allowance being made for radiation, is 328,000 kw.-hr.

During the test there was produced 93.2 tons of ferromanganese. The theoretically required power is therefore

$$\frac{328{,}000}{93.2} = 3{,}520 \text{ kw.-hr,}$$

or, say, 3,500 kw.-hr. per short ton.

PERCENTAGE HEAT DISTRIBUTION

	Per Cent Total Heat Required
Reduction of manganese	40.1
Reduction of iron	1.8
Reduction of silicon	12.8
Calcination of $CaCO_3$ and $MnCO_3$	15.1
Distillation of volatile from coal	4.5
Expulsion of moisture	4.9
Sensible heat in gases	4.3
Sensible heat in slag	7.6
Sensible heat in metal	8.9
	100.0

From the above it would at first appear that considerable saving might be effected by calcining the ore and limerock previous to charging it into the furnace. This assumption, however, does not seem to be borne out in practice. The greater part of the work of calcination is brought about in the upper part of the charge column utilizing heat which would otherwise be lost. Some economy of operation should, however, result and the practicability of the operation should be carefully investigated.

*Sensible heat in gases at 300 deg. C

	Kilogram-Calories
CO, 166,445 lb. = 60,000 cu.m. × 0.311	18,660
CO_2, 122,872 lb. = 28,148 cu.m. × 0.436	12,273
H_2O, 68,982 lb. = 38,630 cu.m. × 0.34	13,134
Vol. from coal, 46,926 lb. = 21,285 cu.m. × 0.311	6,620
Vol. manganese, etc., 42,472 lb. = 4,816 cu.m. × 0.8	3,863
	54,550
54,550 × 300	16,365,000

From the above computation we are enabled to compute the heat efficiency of the furnace tested to have been 71.7 per cent. This figure is very good for a furnace of the size upon which the test was conducted.

The heat loss is due of course in part to radiation of heat from the furnace itself and in part to I^2R losses. A test carried out on a similar furnace showed 40 per cent of the heat loss to be due to radiation and 60 per cent to the I^2R losses. Of this 60 per cent the following distribution may be made:

	Per Cent		Per Cent
Transformers	17.5	Contacts	37.5
Conductors	30.0		
Electrodes	15.0	Total	100.0

The above analysis gives us, I think, a very comprehensive idea of the heat requirements of an electric furnace producing ferromanganese. Due to lack of accurate data certain assumptions had to be made in computing the theoretically required power, but the result obtained is sufficiently accurate for all practical purposes.

Slags

In studying electric furnaces producing ferromanganese my attention was called to the great variety of slags produced. It seemed worth while to investigate the question of slags with the idea in mind of seeing whether or not means could be found to calculate a charge which would give a slag of low manganese content. From a considerable number of samples, eight typical slags were selected and carefully analyzed.

No. 1. A hard gray slag containing ferromanganese inclusions.

No. 2. A medium green hard slag with few, if any, metal inclusions.

No. 3. A dark green hard slag with little in the way of inclusions.

No. 4. A high-lime air-slacking slag.

No. 5. A high-lime air-slacking slag.

No. 6. A light-gray glassy slag.

No. 7. A light-green hard slag.

No. 8. A light pea-green hard slag.

ANALYSES OF SLAG SAMPLES

	1	2	3	4	5	6	7	8
SiO_2	28.2	31.5	26.6	34.4	22.4	30.9	31.9	32.9
FeO	1.2	0.7	1.0	0.1	0.1	1.1	1.3	0.8
Al_2O_3	17.3	8.0	9.6	7.7	6.8	10.0	10.1	8.7
CaO	41.4	35.7	31.1	42.2	46.8	37.8	35.3	36.0
MgO	7.6	1.8	1.1	1.8	4.0	10.2	10.4	2.1
BaO	0.4	1.3	4.8	1.1	0.2	0.2	0.3	1.2
Mn	2.1	14.5	19.9	8.1	5.3	4.7	5.8	12.2
Total	98.2	93.5	94.1	95.4	85.6	94.9	95.1	93.9

It will be noted that in this collection of slags we have two types only as regards their physical condition, *i. e.*, hard slags and air-slacking slags. Air-slacking is due to a composition such that calcium orthosilicate, $2CaO.SiO_2$ separated as one of the phases. The orthosilicate crystallizes in three distinct forms, the alpha-form, stable above 1,410 deg. C. to the melting point, the beta-form, stable between 675 and 1,410 deg., and the gamma-form, stable below 675 deg. C. The transformation of the beta-orthosilicate into the gamma-form is accompanied by a 10 per cent volume increase. It is this volume increase, therefore, that accounts for what I have termed the air-slacking of slags 4 and 5: The presence of much magnesia in the slag tends to prevent this latter transformation.

Manganese occurs in the slags in three ways: first, as ferromanganese inclusions; second, as manganese silicate, and third, as manganates or manganites of calcium or in some cases as oxides of manganese in solution in the slag. Any slag that is insufficiently fluid will contain more or less in the way of ferromanganese inclusions. Lack of sufficient carbon to reduce the manganese will, of course, promote the formation of manganates and manganites. Excess silica seems to tend to form silicates even when sufficient carbon is at hand to reduce all the oxides of manganese to metal.

A green slag is evidence of lack of sufficient carbon to carry out the reduction of the manganese oxide. The depth of color is an indication of the amount of manganese present. When there is an excess of silica present, slags are sometimes pink due to the presence of manganese silicate.

An excess of reducing agent tends to the formation of calcium carbide and graphite accretions in the furnace. This may in some cases be carried so far as to leave an excess of silica and promote the formation of manganese silicates in the slag; in any event, there is a waste of power and the accretions interfere with operations, rendering it necessary to shut down and dig out the furnace at frequent intervals. The best slags seem to have a composition of about 30 per cent silica, 15 per cent alumina and 50 per cent lime plus magnesia, or better, should have an oxygen ratio, alumina being counted as base, of between 1.25 and 1.50. A slag of this composition is easily fusible, separates well from the metal and is economical to make.

Volatilization Losses

Under volatilization in the balance sheet has been included losses by dusting. In the electric furnace losses by dusting should not be large. Some loss by dusting is caused by occasional blows and boils occurring during periods of irregular operation. That the greater part of the manganese lost except for that contained in the slag is volatilized in some manner is very evident. In just what form or forms the manganese is volatilized I do not know nor have I ever seen a satisfactory explanation of the phenomenon. It is usually considered that the manganese is volatilized, as the metal escaping from the furnace burns at the surface of the charge to the oxide. The presence of brownish fumes in the gases escaping from the furnace would readily lead one to this conclusion. On the other hand, I have observed furnaces running with a comparatively cool top when there was no evidence of these brownish fumes but which were still volatilizing a considerable amount of manganese.

In the case of furnace volatilizing considerable amounts of manganese, I have observed that considerable amounts of iron also vanish, in fact, based on the relative proportions of iron and manganese in the charge, more iron than manganese is volatilized.

An attempt to reduce the manganese content of the slag by using more carbon is accompanied in most instances by an increased volatilization loss.

In order that we may learn how to minimize our volatilization losses, it is important that we should know in what manner manganese is volatilized.

Excessive volatilization will occur inevitably in a furnace improperly designed as regards heat distribution. A furnace must be properly proportioned with reference to the power input in order to operate efficiently. Given such a furnace, however, we often find that the volatilization losses vary widely from time to time. The theory has been advanced that manganese and iron are volatil-

ized as carbonyls which in the hot top furnace burn to the oxides of the respective metals and carbon dioxide, and in the case of furnaces operating with a cooler top may pass off unnoticed as gases. This fits in very nicely with my observations with reference to addition of carbon, and its effect on increased volatilization. The formation of carbonyls if such exist may be due to the formation of carbides of iron and manganese which in turn react with the metallic oxides present, reducing them and at the same time setting free carbonyls.

As in many cases the slags produced by the electric manganese furnaces have a distinct fluxing value, it might be well to throw more manganese into slag by cutting the carbon on the charge provided the combined loss in manganese is not increased thereby.

Calculation of Charge

The charge will be calculated on the following basis:

1. We shall assume that the metal is to contain 70 per cent manganese, 5 per cent carbon, 5 per cent silicon and 20 per cent iron.

2. The charge will be calculated on the basis of 100 lb. of ore.

3. In proportioning the amount of reducing agent required, we shall assume that the fixed carbon only is available for bringing about the reduction of the several metals. As has been pointed out, this is not a correct assumption, as some reduction is very evidently effected by the carbon monoxide gases and possibly the volatile hydrocarbons. It gives us, however, a starting point and in the absence of complete data as to the reducing power of the fuel used, enables us to calculate the charge.

4. The magnesia will be calculated to $2MgO.SiO_2$, alumina to $Al_2O_3.3CaO.2SiO_2$, and the balance of the silica to $2CaO.SiO_2$.

5. Sufficient iron will be added to give metal containing 20 per cent iron, assuming 80 per cent of the manganese to enter the metal.

CARBON REQUIREMENT

C to reduce MnO_2 to Mn	$\frac{23.92 \times 24}{87} =$	6.60
C to reduce MnO to Mn	$\frac{26.37 \times 12}{71} =$	4.46
C to reduce FeO to Fe	$\frac{1.14 \times 12}{72} =$	0.19
C to reduce Fe_2O_3 to Fe	$\frac{1.40 \times 36}{160} =$	0.31
C to reduce SiO_2 to Si	$\frac{4.34 \times 24}{60} =$	1.73
C to supply metal	=	2.02
		15.31

We shall, therefore, require $\frac{15.31}{0.5443} = 28.1$ units of coal per 100 units of ore.

In the ore and coal we shall have to flux after allowing for the 4.34 units of silica which is reduced and which enters the metal:

9.82 units	SiO_2	1.24 units	MgO
2.15 units	Al_2O_3	0.03 units	BaO

Now, figuring MgO to $2MgO.SiO_2$, we get

$$\frac{1.24 \times 140}{80} = 2.17 \text{ units } 2MgO.SiO_2$$

Figuring Al_2O_3 to $Al_2O_3.3CaO.2SiO_2$

$$\frac{2.15 \times 388}{102} = 8.18 \text{ units } Al_2O_3.3CaO.2SiO_2$$

Then, 6.31 units of SiO_2 remain to be fluxed.

Calculating to $2CaO.SiO_2$, we have

$$\frac{6.31 \times 172}{60} = 18.1 \text{ units } 2CaO.SiO_2$$

Total lime required = 15.24 units, or marble on charge would be

$$\frac{15.24}{0.55} = 27.7 \text{ lb. per 100 lb. ore}$$

We have in slag

	Theoretical Steel—Per Cent
9.82 units SiO_2	34.4
2.15 units Al_2O_3	7.6
1.24 units MgO	4.4
0.03 units BaO	0.1
15.24 units CaO	53.5
28.48	100.0

Assuming 80 per cent recovery of manganese the iron required would be 6 lb. per 100 lb. ore.

Our charge, based on 500 lb. of ore, would then stand

	Lb.		Lb.
Ore	500	Limerock	140
Coal	140	Turnings	30

If no special attempt is made to keep the silicon down to 5 per cent, the lime can be cut to a considerable extent, depending upon the amount of silicon permissible in the metal. If low silicon metal is desired, the coal may be cut, leaving the limerock as above. The coal may in any event be reduced somewhat, as has been pointed out previously, but this should be done a little at a time and the furnace watched carefully. At least 24 hr. should be allowed to elapse between such changes. The calculation of the charge can at best only serve as a guide. Much depends upon the characteristics of the furnace that is being operated. The operator must watch his furnace and vary the charge to suit operating conditions.

New British Plans for Trade Information

The Overseas Trade Department is now preparing for publication manuals or handbooks of commercial information relating to various countries. These publications, which are intended to be books of reference for British traders, give the stable features of the country described—resources, products, commercial treaties and law, transport, and trading methods. The manuals for France and Argentina are nearly ready, and some material has been accumulated for those on Brazil, Italy, and Greece. They are prepared by the economic and editorial section.

The department is also preparing to issue periodic reports sent in by commercial diplomatic officers on instructions issued last year. These are to take the place of the old consular reports, which were issued periodically from 1858 until the war, but will be a systematic survey of each of the principal countries as a whole. When the organization of the economic and editorial section is complete, it will also be possible to prepare special economic memoranda on topics of outstanding interest which are not otherwise provided, either because of the technical research involved or because of their broad international character. It is hoped that one of the principal categories of such studies will be international commercial finance. At present the section is dealing with reports upon the economic and trade situation in countries severely affected by the war. Sir Hubert Llewellyn Smith called for special reviews of this character, and these are now being brought together so as to form a general survey of European trade conditions at the close of the year 1919.

The German Nitrogen Syndicate*

A Discussion of Germany's Capacity for Nitrogen Fixation Before and After the War, and Her Present Independence—Frank Recognition of the Effect of Foreign Competition—Description of Government Control of Production, Distribution and Prices

By PROF. N. CARO

ONE of the most far-reaching achievements of the German War Ministry was the development of the nitrogen industry. While Germany before the war was obliged to import something like 100,000 tons of nitrogen a year in order to meet the requirements of her agriculture and industries amounting to 220,000 tons per year, she is now able to meet her greatly increased demands solely from domestic manufacture. Before the war, there was produced in Germany each year:

	Tons Nitrogen
1. In coke ovens, gas plants, and other byproduct installations, about 550,000 tons of ammonium sulphate, equal to	110,000
2. In lime-nitrogen plants about 50,000 tons of lime-nitrogen, equal to	10,000
Total	120,000

The nitrogen plants built during the war for the production of lime-nitrogen and ammonia when completed will be in a position to produce about 380,000 tons of nitrogen per year, so that the total yearly production will amount to over 500,000 tons of nitrogen. This output of nitrogen will be divided thus:

	Tons Nitrogen
Ammonia, by the Haber process	300,000
Ammonia from coke ovens, gas plants, and other byproduct installations	110,000
Lime-nitrogen	100,000
Total	510,000

The government took an active part in the increase in nitrogen production secured during the war. It owns the Imperial Lime Nitrogen Plants in Piesteritz and Chorzow, which have a yearly output of about 60,000 tons of nitrogen. It took part in the extension of the plants of the Badische Anilin und Soda Fabrik at Oppau, the lime-nitrogen plants in Waldshut (the Lonza Works), at Knapsack (Aktiengesellschaft für Stickstoffdünger) and Margarethenberg (the Bayerischen Stickstoff Works).

The views of the parties concerned as to whether German agriculture will be in a position to absorb these great quantities of nitrogen are at variance. It is generally agreed that it will be possible to apply to German farms and fields triple the amount of nitrogen which they now receive and so to increase their yields that the importation of foreign food and foodstuffs will be unnecessary or at least limited to particularly high-value products, for it is generally assumed that in most cases this increased nitrogen application still lies below the limits of maximum action. Therefore with a complete fertilization one should count on an increase in yields of about 20 to 25 kg. vegetables (15 kg. straw), or 125 kg. potatoes, or about 150 kg. sugar beets, or 250 kg. fodder beets, per kilogram of applied nitrogen. It is not agreed as to whether the natural limitations of agriculture, the physical peculiarities of the soil, the water supply, the equipment, the efficiency of agricultural labor, will allow the increased production which would be expected from this increased application of nitrogen, for all of these factors either have undergone great depreciation during the war or have been wholly destroyed. In this difference of opinion the decision is of importance as to the beneficial action of nitrogen on the soil when there is a simultaneous impoverishment of phosphoric acid and as to whether there really is any phosphate impoverishment or not.

Pre-War Fertilizer Situation and Present Outlook

Before the war 200,000 tons of nitrogen and 600,000 tons of phosphoric acid were used each year, that is, one part of nitrogen was used to every three parts of phosphoric acid. It is frequently assumed that this relation must be adhered to in order to assure a continuous full fertility of the soil, because the phosphoric acid is utilized only to the extent of about 30 per cent. On the other hand, it is assumed by many of the authorities on this subject and by practical farmers that this ratio can be altered to about one part of nitrogen for every part of phosphoric acid without diminishing the activity of the nitrogen, since great quantities of phosphoric acid have been previously added to the soil and have not yet been used up. The resulting accumulation of phosphoric acid, in conjunction with the increased application of nitrogen and with other improvement of the soil, depending on circumstances, by means of gravel, lime or clay, should make possible a considerably increased utilization of the phosphoric acid. It should be remembered in this connection that plant material on the average contains only one part of phosphoric acid to two parts of nitrogen, so that if phosphoric acid were applied even in this ratio no impoverishment of the soil in the strict sense would occur.

In this conflict of opinion one thing can be taken as certain—namely, that under given conditions in the next few years very much greater quantities of nitrogen than before the war can be supplied with full effect, even if the possible maximum does not hold.

The situation as regards prices will be of the very greatest importance for the utilization of this increased amount of nitrogen; in the first place, because the cost of fertilizers in general, as a result of the inevitable increase in cost of phosphoric acid, will be greater than before the war; and also in view of foreign competition.

Importance of Foreign Competition

In fixing nitrogen by the Haber process coal, and by the Frank-Caro process coke, is required. The price of coke has advanced since the upheaval of the war by about 60, that of coal by about 50, and that of brown coal

*Translation from *Chemische Industrie*, Nos. 13 and 14, July, 1919, by Arthur B. Lamb.

by 9½ marks per ton. Wages, in spite of their already extreme high level, are still tending to rise.

How far the German nitrogen industry will be able to cope with foreign competition, in view of these high wages and high costs of combustibles, cannot at present be predicted. Since the cost of coal, which in the future is sure to be one of the most important items of expense, can hardly decrease, the lime-nitrogen industry, on account of its unusually small consumption of coke, will be in a very favorable situation. This will be particularly true when the construction market sinks to some halfway normal level so that the capital cost of water-power developments will be more reasonable. On the other hand, if this rise in the cost of coal continues, those lime-nitrogen plants which depend on steam power will surely be forced to transfer their carbide furnaces to places where water power is available.

Saltpeter, in addition to lime-nitrogen, is of considerable significance as regards foreign competition in fixed nitrogen. How far Chilean saltpeter can meet a reduction in price, and therefore come again into use here, depends largely on the price of coal and the level of wages in Germany. One should not overlook the fact that extensive improvements and economies in operation are possible in the Chilean saltpeter industry and that the development of the fixed-nitrogen industries in other lands will surely force the Chilean producers to undertake these improvements. Certainly the high freight rates and the small exchange value of the German mark outside of Germany will prevent the importation of saltpeter into Germany; but how long these circumstances will persist it is difficult to predict with certainty. Anyway, we must expect that if any further rise in the cost of coal or the level of wages in Germany occurs, competition with Chilean saltpeter is not out of the question.

Far more dangerous, however, at the present time, appears to be the possibility of competition with artificially fixed nitrogenous fertilizers produced in foreign countries.

American Competition

The fixed-nitrogen industry has undergone an extensive development in many foreign countries, chiefly through the construction of new lime-nitrogen plants. Almost without exception these plants are situated near sources of very cheap water power or of natural gas, and are therefore but slightly affected by the increase in cost of combustibles.

The largest of these plants is located in the United States, in Alabama. Its situation is most excellent. It is connected with the ocean by means of the Coosa River,[1] which has been made navigable. It is situated at a source of almost constant water power amounting to 400,000 horsepower, and is right in the midst of a locality where all the raw materials of the lime-nitrogen industry are present in the highest purity and at the very lowest prices. From the extensive deposits of bituminous coal the very best coke can be obtained, which cost during the war only about 75c. per ton.[2] For burning the very pure marble limestone, the otherwise unutilized gases from the coke ovens are available. Great quantities of copper-bearing pyrites furnish, on smelting, sulphur dioxide, which must be converted into sulphuric acid, but which at the present time is not used on the spot. Near by are inexhaustible deposits of high per cent phosphate rock. The possibility therefore exists of using the otherwise wasted sulphuric acid and phosphate to make phosphoric acid, and by neutralizing this with ammonia from lime-nitrogen, producing cheaply the so-called American "ammophos," or ammonium phosphate, containing roughly 45 per cent of water-soluble phosphoric acid and 20 per cent of nitrogen.

To be sure, the United States is in a position to use right there the nitrogen thus produced, amounting to about 130,000 tons per year; particularly as the plants are located in the midst of an extensive cotton-growing district. Nevertheless, a considerable extension of this project is contemplated and because of the high intrinsic value of the product (ammonium phosphate) it will be possible to ship it to long distances to places where its phosphoric acid content will be of importance, and hence it will be sure to offer very strong competition to the German fixed nitrogen industry.

Norwegian and Other Competitions

The economy with which nitrogen can be produced in the Norwegian lime-nitrogen plants is of a similar order, but the situation is perhaps not quite so favorable as in the above case. According to recent information the yearly production of these plants is between 100,000 and 130,000 tons of nitrogen. They, too, are located near cheap water power, and since they can utilize their product as return freight in ships bearing English coke, they are in a position to operate cheaply and to ship their output to great distances.

Published figures from other countries show that their output from lime-nitrogen per year is as follows:

	Tons Nitrogen		Tons Nitrogen
France	30,000	Bohemia	7,000
Spain	10,000	Lower Rhine	7,000
Italy	30,000	Japan	48,000
Dalmatia	24,000	Canada	40,000

So, as far as is known, about 450,000 tons of nitrogen can be produced as lime-nitrogen every year in foreign countries, while a further output of 500,000 tons per year will be provided by great plants already under construction. Moreover, the very great increase in the amount of ammonia secured in byproduct coke ovens in all countries where coal and coke are produced, particularly in the United States and in England, must be taken into consideration, so that an increase in the yearly output of fixed nitrogen from foreign countries amounting to 500,000 tons must be assumed.

Economic Outlook of the Nitrogen Industry

The total increase, then, in the yearly output of nitrogen in Germany and all foreign countries amounts to about 800,000 tons and is considerably greater than corresponds to the total output of Chilean saltpeter before the war (3,500,000 tons). This will surely affect the nitrogen market very decidedly, even if we can count with certainty on a very great increase of the nitrogen consumption in all countries. The competition of foreign countries is of even more consequence in considering the future German situation, when it is recalled that even in the year 1914, before the war, a combination of the saltpeter and lime-nitrogen producers of the whole world was proposed.

We can be very sure that faced by such circumstances the German industry will have no easy task in furnish-

[1] The author is in error regarding the location. The plant is at Muscle Shoals, on the Tennessee River.—Editor.

[2] This figure is evidently a mistake. As reported during the hearing before the House Committee on Military Affairs (Chem. & Met. Eng., vol. 21, No. 2, July 15, 1919, p. 67), the cost of coke at U. S. Nitrate Plant No. 2 was $6 per ton.—Editor.

ing an adequate supply of this material to German agriculture at *cheap* prices. The government, therefore, as soon as it had begun to take an interest in the nitrogen situation, was busied with arrangements to consolidate the German nitrogen industry, so that it might fulfill its function satisfactorily and be resistant to outside attack.

Establishment of the Nitrogen Traffic Monopoly

For this purpose in 1915 the government brought forward legislation permitting the establishment of a nitrogen traffic monopoly. The purpose of this proposal as appeared from the discussion was not so much the introduction of a traffic monopoly itself as the establishment of a close organization of the industry and the assurance to agriculture of suitable, and, indeed, extremely cheap prices for nitrogen (namely, 70 pfennigs per kilogram of nitrogen in lime-nitrogen). The proposal was not rejected, but also it was not adopted. It remained unacted on in the Commission.

Meanwhile, a further increase in the nitrogen industry of about 200,000 tons per year has taken place. The whole situation has altered and the production costs of all the processes have undergone a complete re-alignment. Certain efforts by the government have resulted in the establishment of an autonomous combination within the industry. On May 8, after the Finance Commission of the National Assembly had granted permission, the Nitrogen Syndicate, in co-operation with the government, was established as a limited company (Gesellschaft mit beschrankter Haftung) which included the whole nitrogen-producing industry, as well as other industries related to it. The incorporators of this undertaking, which has a nominal capital of 241,800 marks, are as follows:

	Shares in Marks
1. Badische Anilin und Soda Fabrik	150,000
2. The lime-nitrogen firms	41,800
3. The German Ammonia Sales Co., together with its affiliated organizations of the Oberschlesian Coke Works and the Union of German Gas Works	50,000
Total capital	241,800

The allotment of production is as follows:

	Tons Nitrogen
1. The Badische Anilin und Soda Fabrik up to	300,000
2. The lime-nitrogen industry up to	93,000
3. The byproduct industries up to	120,000
Total	513,000

The government, and each of the three incorporations, have the right to name one member of the four-membered board of directors.

The government has retained for itself the far-reaching right for the conduct of the business, and particularly for the allocation of the product, and the fixing of prices. The board of managers of the company is to consist of ten persons, who will be intrusted with most of the control of the business. The government, the Badische Anilin und Soda Fabrik and the byproducts industries will elect three members each of this board, and the lime-nitrogen industry one member. Each group will further appoint alternates equal in number to its members. The chairman of the board, as the foremost director of the business, will be selected by the government, and the vice-chairman from the three members named by the Badische Anilin und Soda Fabrik. The function of the board of directors is an honorary one. The chairman, as business director, only will be paid. Decision as to sales, prices, etc., will require approval of the government representative. As a fundamental basis, the price of nitrogen in lime-nitrogen, ammonium sulphate and saltpeter has been fixed in ratio of 8 : 9 : 10.

The sale of the output depending on the demand will take place according to the deserts of the single products. Every output will be computed on its own basis and all the plants will receive for every product the prevailing average price. Exportation can take place only after all domestic demands have been met.

How the distribution will be carried through in detail has not yet been decided, but it will be carried out on a basis of the already existing organizations of agriculture and of legitimate trade. For this purpose, at the instigation of the Finance Ministry, a joint body consisting of the producers and consumers was established, called its Nitrogen Commission, to which the determination of the prices, conditions of delivery, etc., were intrusted. The Commission consists of twenty-two members. The Nitrogen Syndicate, the government and agriculture name five each, the fertilizer manufacturers and the fertilizer dealers each elect one. Three members are appointed by the Associated States and one each by the Labor Bureaus of Industry and Agriculture.

Future Developments of the Organization a Matter of Conjecture

The organization thus fixed upon gives each of the industries concerned and any new industries the possibility of far-reaching development, and on the other hand, at the same time permits the government, by the control of all distribution, exportation and prices, to safeguard the social and financial interests intrusted to it, as had been demanded by the National Assembly. It makes possible the distribution of nitrogen in a more rational manner than has previously been the case, since, by a centralized control of distribution, transportation and storage facilities are utilized in the most efficient manner possible.

By the establishment of the Nitrogen Snydicate and of the Nitrogen Commission an important step has been taken to assure the success of the German chemical and agricultural industries. How far the Nitrogen Syndicate can also be looked upon as a money-making enterprise will depend on future developments, particularly on how large production costs will prove to be. The government takes a leading part in this production and therefore is in a position to judge regarding all the factors which come into play and to influence them. For the present it will maintain the existing standards of maximum prices and assessments (in agreement with the requirements of the National Food Ministry of March 13, 1919) until a clearer insight can be had into production and importation situations.

Exposition of United States Manufacturers in Buenos Aires

Twenty-two countries are holding foreign trade fairs during 1920, and of these France schedules eight, Germany twelve, Great Britain nine and Italy four. Among others of interest to manufacturers in the United States is the National Exposition of U. S. Manufacturers to be held at Buenos Aires in October. It is to be arranged and managed by the American National Exposition, Inc., of New York, G. Hough Perry, director.

Classification and Salaries for Chemists

Report of the Congressional Commission on Reclassification of Government Salaries, Outlining the Qualifications, Principal Lines of Promotion and Compensations for Government-Employed Chemists

By R. S. McBRIDE

THE report of the Congressional Commission on Reclassification of Government Salaries, presented recently, gives us the first systematic classification which has ever been made in the varieties and grades of technical positions which are encountered in our complicated professional life. This classification has a very large interest to executives and employing chemists, for it gives a clean-cut basis upon which they can judge the relative responsibility which should be intrusted to men of different grades in technical and scientific work. The relative responsibility for planning and execution of research and for the conduct of executive work in a chemical organization is particularly important, as in many cases there is very little understanding of the degree of experience really required for executive work in different places.

The classification of chemists which is proposed divides workers in this science into two major groups—those in the sub-professional grades, who are called junior aid or senior aid in chemistry, and the group which includes those who are graduated from a collegiate course specializing in chemistry, who are called junior chemist, assistant chemist, associate chemist, chemist, or senior chemist, according to the exent of their experience. A very similar classification using the same titles and the same general qualifications and duties was adopted by the commission for all the other engineering and scientific services of the Government. In other words, the commission has recognized the same principles to govern in all of these professional fields. The definite statements of the commission with respect to these various classes in chemistry are as follows:

Junior Aid in Chemistry

Duties: To assist chemists in the performance of routine laboratory work; and to perform related work as required.

Qualifications: Training equivalent to that represented by graduation from high school, including one year of chemistry and one year of physics; accuracy and carefulness.

Principal Lines of Promotion: To, senior aid in chemistry.

Compensation for Class: $840-$900-$960-$1,020-$1,080-$1,140-$1,200 per year.

Senior Aid in Chemistry

Duties: To assist chemists in the performance of chemical work, or to make routine chemical analyses; and to perform related work as required.

Qualifications: Training equivalent to that represented by graduation from high school, and by not less than two years' college work, including at least fifteen college credits in chemistry; accuracy and carefulness.

Principal Lines of Promotion: From, junior aid in chemistry. To, junior chemist, junior metallurgist.

Compensation for Class: $1,200-$1,320-$1,440-$1,560-$1,680-$1,800 per year.

Junior Chemist

Duties: To perform, under immediate supervision, routine work in chemistry; and to perform related work as required.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry, including general inorganic, analytical, and organic chemistry; additional training in one or more of the following optional lines; biological, dairy, engineering, explosives, food, fuel, inorganic, metallurgical, organic, petroleum, pharmaceutical, physical, or soil chemistry; ability to read scientific French or German; and initiative.

Principal Lines of Promotion: From, senior aid in chemistry. To, assistant chemist.

Compensation for Class: $1,800-$1,920-$2,040,-$2,160 per year.

Assistant Chemist

Duties: To perform, under supervision, either individually or with the assistance of subordinates, general work in chemistry; and to perform related work as required.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry, including general inorganic, analytical, and organic chemistry, and by not less than two years' graduate work in one or more of the following optional lines: Agricultural, analytical, biological, dairy, engineering, explosives, food, fuel, inorganic, metallurgical, organic, petroleum, pharmaceutical, physical, or soil chemistry; ability to read scientific French and German, and to prepare chemical manuscripts in clear and concise English; and initiative.

Principal Lines of Promotion: From, junior chemist. To, associate chemist.

Compensation for Class: $2,400-$2,520-$2,640-$2,760-$2,880-$3,000 per year.

Associate Chemist

Duties: To perform, under general direction, either individually or with associates or subordinates, specialized work in chemistry which may or may not involve supervisory duties; and to perform related work as required.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry,

including general inorganic, analytical and organic chemistry, by not less than three years' graduate work, and by one year's professional experience, in one or more of the following optional lines: Agricultural, analytical, biological, dairy, engineering, explosives, food, fuel, inorganic, metallurgical, organic, petroleum, pharmaceutical, physical, or soil chemistry; ability to read scientific French and German, and to prepare for publication, in clear and concise English, manuscripts embodying the results of chemical investigations; and proved technical and scientific proficiency.

Principal Lines of Promotion: From, assistant chemist. To, chemist.

Compensation for Class: $3,240-$3,360-$3,480-$3,600-$3,720-$3,840 per year.

Chemist

Duties: To perform one or more of the following functions: (1) to carry on, either individually or with associates or subordinates, highly specialized lines of chemical research; (2) to act in a consulting or advisory capacity on problems in chemistry; (3) to plan and execute major lines of chemical work; or (4) to perform major administrative work under executive director; and to perform other related work.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry, by not less than three years' graduate work in chemistry, and by not less than four years' professional experience, of which at least three years shall have been in work of the grade required of an associate chemist; proven ability to carry on or to direct research work in chemistry; ability to read scientific French and German, and to prepare for publication in clear and concise English, manuscripts embodying the results of chemical investigations.

Principal Lines of Promotion: From, associate chemist. To, senior chemist; assistant chief, Bureau of Chemistry; chief, Bureau of Chemistry.

Compensation for Class: $4,140-$4,320-$4,500-$4,680-$4,860-$5,040 per year.

Senior Chemist

Duties: To perform one or more of the following functions: (1) to carry on or direct the most difficult and comprehensive lines of advanced chemical investigations; (2) to act as consulting specialist in the field of chemistry; or (3) to perform major administrative work involving the broadest lines of policy; and to perform other related work.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry, by not less than three years' graduate work in chemistry, and by not less than eight years' professional experience, of which at least three years shall have been in work of the grade of chemist; large capacity and proved ability to perform, direct, or administer work in the most difficult and comprehensive lines of chemistry.

Principal Lines of Promotion: From, chemist. To, assistant chief, Bureau of Chemistry; chief, Bureau of Chemistry.

Compensation for Class: (Not specified).

Assistant Chief, Bureau of Chemistry

Duties: To assist the chief in the administration of the work of the Bureau of Chemistry, including the supervision of its field force, inspectional, and clerical personnel, and in the enforcement of the food and drugs act; to act as chief in his absence; or, to assist the chief in the administration of the research work, scientific personnel, and related work of the Bureau of Chemistry; and to perform other related work.

Qualifications: Either (1) training equivalent to that represented by graduation with a degree from an institution of recognized standing; preferably professional legal training in addition; extended executive experience; not less than five years' experience in the administration of the food and drugs act; judicial temperament and exceptional executive capacity; or (2) training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in chemistry and related subjects, and by not less than three years' graduate work in chemistry; extended experience in conducting and administering research work in chemistry; large capacity and good judgment of men.

Principal Lines of Promotion: From, chief of district; senior chemist; chemist. To, chief, Bureau of Chemistry.

Chief, Bureau of Chemistry

Duties: Under the general direction of the Secretary of Agriculture, to have administrative charge of all the activities of the Bureau of Chemistry; to be responsible for its expenditures and the efficiency of its employees; to administer the work required in the enforcement of the food and drugs act; to initiate and direct research in agricultural, food, drug, and industrial chemistry, as well as in the field of pure chemis-

SALARIES RECOMMENDED FOR CHEMISTS AND ENGINEERS

	Qualifications for Chemists	Salaries Recommended by Chemists Committee	Salaries Recommended by Engineering Council Committee (for Engs.)	Salaries for Chemists and Engineers Recommended by Classification Commission
Junior aid	High school graduate	$1,200–1,560	$1,080–1,560	$ 840–1,200
Senior aid	Two years' college work	1,680–2,400	1,680–2,400	1,200–1,800
Junior chemist	College graduate major in chemistry	1,800–2,760	1,620–2,580	1,800–2,160
Assistant chemist	Two years' post-graduate work *	3,000–3,960	2,700–4,140	2,400–3,000
Associate chemist	Three years' post-graduate *, and one year's professional experience	4,320–5,760	4,320–5,760	3,240–3,840
Chemist	Three years' post-graduate work *, and four years' professional experience, of which three years must be in responsible position	6,000–9,000	5,940–7,860	4,140–5,040
Senior chemist	Three years' post-graduate work *, and eight years' professional experience, of which three years must be in work of chemist grade	10,000–25,000	8,100 and up	No recommendation

* One and one-half years' practical experience judged equivalent of one year of post-graduate work.

try; to consider and take action on questions concerning chemistry and related subjects referred by the Secretary; and to perform other related work.

Qualifications: Training equivalent to that represented by graduation with a degree from an institution of recognized standing, with major work in science, and by not less than three years' graduate work in chemistry; extended experience in the application of scientific methods of research to the solution of problems in chemistry and related subjects; not less than five years' responsible administrative experience; ability to determine productive lines of research relating to chemistry, and to organize and direct staffs of investigators and regulatory workers.

Principal Lines of Promotion: From, assistant chief, Bureau of Chemistry; senior chemist; chemist.

Experience Required

It should be noted in this series of statements regarding qualifications that emphasis has been laid by the commission upon post-graduate experience in college work. This conclusion is in accordance with the recommendation which was made to it by the committee of chemists of the Government service selected to advise the commission regarding the needs in this field. This committee urged that a distinction be made between the scientific and the technical services in this particular. An engineer typically gains his advanced work in practical, field or plant experience and he advances most rapidly in his profession under these circumstances, in the opinion of those who were advising the commission. On the other hand, the chemist who goes into some laboratory or plant without the broadening influence of post-graduate work is apt to become highly specialized, or narrow in his conception of research and development methods. It is believed, therefore, that post-graduate training is more valuable for a chemist than a corresponding length of time in practical work. However, it was recognized by this committee of chemists, and so recommended to the commission, that three years of practical experience be regarded as equivalent to two years of post-graduate college work. This relationship should be borne in mind when contrasting the qualifications specified for chemists and for engineers.

Salary Recommendations

The Classification Commission had to guide it a large amount of information which had been gathered by the experts sent out to interview persons in the industries, representing altogether in this field many hundred positions for which data were available. The commission also had the report of the committee on classification and compensation of engineers, presented by the representatives of Engineering Council. To supplement these, the committee of Government chemists appointed to advise the commission regarding the chemical services drafted certain recommendations, discussed these in various ways with the chemists within and without the Government service and formulated certain recommendations as to salary schedules. These various recommendations are tabulated and charted to show the contrast.

It will be noted that the recommendations of the chemists are much higher than those which were recommended by Engineering Council's committee. However, there was considerable justification for this, since the data gathered by the chemical investigators of the commission showed that chemists were in general receiving materially higher salaries than engineers of corresponding experience. In explanation of this rather surprising statement, it should be borne in mind that the demand for chemists has increased very rapidly during recent years and the supply has probably not correspondingly increased. It has been inevitable, therefore, that chemical salaries should advance more rapidly than salaries in the engineering field, probably more nearly keeping pace with the increasing costs of living than the salaries of most any other group of technical or scientific workers.

In making the recommendations to the commission regarding salary, the chemists did not anticipate that the salaries recommended could actually be granted immediately, but despite this fact they felt it necessary to set forth a schedule of salaries which could be considered reasonably adequate to meet the competition of the industries for the services of chemists well trained in various fields. In the judgment of this committee, the schedule suggested represents the compensation which any employer of chemists must pay at the

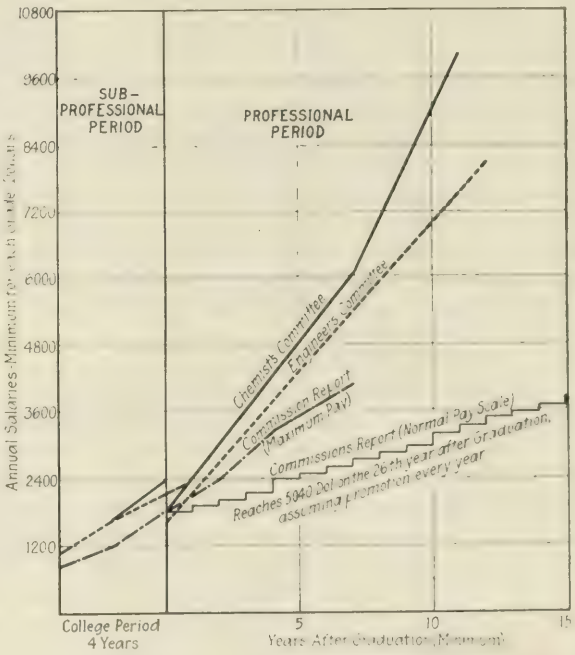


CHART SHOWING SALARIES OF GOVERNMENT CHEMISTS

present time if he is to secure the services of men equal to or above average ability in the different grades. Undoubtedly, many men can be secured at lower rates, but the qualifications or ability would, it is believed, be correspondingly less.

Initial Salary for Government-Employed Junior Chemists as an Inducement for Beginners

In reference to the salary schedule recommended by the committee of chemists, another point should be mentioned, namely, the beginning salary for junior chemists, which was fixed at $1,800, both in the recommendations to the commission and in the commission's recommendations to Congress. This is recognized by all concerned as being a figure slightly above that usually paid in the industries for men just graduated from college in chemical courses. It was believed by the committee that $1,500 per annum would represent more

nearly the beginning salary in industrial work of this sort, but a man going into the industries is usually advanced very rapidly, generally once or twice within the first year of service, if he is really making good. In the Government service such rapid advance is not at all feasible and therefore, in order to attract some of the best available talent from the young graduates, an initial salary slightly greater than that paid by the industries is found essential. Even with this slightly greater starting salary, it is believed that the men in the industries will within a year or two be receiving substantially as much or perhaps a trifle more than those in the Government service, even if the committee's recommendations were adopted.

Promotions

One of the difficult problems in any scientific organization is the question of how often the younger members of the staff should be promoted. In the judgment of the commission, and according to its recommendations to Congress, members of the Government scientific services should be promoted more or less automatically every year, if they are satisfactorily filling their positions. However, these promotions would continue only within the salary range of a single class. For example, a man might be advanced from the initial salary of $1,800 proposed for junior chemists by $120 a year under normal circumstances for three successive years, thus reaching $2,160 per year even though he was just an ordinarily successful man in this grade. To advance from the highest salary in the junior chemists' grade to the lowest salary in the assistant chemists' grade, however, would require a special action of some sort, since it is deemed to be not a normal increase in salary to go from a position of one title to a position of higher title.

It is realized, of course, that these automatic promotions are not sufficient for special cases of unusual merit or ability. Therefore it is anticipated that double promotions would be given to some of the better men and that some men who really were not making good, but who were sufficiently valuable to make it unnecessary to discharge them, would probably not be given any advances at all, even within the grade. However, the thought seems to have been throughout that a normal increase of the size indicated would come more or less regularly each year to most of those within that grade.

General Status

The bulk of the commission's salary material and much of the data presented to them by various agencies has not yet been made public, but will undoubtedly be brought out in the course of any action which the Congressional committees may take upon this report.

In general, the report of the Classification Commission has been very favorably received by the scientific and technical people of Washington, who think the system of classification proposed is excellent and that the general provisions are quite satisfactory. However, the salary schedules recommended for the middle and upper grades are very frequently criticized as being wholly inadequate to hold the technical men required for proper development of the Government service. It is to be expected, therefore, that considerable debate on these points will be developed during any further Congressional action.

Low-Temperature Carbonization of Coal in England

THE coal output of the United Kingdom in 1913 was estimated at 280,000,000 tons, valued at $973,300,000. Between 40,000,000 and 50,000,000 tons is devoted to domestic consumption, and if this amount were converted into smokeless fuel by low-temperature carbonization, some 640,000,000 gal. of fuel oil would be obtained annually. If this system were applied to all coal consumed in the United Kingdom, the quantity of by-products recorded would be enormous.

A recently organized British company is manufacturing a smokeless fuel known as coalite, which is claimed to be a natural briquet, generating as much heat per unit as coal. The volatile constituents of the coal are collected by a process of low-temperature carbonization, recent experiments establishing the following products obtained at one time from one ton of bituminous coal:

(*a*) Three gallons of motor spirit—nearly double the usual yield of motor spirit from processes where coal is distilled at a high temperature. This spirit is refined, and suitable for motor cars, aëro engines, tractors, and every purpose for which petrol (gasoline) or benzol is used today.

(*b*) Sixteen gallons of oils for burning, lighting, and lubricating. This oil is similar to crude petroleum. It can be burned without refining, direct under boilers for naval and maritime purposes generally. If distilled the products obtained are even more valuable and find a ready market for many purposes. The crude oil may be separated into motor spirit, cresylic oils, burning oils for lamps, lubricating oils, oils for Diesel engines, and pitch of superior quality for insulating and other purposes.

(*c*) Seven thousand cubic feet of gas. This gas is of higher quality than that made by gas works and is of great value for lighting, heating, and power purposes. Its heat value is 600 B.t.u. per cubic foot, after removal of the light oils, whereas that of ordinary coal gas, similarly treated, is about 500 B.t.u.

(*d*) Twenty pounds of sulphate of ammonia, for fertilizers and high explosives.

(*e*) Fourteen hundredweight of smokeless fuel.

The question of coal reserves and consumption is receiving a great deal of attention and is bound up with such problems as the generation of electricity by central power stations where coal can be economically consumed with due reference to the salvage of valuable by-products, as well as the provision of smokeless fuel for household use, the provision of motor spirit capable of replacing gasoline, and the supply of fuel oil for naval and mercantile use.

At a recent meeting of the British Association for the Advancement of Science, Sir Dugald Clark stated that if the average figure of 5 lb. of coal per horsepower be reduced to 1½ lb. or less, the industrial civilization of the United Kingdom would be prolonged from 500 to 1,000 years. At the 1913 rate of consumption the coal reserves of the United Kingdom will be exhausted in 500 years, and there is every prospect of increased consumption unless more economical measures are adopted. Therefore as a matter of national economy and conservation of natural resources the burning of bituminous coal in open hearths and furnaces is being deprecated for extravagance no less than in abatement of the dirt, dust, and smoke nuisance.

Peat as a Possible Source of Industrial Power*

Extent and Formation of Peat Deposits—Mechanical Preparation of the Peat Previous to Its Use as Fuel for Steam Raising or in a Gas Producer and the Economic Factors Involved in Its Competing With Coal—Peat as a Source of Ammonia Fertilizer

By HERBERT PHILIPP

THE use of peat as a source of heat goes back beyond the historical period into the ancient history of the early tribes in northern Germany. Pliny, the Roman naturalist, gives us possibly the first indication of the use of peat. He reports that the Teutons on the border of the North Sea dried and burned mud, what we now would call peat. In Ireland, Great Britain, Russia, Scandinavia, Germany, Holland and parts of France peat has been used as a fuel since time immemorial. The peat was cut from the bog very much in the same manner as it is still being done in many parts of Europe, where it is cut in brick shapes, allowed to dry in the wind and sun and stacked up, similarly as the American farmer piles his cord wood.

It is only in the last seventy years that any progress has developed in this industry, and although very little has been done in this country to obtain efficient results in using peat as a source of power, much can be expected in the near future of making this resource valuable and an economic factor in our industrial life.

Extent and Formation of Peat Deposits

Peat is disintegrated vegetable matter accumulated in areas of poor drainage where the chemical decomposition has been partly retarded according to a variety of conditions. Some of the conditions have resulted in complete decay, so that the original substances have disappeared, while others have simply resulted in the loss of more easily changed compounds and gaseous elements, the material retaining its original form and mechanical structure. The deposits of peat are not uniformly distributed over our country, but occur in practically every state east of the Dakotas and north of the Carolinas to the Canadian border. This is supplemented by deposits all along the Atlantic coast, the state of Florida and across Texas to the Mexican border. In the Pacific coast states are some areas of peat deposits, especially in California and in the valleys of some of the lakes and rivers of Oregon and Washington. It is estimated that there are approximately 12,000 square miles of peat deposits in the United States of an average depth of 9 ft. which would represent a total of about 14,000,000,000 tons of fuel, provided the whole were converted into peat fuel, which is no small resource and represents a possible means of furnishing heat and power for a considerable number of years.

It is only in recent years that peat has become of enough interest in this country to endeavor to classify the various kinds which are made. This work is being undertaken by Dr. Alfred P. Dachnowski of the U. S. Bureau of Plant Industry, and his initial attempt represents an admirable contribution to our peat literature. The terms muck, humus, moor, marsh (fen), bog, heath and swamp are terms used without any definite relation to the stage of development of the peat in the deposit. These terms usually relate to the marked physiognomy of vegetation appearing on the deposit. A peat deposit can be defined as a compact accumulation of plant remains of at least 8 to 10 in. (20 to 25 cm.) in thickness. No deposit containing more than 40 per cent of mineral matter must be included in this definition. Peat deposits usually occur upon gentle slopes, flat areas, in shallow depressions on the earth's surface which have neither drainage or are poorly drained so that the surface is always wet or covered by water.

Owing to the various conditions under which peat deposits have been formed and to the various types of vegetable matter composing them and also to the various locations and climatic changes to which they have been exposed, each deposit is practically a study in itself. There are possibly no two deposits that are exactly alike, although a large number may be very similar in composition. This explains one of the reasons why difficulties have been met with in trying to work one deposit by means adapted on another deposit. Even great variations can be noted in deposits which are only a few miles separated.

Growth of Peat Industry

A peat industry exists in this country, and has grown steadily the last twelve years till it now represents a real industry. However, only a small quantity of peat up to the present time has been manufactured for fuel purposes, the largest amounts being used in agriculture and in the fertilizer industry. The statistics in the table show the amount of peat produced and also the quantity used for fuel purposes.

CRUDE AIR-DRIED PEAT AND PEAT FUEL PRODUCED IN THE UNITED STATES, 1908-1918

Year	Total Peat Produced Short Tons	Total Peat Fuel Used Short Tons
1908	24,800	900
1909	29,167	1,145
1910	37,024	...
1911	55,143	300
1912	47,093	1,300
1913	33,260	...
1914	47,093	1,925
1915	42,284	...
1916	52,506	...
1917	97,363	...
1918	151,521	20,567

It will be noted that during the last few years the production of peat has practically trebled due to the extensive application of this material in fertilizers. It will be well to mention here that peat in this country is generally comparatively rich in nitrogen, and that is the reason why the use of peat in agriculture is proportionately greater in the United States. The peat fuel production was negligible until 1918, when the high price of coal gave quite an impetus to this indus-

*Read before the New York Section of the American Electrochemical Society, Feb. 27, 1920.

try, and the future offers very promising developments for a successful peat fuel industry in this country.

In Europe practically all the peat which is excavated is used for fuel purposes. Since coal has become high in price and as far as we can determine will remain so, peat becomes an economic factor in our future industrial progress.

Many Failures to Produce Peat Economically

A large number of attempts have been made in the past to produce peat fuel economically, but the majority have proved uncommercial and we cannot speak of any successful peat fuel undertakings before 1918. The large number of failures were due to many factors, which were, chiefly, lack of capital, poor engineering, difficulties of distribution, prejudice, stock jobbing, and competition of low price coal. From this it will be seen that too many efforts have been made with small capital and poor engineering ability to allow the industry to get on its feet, and that has for years given the industry a bad reputation and prevented any attempts being made on a big scale and has generally created ridicule in suggesting a development of a peat fuel industry. With the present high price of fuel and the inability to obtain a steady supply, a peat fuel industry is now looked upon as a remunerative possibility.

There is more than one way of utilizing peat for the production of industrial power, yet whatever method is used the peat must first be excavated from the deposit, and the economic excavation of peat has been the biggest bugbear in the peat industry.

Operation Feasible Only in Dry Season

The average peat deposit contains from 80 to 90 per cent water, and that must be economically driven off to make the peat available as fuel. It will therefore be easily realized that for every ton of raw peat excavated there is only 100 to 400 lb. of theoretically dry peat available. Peat deposits vary, and according to the grade of decomposition they will dry in the air at various rates. The more highly a peat is decomposed the quicker it will allow the moisture to evaporate and the more fibrous the material is the slower it will evaporate. This phenomenon is due to the fact that the moisture present is not all there as absorbed moisture, but the water present is in the cells of the vegetable mass. It is therefore necessary in most cases to pass the peat through a pugging or macerating mill.

Dependence on Local Climatic Conditions

In order to obtain a cheap fuel it can be inferred that peat cannot afford to be handled very much, and therefore the largest part of the drying has to take place on or near the deposit. It is manifestly unfeasible to use any artificial heat for producing peat fuel. However, there are conditions where waste heat can be used to advantage to reduce the moisture content of peat, as will be shown later. There is no cheaper method of drying than by nature herself, and the sun and wind have to accomplish the largest part of the drying in any development of a peat fuel plant. This shows how dependent the industry is on local climatic conditions—not only on the total hours of sunshine, but also on the winds and humidity of the atmosphere. Further the temperatures of the season play a big factor in the excavation and drying of peat; it is impossible to excavate peat when the ground is frozen. In other words, enough material has to be excavated in the good season of the year to supply a plant for the whole twelve months, and this is the point that so many plants have failed to realize, so that they have been forced to shut down for lack of material. The length of time that excavation work can take place varies with the location of each deposit and due regard must be taken of the climate of the locality.

Mechanical Excavating and Handling Apparatus

In most countries the peat is commonly used as fuel and the hand digging of peat is still used. The mechanical handling of peat, which originated in Germany, is only being taken up by deposits where large amounts of peat have to be excavated. Where peat is used as an industrial fuel, only mechanical excavating and handling apparatus can be considered. There are two possibilities of opening up a peat fuel deposit or peat bog; namely, the operation of excavating a dry peat bog and the excavation of peat from an undrained swamp.

In the first case that part of the deposit which is to be used is drained, generally by preparing small ditches which lead into a main ditch. The deposit is then cleared and leveled so that the surface can be used as a drying ground. These ditches should not be too deep and should not go beyond the depth of the deposit to prevent in the latter case contamination with mineral substances. It is often necessary during the winter season to allow the water to accumulate in the deposit and in case the deposit takes fire it can be quenched by allowing the water to rise in the ditches.

The machines used for excavating the peat are generally of the simplest form of construction and are similar to those used ordinarily in ditching and digging. The modern tendency in using power ditching machines corresponds to the types of side chain and bucket excavators, which are very effective in peat which is well decomposed, but cause trouble in poorly decomposed deposits on account of tree stumps which have not yet disintegrated. These machines generally work from the side of the ditch, which has the advantage of mixing the peat from the different depths and thereby securing a homogeneous product. On account of the high cost of labor in this country the peat excavated, even in small plants, is found to be done more economically by machines than by hand digging. The steam shovel has also been used in this country and gives satisfactory results. On account of producing homogeneous material and the ability to spread the material easier on the drying ground, the chain and bucket excavator seems to be most favored.

Difficulties to Be Overcome

In devising machines of this nature not only has the ability of excavating efficiently to be taken into consideration but also the expense and labor incurred in handling the material after it leaves the excavating machine. As peat deposits will not hold a very great weight per square foot, thought has to be given to properly mount the machine so that the weight is distributed as uniformly as possible. The machines are generally mounted on cars having wheels with very wide treads, which have on some deposits, even then, to be supplemented by timbers. The more modern machines are provided with caterpillar tractors, which have proved very satisfactory in this kind of work. Where possible these machines are operated by elec-

tricity, otherwise the power plant has to be installed on the machine. However, this should be obviated as far as possible on account of the possibilities of setting fire to the deposit during the dry season. Peat fires can become very disastrous and are often very hard to put out.

No Standard Peat Digging Machines

There are no standard peat digging machines in this country, and generally in each case they have to be designed to meet the local conditions. These machines have to be of an efficient form and provided with a hopper for receiving the peat which falls into a cutting or macerating trough, thus pulping the peat and cutting up its strands. These macerating machines are provided with screw conveyors and on the same shaft can have knives for cutting up the fibers, while other machines have sections provided with both fixed and movable knives which work together like the blades of scissors.

After the peat has passed through the above-mentioned machinery, it is then spread on the drying grounds, which is generally the surface of the deposit, and here exposed to the sun and wind. Every once in a while a new surface of this layer is exposed and eventually the material is scraped together and hauled to the plant. By this method peat originally containing 80 to 95 per cent water can be dried down to 25 to 35 per cent water right on the field, and this moisture content is low enough where peat is used in gas producers, but for cases where it is used for making steam direct it should be dried down to about 15 per cent water, although 20 per cent is frequently used; in a large power plant this can generally be accomplished at the plant, where enough waste heat exists to reduce the moisture content economically.

In excavating an undrained deposit the machinery has to be mounted on a barge or float and either a dipper-dredge or pumping system is used. Both of these systems are satisfactory; their use depends entirely on the local conditions, quantity of peat to be handled and its stage of decomposition. In each case, however, the peat has to be handled on drying grounds after it leaves these excavating machines. Highly decomposed peat can be very efficiently handled by pumping if very little fibrous matter is present in the deposit.

Costs and Methods of Burning Peat

The cost of excavating and air drying peat governs the success or failure of a peat fuel plant. All the cost involved in handling the peat from the deposit to its storage pile should not exceed $1.30 per ton of theoretically dry peat. The cost depends very much on the size of the excavation plant and on the climatic conditions. My experience in excavating peat covers a cost ranging between 25c to $1.30 per ton of theoretically air-dried peat on the field. It is seldom that the excavation price exceeds $1 per ton of peat, the average being in the neighborhood of 75c. per ton of theoretically dried peat.

In producing power from peat we have available the same methods as are now used for coal, either firing peat direct under a boiler for raising steam or gasifying it in gas producers and using the gas in gas engines or under boilers and in furnaces. Where industrial power is produced from peat, it is necessary to locate the power plant at the edge of the deposit or in very close proximity thereto. The reason for this is that the handling of large quantities of peat fuel involves several problems of a serious nature; on account of its bulkiness and low heating value, compared to coal, it necessitates handling larger volumes and burning an appreciably larger quantity than is the case when coal of a good quality is used for raising steam. Furthermore, very large stocks of peat fuel have to be held, and the sensible heat contained in the flue gases, together with exhaust steam, is used to advantage in reducing the moisture content of the air-dried peat. Peat fuel generally burns freely to a fine easily handled ash. Thus it is practically totally combusted and the handling of the ash is reduced to a minimum.

Analysis of Good Peat Fuel

An approximate average analysis of a good peat fuel is as follows:

	Per Cent
Volatile matter	60
Fixed carbon	30
Ash	8
B.t.u., 8,500	

When peat fuel is burned direct on a grate it is necessary that not too much fine material is mixed in the lumps and it is therefore frequently advisable to briquet the peat before using it for such purpose. Many peats have enough binding material present in them and others will not hold together at all unless mixed with pitch or similar material. In making machined peat it is advisable to form the bricks while the peat is still plastic and then let them dry. Some peat briquets form easily without the addition of any foreign binder, especially when heated up to about 100 deg. C., when the natural paraffine present will hold the peat in its form and produce briquets which are comparatively easy to handle.

Requisites of Boiler for Using Peat Fuel

The points to be considered in constructing a boiler for using peat fuel are a large grate area with very small air spaces, large combustion chamber, and long travel for the flue gases; 15 lb. of peat per sq.ft. of grate per hr. has been found good in practice. Peat has a disadvantage in allowing unburned hydrocarbons and hydrogen to escape in the ordinary combustion chamber built for burning coal. It is therefore necessary to have a specially constructed combustion chamber to insure complete combustion when using this fuel. Peat has another disadvantage, because when firing with peat the fire door has to be open quite a considerable part of the time, because men cannot handle as much peat on a shovel as coal owing to its low specific gravity. However, if the peat is used as a pulverized fuel it will be found not only economical to prepare but can compete with coal more advantageously.

When peat is dried, even air dried, it does not absorb moisture from the atmosphere very readily, and even with 20 to 25 per cent moisture content it has the physical characteristics of a dried material. Provided it has been properly macerated it is very easy to pulverize and will not pack, running and behaving similarly to dried sand. With these conditions, together with its low specific gravity and high combustibility, it makes an ideal powdered fuel. Peat has been used in this way in Sweden and has shown that it is possible to obtain better calorific value than by burning the peat on a grate, and every indication points to the fact that peat fuel can be used practically and commercially for

raising steam when used as a powder, so the future developments of the use of peat as an industrial steam raiser will tend to be in this direction.

Cost at Which Peat Can Compete With Coal

The maximum cost per ton which peat fuel can stand and still compete with coal is governed by the cost of steam coal at the place where the power plant is located. There is, however, a fixed minimum cost, determined by the cost of its manufacture, below which peat fuel cannot compete with coal. Peat used directly under a boiler for raising steam can generally compete with good steam coal costing $4.50 or less per ton or $4 or less per ton when the peat is used in a pulverized condition. Above this price where peat deposits which are suitable for fuel are available, they become a serious competitor of coal. The more economical method to convert peat fuel into power is to burn the same in a producer to form combustible gases and then use gas engines or burn the gas under boilers to obtain the desired results.

Inasmuch as peat used for generating steam contains generally from 16 to 21 per cent moisture, less water is evaporated than would be the case if peat were theoretically dried. Peat of this nature directly on the grate will evaporate on an average 4 lb. of water per lb. of peat, while pulverized peat evaporates about 5.25 lb. of water per lb. of peat powder.

Peat Producer Gas

The most economical method for producing power from peat is to convert the peat into combustible gases in a specially constructed gas producer, or if the gas contains any nitrogen to burn the same in a byproduct recovery producer. Since several of the peats examined in this country have a high nitrogen content, it would be possible to recover the largest part of this nitrogen in the form of ammonia.

The commercial use of peat in gas producers seems to have been successful in Germany and Sweden, where they have been used for several years in metallurgical operations, brick and glass making and in lime burning. Tests have been made on this continent both in Canada and at the fuel-testing stations of our Government, where it has been shown that gas of good calorific quality can be produced, similar results being obtained as in producer gas from bituminous coal. About 40 cu.ft. gas is produced from a pound of peat having a calorific value from 130 to 150 B.t.u. per cu.ft. These producers have the great advantage that peat containing as high as 25 per cent or over of moisture can be used. The most economic method of course for using this is for driving gas engines, but engines of large units have not yet proved very satisfactory in this country. In Europe they are operating and have been for a large number of years apparently with a high degree of satisfaction. It therefore appears that for the present it would be most desirable to use this gas under boilers for raising steam.

Ammonium Sulphate Successfully Recovered Abroad

When the peat contains nitrogen, the latter is converted in the producer to ammonia, which can be recovered as ammonium sulphate and prove very profitable. There are several plants in existence in Germany, Italy, Holland and France where the Mond producer, modified by Lihme, is working very successfully. In these producers, gas of about the same quality and quantity as described above is obtained and in addition thereto about 80 per cent of the nitrogen is recovered as ammonium sulphate. These producers are very useful to the peat industry inasmuch as peat containing as high as 42 per cent moisture can be used satisfactorily. In Germany peat containing 50 per cent water and 1.05 per cent nitrogen has been operating for eight years or more delivering a gas of 150 B.t.u. and producing 70 lb. of ammonium sulphate per ton of theoretically dried peat. The nitrogen content of the Italian peat is 2.3 per cent and they recover 215 lb. of ammonium sulphate per ton of theoretically dried peat.

Previous to the war the peat was excavated, dried and conveyed to the producers at a cost of 60c. per ton of peat (theoretically dried). In an ammonia recovery producer the ammonium sulphate obtained will generally cover the total cost of the peat and also the maintenance and operating expense of the gas plant, and even then show a profit. When peat has to be converted into combustible gas it is very easy for a power plant to take this gas and use it for raising steam or generating power by direct explosion in a gas engine. The gases from a peat producer are composed on an average of 20 per cent carbon monoxide, 9 per cent carbon dioxide, 1 per cent ethylene, about 4 to 5 per cent methane and 6 per cent hydrogen; while an average gas from an ammonium recovery producer contains 10 per cent carbon monoxide, 20 per cent carbon dioxide, 20 per cent hydrogen and 5 per cent methane. The building of large gas engine units to use low power gases cannot be an impossibility. Since this has been achieved satisfactorily in Europe, our American power engineers must make up their minds to design an efficient engine of this type, else they will have to be imported from Europe. The power engineer can easily realize from the figures given that we have here an economical and cheap source of power, but it must be realized that economic results cannot be obtained unless large installations are designed and that our capitalists must be willing to break a new path in developing and utilizing a resource so easily obtainable.

Conclusion

There is no difficulty whatsoever in either using a peat for steam raising as a powdered fuel or using a peat in a gas producer. The difficulties, or better the failings, in producing peat as a source of fuel lie in the lack of attention which has been paid to the excavation and drying of the same and the poor engineering ability which has tried to overcome these troubles.

Industrial Laboratories,
New Brunswick, N. J.

Concrete Tanks Used for Water Storage

The test of concrete tanks made of 1:2:4 mixture and used for water storage, undertaken by the Bureau of Standards, Department of Commerce, has been discontinued after 150 days because the day-loss curves have taken the form of a straight line, showing that the daily loss has become constant. It may be of interest to note that these tanks, although showing some actual loss, due to water penetrating the concrete, remained dust dry on the exterior. It would seem from this that although the head of water was 35 ft., the mixture is sufficiently waterproof for this purpose.

Aluminum Rolling-Mill Practice—V Finishing Operations

Production of Thin Sheets to Exact Gage, Hardness and Required Surface Finish Is Described in Detail, Together With the Associated Shearing, Annealing, Inspecting and Shipping Operations*

BY ROBERT J. ANDERSON AND MARSHALL B. ANDERSON

PRIOR to finishing and after the slabbing operation, aluminum slabs are roughed on roughing mills. In general, all sheets which are to finish lighter than 0.080 in. (2 mm.) thick are roughed to within two gage numbers of the finished gage e.g., slabs which are to be rolled into 16-gage sheets are roughed to 14-gage. There are certain exceptions to this rule, and these will be pointed out later.

Ordinarily, sheets which are to finish wider than 48 in. (1.2 m.) and longer than 144 in. (3.7 m.) are rolled singly, while smaller sheets are rolled in pairs. When roughing singly, only one sheet is on the mill, but when rolling in pairs, the roller is passing one sheet through the rolls while the catchers are returning the other sheet over the upper roll. One roller and two catchers can operate a roughing mill, and the production is variable—from 500 to 1,000 lb. per hr. (225 to 450 kg.). The number of passes given, during roughing, and the percentage of reduction depend upon the size and gage of the desired sheets, and to a less extent upon the condition of the mill. Under normal conditions, ten to forty passes are given with three or eight sets of the mill, the variations being due to the gage and the condition of the mill.

After cold roughing, the ends of the rough sheets are sheared so as to prevent undue cracking on finishing; ordinarily, only a small amount of scrap results here, and shearing may be omitted if the ends of the sheets are in good shape. As a matter of fact, it is better to say that sheets to be rolled in pack (20-gage and lighter) are sheared, while those rolled singly (heavier than 20-gage) are not. In general, however, sheets for pack finishing are sheared on both ends and sides, because they are more liable to crack during finishing than the heavier gages.

As has been mentioned above, all sheets, with some exceptions, are roughed to within two gage numbers of the finished gage. In rolling 20-gage (0.81 mm.) sheet, however, the slabs are roughed to within one number of the finished gage, i.e., 19-gage. In roughing, 20-gage is run two in a pack, and the roller will roll one sheet at a time until the sheets are thin enough to run in pack. For 20-gage sheet, the hot-mill slab is cold slabbed to $\frac{1}{8}$ in. (3.2 mm.) and during preliminary roughing the roller will take one sheet and make about six to eight passes with two sets of the rolls. This is repeated for three other sheets, so that the metal is finally run two in a pack and in pairs, i.e., there will be four sheets on the mill. While the roller is passing one pack through the mill, the catchers are passing the other pack back to the roller over the upper roll. As each pack is finished, the metal is stacked on trucks adjacent to the mill by the catcher.

When aluminum is rough-rolled, it is dull gray in color, as no buffs are used on the roughing mill. During roughing, the rolls and the rough sheets are occasionally rubbed over with a swab soaked in kerosene, so as to prevent the metal from sticking to the rolls.

An indicated above, some rough sheets are sheared so as to lessen the liability of further cracking during finishing. All sheets to be run in pack are sheared $\frac{1}{2}$ in. (1.3 cm.) on each side and whatever amount on each end as is necessary to remove the cracked metal at those places. Occasionally, thick sheets run singly crack during the roughing operation; it is then necessary to shear off the cracked metal so as to prevent further cracking. Cracking during rolling may affect the total scrap loss if it becomes excessive.

FINISHING ALUMINUM SHEETS

Cold finishing to gage is performed upon a mill similar in its general features to a roughing mill except that buffs are used on the rolls to keep them polished. Most of the sheet aluminum is sold as planished sheet, i.e., highly polished, and the rolls must be kept bright and free from dust and flakes of aluminum.

Two buffs are used on each mill, one for each roll. Buffs are made by nailing two 1-in. boards together at an angle of 90 degrees; the boards should be 4 to 6 in. wide; the lower board should be as long as the rolls are wide, but the upper board should be sufficiently longer so that it may rest on the roll boxes. The space in the 90 degree angle is filled with waste, and heavy duck is tacked from one board to the other so as to hold the waste in place. Then two pieces of cloth, the length of the boards and 8 to 10 in. wide, are placed together and nailed to one board so that the free end may drag on the roll. The buffs, built up in this way, are secured with bolts and nuts to the roll box so that they rub against the revolving rolls.

A product known as "gray plate" is manufactured on finishing mills with the buffs removed. The surfaces of so-called "finished sheets" are bright and glossy, while those of gray plate are dull and gray. Gray plate is run most often in 14- to 17-gage, and is used considerably for cooking-utensil stock. Gray plate is cheaper to manufacture than finished sheet, for it can be rolled faster. Indeed, manufacture of gray plate may be regarded properly as roughing to finished gage.

In the manufacture of planished sheet aluminum, the finishing operation calls for running down the rough sheets with from twenty-five to forty passes with one set of the rolls, which brings the sheet nearly to gage; the rolls are given such an additional set as will bring

*For parts I, II, III and IV see CHEM. & MET. ENG., March 17, 24, 31 and April 7, 1920, pp. 489, 545, 599 and 647.

the sheet exactly to gage with five or six additional passes. After finishing to gage, the metal will be sent to the squaring shears, where it will be cut square to the required sizes.

Ordinarily, sheets to finish 20-gage and lighter are run in pack, while heavier sheets are run singly. The number of sheets per pack varies with the gage and depends upon whether the ultimate sheet is to be dead soft annealed or hard rolled. If dead soft annealed sheet is being rolled, more sheets can be run in a pack for a given gage than where hard rolled or intermediate sheet is desired. This is so because the soft sheets will be annealed after finishing, and annealing will remove any buckles or waves in the metal. If too many sheets are rolled in pack for a given gage, the ends will curl up, and it is exceedingly difficult to straighten the metal later. As a rule, however, the number of sheets per pack for various gages will be about as shown in Table XIV.*

Light gage sheet must be rolled in pack, because it is otherwise impossible to reduce the metal to gage; this is true for the reason that the rolls are nearly tight from 26-gage (0.4 mm.) up, and to reduce the metal it is necessary to roll several sheets together. Rolling in pack might appear to be a method of speeding up production, but this cannot be regarded as a correct statement for a wide range of gages. Thus, while it is possible to roll more 20-gage sheet in pack than 18-gage singly, it is not possible to roll lighter gages in pack as fast as say 10- or 12-gage.

The figures in Table XIV vary with the condition of the mill, the kind of sheets rolled, and the iron content of the aluminum. As a general procedure, sheets to be rolled in pack are first given a few passes singly (starting with the already roughed sheets); they are then rolled two in a pack, then three, and so on; as the thickness is reduced, the pack is built up. In rolling to gage, whether singly or in pack, the rolls are occasionally swabbed off with kerosene so as to prevent the sheets from sticking. Production is variable, depending upon the gage and size of sheets; figures obtained vary from 100 to 200 lb. per hr., and a yearly average for a plant of capacity 25,000 lb. (11.5 metric tons) per day was 120 lb. (54 kg.) per hr.

Flattening

In order to remove slight buckles and waves in aluminum sheets and make them flat, the sheets are run through a "flatter." Flattening is an effective operation on sheets from 8 to 17 gage (3.26 to 1.15 mm.). Where a perfectly smooth, unmarked surface is called for, flattening should not be attempted, since the flatter rolls may mar the surfaces of the sheets. As a matter of fact, however, sheets should be made on the mills and not on the flatter, and buckled sheets are due to high ridges on the rolls.

Finish Shearing

Commercial aluminum sheets as they appear on the market are finish sheared, squared, and cut to the desired size. The scrap loss arising from shearing may, at times, be considerable, and this is usually the result of mis-shearing and poor finishing practice, although the condition of the metal and the mills, the previous roughing, hot rolling and calculations may all be contributory factors. When sheets are to be cut to a specified size, the usual scrap allowances for shearing on the sides and ends are as given in Table X.†

Shearing, as already pointed out, is a simple mechanical operation, devoid of any features of descriptive interest, but it should be performed by competent shearmen; poor shearing practice invariably leads to high scrap losses and increases production costs. If sheets are sheared too large, they must be re-sheared, and if cut too small they must also be re-sheared to work them into other orders.

Some sheet aluminum goes on the market in the form of circle stock, particularly for the fabrication of aluminum utensils. Much circle stock is made from strip-rolled metal; the strips are sheared into squares; and these are cut into circles on a circle shear allowing ½ in. for scrap, i.e., a side of the square should be 1 in. (2.54 cm.) greater than the diameter of the desired circle. The usual practice in circle shearing is to shear before annealing, since soft metal will bend too readily and get out of shape; further, annealed aluminum will burr badly on shearing. This can be avoided entirely by shearing cold-rolled sheets and strip.

Strip Rolling Aluminum

As previously mentioned, some sheet aluminum is finished to gage on strip mills, so called because narrow slabs or strips are rolled. The product is known as strip metal, coils, etc. It has been said that D and E ingots‡ may be used for strip rolling because the metal is here drawn out rather then spread. High-scrap ingots will result in heavy losses due to cracked sheets in finishing mills, but these ingots work very well in strip mills. Slabs for strip rolling are sheared on both ends and sides, and the slab is reduced to gage with from ten to twenty passes; for example, a ⅜-in. or a ¼-in. slab will be reduced to 14- and 20-gage respectively with about fifteen passes (9.5 or 6.4 mm. is reduced to 1.63 or 0.81 mm.). The first passes should be heavy and the last ones light.

A special lubricating oil is used to lubricate the rolls, but if used in excess as the strip is nearing gage, it does not allow a bright finish on the surfaces of the strips. Hence, on the first two or three heavy passes, it is good practice to use much oil, and as the reductions become lighter as the metal nears gage the excess of oil should be removed. In that way, a bright, glossy appearance will be imparted to the sheets.

There are but two rolling operations in the manufacture of strip metal, viz., hot rolling and strip rolling; no slabbing or roughing is performed. Three men can operate a single unit strip mill, i.e., one roller and two catchers. As a strip becomes elongated by rolling, it becomes increasingly difficult to handle because of its length. Hence, at about 14-gage, the catchers will coil the strip into coil boxes so as to facilitate handling. All strip mills should have a self-coiler as an accessory part; such a coiler will permit a mill to be run with one roller and one catcher. When finished, the strip is cleaned in a strip cleaner and re-coiled.

Strip may go on the market in the form of coils, squares, rectangles, circles, etc. Narrow coils are manufactured by slitting a wide coil into several long pieces on a gang shear, which also rewinds the separate coils so produced. The slab-shear scrap from the strip mill will be greater in quantity than from finishing mills,

*Chem. & Met. Eng., vol. 22, No. 13, March 31, 1920, p. 604.

†Chem. & Met. Eng., vol. 22, No. 13, March 31, 1920, p. 601.

‡Chem. & Met. Eng., vol. 22, No. 12, March 24, 1920, p. 548.

because all slabs for strip metal are sheared on both ends and sides; usually slabs for sheets are sheared only on the ends.

Strip Cleaner

Strip-rolled aluminum is cleaned in a strip cleaner for the purpose of removing lubricating oil. Any oil remaining on the metal will result in a brown or black discoloration on subsequent annealing. A strip cleaner may consist of a cast iron vat supported on four legs; inside dimensions of the vat may be about 4 x 6 ft. (1.2 x 1.6 m.). At one end of this vat, a smaller vat is fastened; this latter is filled sufficiently full with gasoline, and the coil of strip is run through the gasoline. At the other end of the larger vat, a self-coiler is attached. A series of motor-driven rolls for guiding the metal is placed at intervals in the cleaner, and the large vat should be filled with sawdust. To clean a strip, the coil will be placed in the vat of gasoline and one end of the strip will be forced through the rolls, down into the sawdust, and up through a set of revolving brushes to the self coiler.

In some places, soap and water has been used instead of gasoline; a soap which will emulsify the oil on the strip may be effective, but it is the writers' experience that it is far safer to use gasoline for effective cleaning, in spite of the fire hazard. Carbon tetrachloride is a highly effective agent for removing strip-metal oil, but the cost is much higher. Too much emphasis cannot be laid upon proper cleaning of strip coils which are subsequently to be annealed.

Production of Intermediate Sheets

Aluminum sheets, whether finished, gray plate, or strip rolled, may be furnished in various hardnesses; sheets are thus furnished as soft annealed, intermediate, and hard rolled. The hardness is usually measured by the Shore scleroscope, which, while it cannot be entirely accurate for light gages, is sufficiently accurate for all practical purposes. Soft annealed sheets are produced by annealing the products of the finishing and strip mills, while hard-rolled sheets constitute the products of these mills. Intermediate sheet may be in various hardnesses between those of annealed and hard rolled sheet.

In dealing with sheets of intermediate hardness, it is convenient to use a series of symbols for different kinds of sheet. Thus, suppose dead soft annealed sheet is called *XA*0 and hard rolled sheet is called *XAH*; then sheets of intermediate hardness may be called *XA*2, *XA*4, *XA*6 and *XA*8. Provided the previous percentage of reduction is the same for all gages, it is correct to say broadly that the Shore hardness numbers corresponding to these grades in aluminum sheets will be as shown in Table XVI. The methods of manufacturing intermediate sheets are perforce empirical, and a large number of combinations are possible. It is possible to produce intermediate sheets by annealing the partly finished sheet at a gage equal to the finished gage minus the number indicating the intermediate hardness desired. Thus, in making *XA*2 sheets, 18-gage, the partly finished sheet would be annealed at 16-gage, or after roughing. If *XA*6, 18-gage sheet was to be made, the annealing would be done at 12-gage (in the roughing operation); after annealing, the rough sheets would be brought back to the mill, roughed to 16-gage, and then sent to the finishing mill. In the manufacture of *XA*½*H*, or *XA*7, 16-gage, it is necessary to anneal at ⅛ in. in the slab; that is to say, the hot-mill slab is cold slabbed to ⅛ in., and then annealed. The annealed slab is then sent to the roughing mill and roughed to 14-gage, and finally sent to the finishing mill and finished. More simply explained, a broad dictum may be laid down with regard to the annealing for the production of intermediate sheets: Usually such sheets will be annealed *n* gage numbers from the finished gage, where *n* may be 2, 4, 6, 8, etc., in the terminology *XA*2, *XA*4, *XA*6, and so on.

TABLE XVI. SHORE HARDNESS NUMBERS FOR VARIOUS GRADES OF ALUMINUM SHEETS

Grade	Shore H. N.	Grade	Shore H. N.
XA0	4 to 5	XA6	10 to 11
XA2	6 to 7	XA8	12 to 13
XA4	8 to 9	XAH	14 to 15

Annealing Aluminum Sheet

The usual practice employed for annealing cold-rolled sheet aluminum entailed heating the metal for periods of time varying from 18 to 30 hr. at about 370 deg. C. Late reports indicate[9] that at some plants this annealing period has been changed to 2 to 5 hr. at 350 to 500 deg. C. The shorter period is certainly a much more rational procedure, because hard-rolled aluminum may be softened with only short annealing periods at moderate temperatures.

At the present time, aluminum sheet is annealed in gas- or oil-fired furnaces and in electrical furnaces. The car-type electric furnace shown in Fig. 3 has been used for annealing; accurate control of the annealing temperatures is readily possible in this furnace. Annealing furnaces may be built in various sizes according to the desired capacity; for example, a furnace may have inside dimensions of 35 ft. long x 8 ft. wide x 6 ft. high (10.7 x 2.4 x 1.8 m.) The shell of the furnace is built up from ⅜-in. (10-mm.) steel plates, held together with rods and I-beams; adjacent to the steel plates is a layer of common brick, then a layer of kieselguhr, and then a lining of firebrick.

Metal to be annealed is placed upon large iron plates in staggered piles, so as to allow free access of the heat to all parts. The plates with the piles of aluminum are placed by crane upon small cars, and these are pushed into the furnace. It is convenient to have the tracks for the cars extending to about 20 ft. (6 m.) beyond both the front and rear doors of the furnace, so that the cold metal to be annealed may be loaded at one end, and the annealed metal withdrawn from the other end. After the anneal, the aluminum is removed from the furnace and allowed to cool in air.

Some further aspects of the annealing and recrystallization of cold-rolled aluminum sheet have[10] already been dealt with by one of the writers, and these matters will not be further amplified in this place. It will be pointed out again, however, that cold-rolled aluminum sheet after various heavy reductions may be softened to 4 to 5 Shore hardness by relatively short annealing periods at moderate temperatures. For an-

[9] Dwight D. Miller, CHEM. & MET. ENG., vol. 19, 1918, p. 254.

[10] Anderson, Robert J., "Erichsen Tests on Aluminum Sheet," *Iron Age*, vol. 101, April 11, 1918, pp. 950-951; "Annealing and Recrystallization of Cold-Rolled Aluminum Sheet," MET. & CHEM. ENG., vol. 18, May 15, 1918, pp. 523-527; "The Testing of Sheet Aluminum," *Iron Age*, vol. 102, July 18, 1918, pp. 148-149; "Annealing Cold-Rolled Aluminum Sheet, etc.," *J. Inst. Metals*, vol. 20, No. 2, 1918, pp. 203-220; "The Metallography of Aluminum," *J. Frank. Inst.*, vol. 187, January, 1919, pp. 1-47.

nealing slabs and large sheets, a car-type furnace appears to be entirely satisfactory. For annealing utensil stock, a continuous furnace will doubtless prove more advantageous.

Inspection of Aluminum Sheet

After aluminum sheets have been rolled to gage, sheared to size, and annealed if necessary, they are sent to an inspection room to avoid much trucking of the metal back and forth. Sheet aluminum may be inspected conveniently on benches about waist high. Two men should be able to handle the inspection for a mill rolling 25,000 lb. (11,350 kg.) of sheet per day. Two men are needed for inspecting, because it will be difficult for one man to turn over the larger sheets for inspection on both sides.

In mill practice, carbon copies of the orders or lot numbers should be furnished to the inspector. When a lot of metal is ready the inspector will indicate the total number of pounds accepted and rejected on his carbon copy and return this to the office. The inspector will also keep a detailed account in a book provided for that purpose of the number of pounds of sheet inspected daily, the amount passed, and the amount rejected, and make notations as to the reasons for rejection. The inspector should also collect data daily from the hot mill records with regard to the total weight of ingots rolled, and from the slab-shear reports as to the weight of slabs sheared and the scrap.

With this information, the office should render a monthly report to the superintendent showing the vital figures which affect the operation of the mill. Over a period of a year, such a report will appear as in Table XVII, giving detailed figures for defective sheets and the reasons for the defects.

A detailed explanation of the table may be advisable. Ingot weight refers to the total amount of ingots broken down in the hot mill to slabs during the periods indicated. Slab weight is the total weight of slabs after shearing; the scrap loss due to shearing averages about 10 to 12 per cent for reasons already explained. Where the scrap loss due to slab shearing is less than 10 per cent, this may be due to the fact that the hot roller broke down more ingots than a certain order called for, say eleven ingots instead of ten; the resultant slab weight would be greater than the apparent amount of metal rolled (as shown by the hot-mill lot requisitions). This happens quite often because of carelessness at the hot mill. Figures for total weight of finished sheets rolled are obtained by weighing the lots as they are delivered to the inspection department; weights for accepted and rejected sheets are taken during inspection. The sum of the weights of the finished sheets rejected because of various defects should equal the total weight of rejected sheets shown in column 5 in the table, but usually these weights do not check. The discrepancies result from errors in weighing, and neglecting to weigh part of the rejected material, as well as from mixing accepted and rejected metal. This is due, of course, to carelessness. Scrap losses resulting in rolling aluminum to finished sheets usually average about 35 to 40 per cent, as shown in column 7; this scrap figure is obtained from the formula

$$100 \quad \frac{\textit{Weight finished sheet rolled}}{\textit{Weight ingots rolled}} \times 100$$

In the same way, the total amount of scrap, including sheets rejected by the inspector, is obtained from the formula

$$100 \quad \frac{\textit{Weight finished sheets accepted}}{\textit{Weight ingots rolled}} \times 100$$

Defects in Finished Sheets

Usually, all sheets are carefully examined for surface defects, cracks, stains, buckles, scratches, etc. Whether any sheet is rejected or not will depend upon the specifications, if any, and the seriousness of the defect.

Blisters are usually sufficient cause for rejection, and this defect is one of the most serious with which the aluminum-rolling mill is concerned. Blisters are thought to result from annealing at too high temperatures; there is little doubt that high annealing temperatures *per se* are sufficient to cause blistering, but whether this

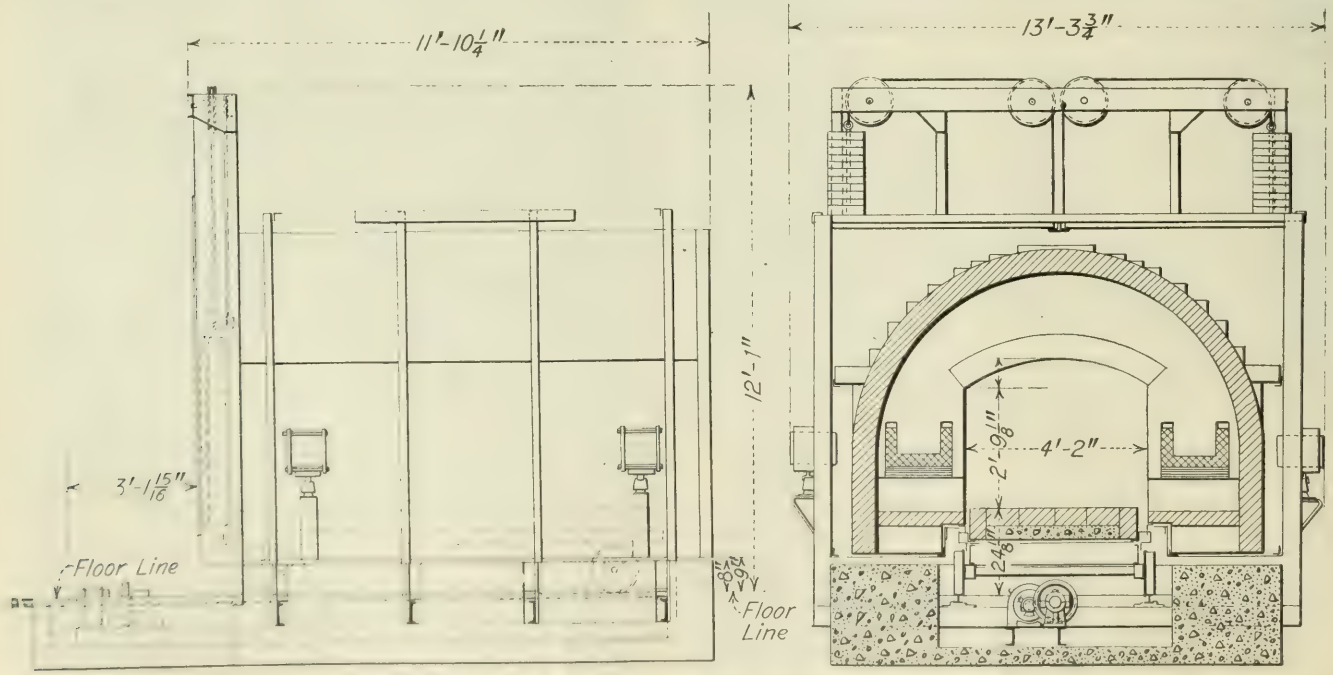


FIG. 5. CAR-TYPE ELECTRIC FURNACE (ELECTRIC FURNACE CO.)

trouble is also intimately associated with gas absorption on melting for casting into ingots is not clear. The facts are that accurate information with regard to this matter is lacking, but corrective measures to reduce the scrap losses from blistering are urgently needed.

In aluminum-rolling parlance, "slivers" are understood to describe the flaking of the metal in long splinters; this occurs on rolling, and entrained dross will usually be found associated with slivers. The explanation offered for this defect is that, during rolling, some of the mechanically entangled dross is forced near the surface of the sheet until this dross is held under a very thin film of metal. The dross is elongated in the direction of rolling, and when finally the film becomes extremely thin, the metal covering the dross flakes off in long splinters—called slivers. This is distinctly a surface defect and ruins the sheets for most purposes.

Roll marks are the buckles or waves in sheets resulting from a high ridge on the finishing rolls; where the sheets must be perfectly free from scratches, the flatter cannot be used for the purpose of ironing out the buckles, and therefore rejections follow.

Scratches result largely from handling. Pulling one sheet over another, so that the slight burr on the edge of the one sheet scrapes across the face of the other is a prolific cause of scratches. Scratches also are the result of handling on shearing, of flattening, and piling and stacking.

Cracks and splits are due to rolling, and often they can be avoided only with much difficulty. Cracks are more numerous in rolling the light alloys than aluminum itself because of their greater hardness. Sheets rolled from ingots made from high scrap heats are also fairly prone to crack on rolling.

"Dirt" means simply the entrained dross which is forced to the surface on rolling; it is sufficient cause for rejection.

Regarding stains, it is advisable to distinguish between oil stains and water stains. Oil stains are usually found on strip rolled metal, and result from the burning of residual oil during annealing. They can be largely eliminated by observing the proper amount of care in cleaning. Oil stains are various shades of brown to black color, and can be readily distinguished from water stains. Aluminum, like copper, may absorb considerable amounts of moisture even on exposure to atmospheres of high humidity; on annealing, this absorbed water is driven to the surface and may cause a whitish stain of a powdery character. This powdery product appears to be oxide of aluminum, although precise information as to its chemical composition is not available. If aluminum sheet, prior to annealing, becomes wetted with water by rain coming in through windows or skylights, it will usually have this white stain after annealing. The stain is objectionable and results in rejection of the sheets.

In column 17 wrong shearing refers to mis-shearing at the finishing shears, and usually sheets sheared wrong are sheared too narrow or too short. "Short" means the fairly large pieces which are found to be too small to shear to the required size; short sheets are the result of miscalculations, rolling the wrong size ingot, cracking on rolling, and shearing to stop further cracking. Short sheets are not necessarily a total loss, although they may not be applicable to the lot in which they were rolled; they are usually worked into other lots by re-shearing to a smaller size, or cut up into squares for circle shearing. Also, short material may

TABLE XVII. ALUMINUM SHEET INSPECTION RECORD

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
	Total Wt. of Ingots Rolled, Lb.	Total Wt. of Slabs Produced, Lb.	Total Wt. of Finished Sheets Rolled, Lb.	Total Wt. of Finished Sheets Accepted, Lb.	Total Wt. of Finished Sheets Rejected, Lb.	Percentage of Scrap Based on Ingot Wt.			Wt. of Finished Sheet, in Lb., Rejected Because of								Percentage of Scrap, Based on Finished Wt., Rejected Because of									
						Slab Scrap (a)	Finished Scrap in Process (b)	Total Finished Scrap (c)	Blisters	Slivers	Roll Marks	Scratches	Cracks and Splits	Dirt	Oil	Water	Wrong Shearing and Short	Blisters	Slivers	Roll Marks	Scratches	Cracks and Splits	Dirt	Oil	Water	Wrong Shearing and Short	Total Rejection per Cent
									—Stains—						—Stains—												
January	142,091	125,242	83,966	76,859	7,107	11 86	40 91	45 91	1,079	1,113	2,312	897	209	758	143	53	601	1 29	1 33	2 75	1 07	0 25	0 90	0 17	0 06	0 72	8 46
February	146,778	129,169	83,041	76,087	6,954	13 18	44 18	48 86	1,363	1,395	476	1,799	211	165	414		1,025	1 64	1 68	0 57	2 17	0 20	0 25	0 50		0 50	1 23	8 37
March	164,998	145,210	100,069	88,769	11,300	11 99	39 35	46 20	3,414	1,669	964	1,938	387	216	191	104	1,248	3 41	1 67	0 96	1 94	0 39	0 22	0 19	0 10	0 25	11 29
April	140,138	124,094	84,387	78,985	5,402	11 45	39 78	43 64	1,498		297		116	587	301		2,401	1 78	0 35	0 23	0 14	0 70	0 36			2 85	6 40
May	164,589	149,247	107,114	103,561	3,553	9 32	34 92	37 08	697	88	41	87	166				2,371	0 65	0 08	0 04	0 08	0 15				2 21	3 32
June	200,881	181,516	131,019	123,752	7,267	9 64	34 78	38 40	1,739		415	72	956					1 33	0 33		0 05	0 73		1 80	0 75	0 51	5 55
July	126,046	110,641	75,264	66,084	9,180	12 22	40 29	47 57	4,885	78			40		57	982	963	6 49	0 10		0 05	0 08		2 79	1 28	1 01	12 20
August	192,369	173,346	120,261	109,569	10,692	9 98	37 55	43 10	1,967	198	162	113	1,009	113	1,914	877	4,315	1 64	0 16	0 13	0 09	0 84	0 09	1 59	0 73	3 59	8 89
September	146,875	132,213	91,669	84,882	6,787	9 98	37 59	42 21	2,669	427	181			168	182	165	2,446	2 91	0 47	0 20		0 02	0 18	0 20	0 18	2 67	7 40
October	198,403	174,427	112,204	101,267	11,027	12 08	43 40	48 96	2,678	3,013	537		430	265	1,015	1,628	2,176	2 38	1 79	0 48		0 38	0 24	0 90	1 45	1 94	9 82
November	180,099	157,988	98,906	87,721	10,906	12 28	45 24	51 29	3,591	1,682	674	283	139	1,044	715	597	2,094	3 64	1 71	0 68	0 29	0 14	1 06	0 72	0 61	2 12	11 06
December	144,757	127,924	82,523	75,576	6,947	11 63	42 99	47 79	1,229	57	681	11	143	2,817	229	735	873	1 49	0 07	0 83	0 01	0 17	3 41	0 28	0 89	1 06	8 42
Total	1,950,224	1,731,017	1,170,234	1,073,112	97,122				26,809	9,017	6,637	5,316	4,295	5,904	9,258	6,105	20,971										
Average	162,519	144,251	97,520	89,426	8,094	11 30	40 08	45 08	2,234	751	553	443	358	492	772	509	1,748	2 39	0 78	0 62	0 49	0 34	0 56	0 76	0 50	1 76	8 20

1 lb. = 0.454 kg. (a) This figure includes shearings, buckled and twisted slabs, etc. (b) Finished scrap in process refers to the scrap resulting in the manufacture of finished sheets, exclusive of inspector's rejections, and includes sheet strips, buckled sheets, etc. (c) This figure embraces all the scrap and includes the finished scrap in process, plus the inspector's rejections

be put in stock and allowed to accumulate for a given period of time.

Inspection Record

If properly interpreted, inspection records are very valuable for the purpose of deciding what preventive measures must be taken to reduce scrap losses. In fact, if scrap figures are plotted weekly in the form of graphs, the interpretation may be readily had at a glance. It is not possible, in the present article, to deal with this subject in exhaustive detail, and it is the writers' object now merely to afford an insight into how inspection records may be gathered and their data interpreted. Both blisters and slivers are difficult to eliminate if high scrap ingots are rolled, but measures for preventing scratches are more obviously and easily applied. After all, the predominating factor which determines the scrap losses in aluminum rolling-mill practice, as in any other industry, is the quality of the supervision.

Shipment of Aluminum Sheets

For shipment, aluminum sheets are packed in paper and boxed or crated. Because of the relatively high value of the metal in sheet form, the packing and shipping should be carefully done. If sheets are loosely packed, so that they slide on one another in transit, there is danger of scratching even though the sheets left the mill in perfect condition.

Commercial Pottery of Japan

IT IS characteristic of Japanese ceramics that the numerous varieties have always been distinguished from one another geographically rather than technically. Thus Satsura ware, Imari ware, Awata ware, etc., names well known to foreign connoisseurs, refer to the districts in which the pottery is made. Japanese wares may be classed roughly in three groups:

1. Stoneware, including tiles and various utility objects, usually glazed and ornamented only by stamping or scoring, made in many parts of Japan and chiefly consumed locally.

2. Faience, most often with a crackle glaze, and highly decorated. It is not fired at so high a temperature as porcelain and is consequently softer and more fragile; but, for the same reason, more delicate colors may be used in decoration. Much of this sort of ware has found its way abroad under the designation of "curios."

3. Hard porcelain and semi-porcelain.

The porcelain of Japan is made in a different way from that of China. Having been fashioned, it is baked in a biscuit state, then painted with such colors as require a great heat and the glaze applied, then burned again at a much higher temperature; any further decoration in enamel colors or gilding is subsequently fired in a muffle kiln. These numerous firings are less tenacious than those used in China, hence Japanese specimens are frequently slightly out of shape.

Production and Export

The value of the earthenware and porcelain produced in all Japan for the year 1918 was 44,214,084 yen (approximately $22,107,000). The relative production of different classes of potteries for 1917 was as follows: Ornaments and art objects, 18 per cent; dishes, 56 per cent; industrial goods, 10 per cent; toys, 5 per cent; miscellaneous, 11 per cent. Table I shows the production of pottery in Japan for the years 1909 to 1918, inclusive, yen having been converted to dollars at the rate of $0.50 to 1 yen.

A glance at the export statistics will show that whereas in the first half of the decade from 1909 to 1918 the export of pottery from Japan kept about the same figure, yet from the beginning of the war the annual export steadily increased until the amount for 1918 had grown to four times the figure for 1914. Before the war the United States took nearly half of Japan's production, but in 1918 this proportion had shrunk to less than one-fourth.

TABLE I. VALUE OF THE POTTERY INDUSTRY IN JAPAN FOR THE YEARS 1909 TO 1918

Year:	Value	Year:	Value
1909	$6,178,838	1914	$7,828,428
1910	6,634,997	1915	8,766,124
1911	7,447,801	1916	12,610,174
1912	8,272,772	1917	14,669,216
1913	8,838,417	1918	22,107,042

In Table II are given the total values of exports of pottery from Japan for the years 1909 to 1918, inclusive, together with the values of such goods destined to the United States.

TABLE II. VALUE OF THE POTTERY EXPORTS FROM JAPAN FOR THE YEARS 1909-1918

Year	Total Export	Export to United States	Year	Total Export	Export to United States
1909	$2,628,416	$1,448,636	1914	$2,955,884	$1,572,374
1910	2,756,961	1,391,036	1915	3,476,476	1,455,072
1911	2,732,799	1,368,383	1916	6,051,996	1,095,694
1912	2,725,799	1,293,170	1917	7,238,967	2,470,395
1913	3,348,668	1,564,350	1918	9,976,896	2,229,467

The classes of porcelain and semi-porcelain products which enter largely into the export trade are: Tableware, including all the pieces comprised in ordinary dinner sets; sanitary ware, such as washbowls and other bathroom fixtures; electrical porcelain, such as insulators, sockets, etc.; and toys and novelties.

Tables III and IV give the analyses of a few typical Japanese kaolins, clays and porcelain stones.

TABLE III. ANALYSES OF JAPANESE KAOLINS AND CLAYS

Variety	Percentage of SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	H_2O
Shiga-raki (Kipto)	56 87	28 56	0 98	0 69	0 47	2 08	0 06	10 16
Owary (Seto)	54 65	32 35	....	0 90	0 37	3 27	2 22	6 30
Hizen (Arita)	49 25	38 89	1 14	0 15	0 36	2 01	0 39	5 90

TABLE IV. ANALYSES OF JAPANESE PORCELAIN STONE

Kind of Stone	Percentage of SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	Na_2O	H_2O
Arita stone I	78 70	14 27	1 16	0 45	2 24		3 29
Arita stone II	83 00	11 60	0 70	0 18	1 90	0 29	2 49
Amakusa stone	73 87	15 25	0 73	0 43	5 46	1 07	2 23
Kutani stone	76 60	14 75	0 86	0 29	3 91	0 65	2 68

The wages in the Japanese pottery industry are exceedingly low when compared to those received for similar work in the United States. Thus the average daily wages received by the workers during 1917 and 1918 were: Girls under seventeen, 0.60 to 1.20 yen; girls over seventeen, 0.90 to 1.30 yen; men under seventeen, 0.60 to 1.25 yen; and men over seventeen, 1.20 to 2 yen. (1 yen = about 50c.) To these figures must be added a rice stipend granted to equalize the present high cost of living.

Legal Notes

By Wellington Gustin

Governmental Power Over Manufacturers

The manufacturer and others engaged in large business enterprises have felt very keenly within the last few years the encroachment of governmental power and authority.

Just what are the limits of authority of governmental officials is hard to determine. The officials naturally appropriate all possible, feeling that the parties affected will assert their own rights and thus arrive at the proper limitation or line of authority between them. The power and authority of the Federal Government is limited to subject matters granted to it by the states, but just where this line lies is left to a determination by the courts. The power to control and regulate commerce between the states was given to the Federal Government. But what is commerce? Are you engaged in commerce which comes under Federal regulation? Are you simply a manufacturer, and as such, not amenable to certain acts of Congress?

Demand of the Federal Trade Commission

In a recent decision the United States District Court sustained the contention of the Basic Products Co. against the Federal Trade Commission, which body, pursuant to a resolution passed by it, had demanded an opportunity to examine any documentary evidence which related to the organization, business, conduct, practice and management of the corporation and its relation to other corporations, and to individuals, associations and partnerships, in order that copies may be made of any portions of said documentary evidence as appears to be relevant to the subject matter of its "investigation." Among more general demands there was the following: "In particular, the Federal Trade Commission demands that it be permitted to examine and take copies, if deemed advisable, of all documentary evidence which relates to the production costs, annual production, and capital investment in the manufacturing of a commodity known as 'Syndolag.'" After service of this demand certain examiners for the Commission presented themselves at the office of the Basic Products Co. at Pittsburgh to secure the desired information, which was refused. The Attorney General, in the commission's behalf, then asked for a writ of mandamus to compel the Basic Products Co. to allow the investigation of its records as desired. (260 Fed. Rep., 472.)

Secrets Refused by Company

The company answered the petition for the writ, saying it had developed "Syndolag," a patented article, after a great expenditure of time and money, and which, besides its other uses, is widely sold by it for repairing the bottoms of open-hearth steel furnaces, a purpose for which heretofore only imported Austrian magnesite could be used. It further averred that in the production of the article it has developed certain refinements of method which are and have been kept secret by the company and which constitute trade secrets of great value, as are also the cost accounts relating to the production of such article.

For further answer the company averred that the Navy Department ordered 250 tons of Syndolag, quoted by the company at $35 per ton, but the Department required the billing at $30 per ton; that under the order 64.9 tons were delivered, the contract being cancelled due to the signing of the armistice; that thereafter repeated demands were made by the Navy Department for affidavits showing cost of production of said article for the pretended reason of enabling the Navy to decide upon a price it would be willing to pay the company for the product; that it then offered, and still offers to accept any price for the material which the Navy may see fit to pay; that while the Navy's demands were being made it nevertheless paid for all the Syndolag delivered at the rate of $30 per ton; that it offers to return any part of such price or the whole thereof should the Navy be unwilling to fix such price; that regardless the Navy has made the demands without reason or just cause; that when the company refused finally to furnish such affidavits the Navy's demands were taken up with the Federal Trade Commission to obtain such through an assertion of its powers.

In view of these things Judge Orr, who tried the case, says it plainly appears that the Commission has undertaken to ascertain the cost of producing a product which is the subject of a patent, and to ascertain also the annual production thereof and the capital invested in its manufacture and the reasons therefor, as given in the company's answer, must be taken as true.

U. S. Has No Reserved Rights in a Patent

Then the court said that there was no reservation of right in the United States as against the inventor. The United States cannot appropriate or use the invention without just compensation in any different way than it can appropriate or use any other article owned by a private citizen.

Again it said the act of Congress under which the Commission proposed to investigate the cost of producing a patented product, in order that the Navy might acquire the same, does not in terms justify such proceeding. Instead, it said the act was aimed at unfair methods of competition in commerce, such commerce being confined to interstate and foreign commerce. The Commission more particularly relied upon section 6 of the act, in the present case, which appears to authorize proceedings without complaints being required to be served. The opening of that section is as follows:

Powers of the Commission

"That the Commission shall also have the power—

"(*a*) To gather and compile information concerning, and to investigate from time to time the organization, business, conduct, practices, and management of any corporation engaged in commerce, excepting banks and common carriers subject to the act to regulate commerce, and its relation to other corporations and to individuals, associations and partnerships."

Other subdivisions of section 6 are here given in substance:

"(*b*) The Commission may require detailed reports from such corporations under oath.

"(*c*) May investigate whether a final decree, intended to restrain any violation of the anti-trust acts, is being carried out, and upon application of the Attorney General are required to do so.

"(*d*) Upon direction of the President, or either house

of Congress, the Commission shall investigate alleged violation of the anti-trust acts by any corporation.

"(*e*) Upon the application of the Attorney General the Commission shall investigate and make recommendations for the readjustment of the business of any corporation alleged to be violating the anti-trust acts.

"(*f*) The Commission may make public information obtained, 'except trade secrets and names of customers,' and may submit recommendations to Congress for additional legislation.

"(*g*) May from time to time classify corporations and make rules and regulations for the purpose of carrying out the provisions of the act.

"(*h*) The Commission may investigate trade conditions in and with foreign countries."

Powers Claimed by Commission's Counsel

The court said it was plain that Congress intended to give the Commission a power unprecedented in its scope. The counsel contended that under the act the Commission was given the right to investigate any question having to do with any business of any corporation, except banks and common carriers subject to the control of the Interstate Commerce Commission, to conduct a hearing at any point in the United States, and compel there the attendance of any witnesses and the production of any records from any point in the United States.

But this argument, said the court, probably assumed that every corporation, with respect to which the Commission intended to conduct an investigation, was engaged in interstate commerce within the meaning of the act. And nowhere was it made to appear that the Basic Products Co. was engaged in interstate commerce in any other way than any other corporation or any citizen may be so engaged, by making one or more shipments of manufactured goods from one state to another.

Earlier Decisions Regarding Limitations of Power of Congress

Touching upon the limitations upon the power of Congress, and likewise upon the Commission in dealing with the activities of corporations or persons, an earlier decision was cited, wherein the court said:

"That neither the production or manufacture of articles or commodities which constitute subjects of commerce, and which are intended for trade and traffic with citizens of other states, nor the preparation for their transportation from the state where produced or manufactured, prior to the commencement of the actual transfer, or transmission thereof to another state, constitutes that interstate commerce which comes within the regulating power of Congress, and further, that after the termination of the transportation of commodities or articles of traffic from one state to another, and the mingling or merging thereof in the general mass of property in the state of destination, the sale, distribution, and consumption thereof in the latter state forms no part of interstate commerce."

The court then cited an opinion of the Supreme Court of the United States, discussing the lack of constitutional authority over industry (9 Sup. Ct., 101). Justice Lamar said in that case:

"Manufacture is transformation—the fashioning of raw materials into a change of form for use. The functions of commerce are different. The buying and selling and the transportation incidental thereto constitute commerce; and the regulation of commerce in the constitutional sense embraces the regulation at least of such transportation. . . . If it be held that the term includes the regulation of all such manufactures as are intended to be the subject of commercial transactions in the future, it is impossible to deny that it would also include all productive industries that contemplate the same thing. The result would be that Congress would be invested, to the exclusion of the states, with the power to regulate, not only manufactures, but also agriculture, horticulture, stock raising, domestic fisheries, mining—in short, every branch of human industry. For is there one of them that does not contemplate, more or less clearly, an interstate or foreign market? Does not the wheat grower of the Northwest, and the cotton planter of the South, plan, cultivate and harvest his crop with an eye on the prices of Liverpool, New York and Chicago? The power being vested in Congress and denied to the states, it would follow as an inevitable result that the duty would devolve on Congress to regulate all of these delicate, multiform, and vital interests—interests which in their nature are and must be local in all the details of their successful management. It is not necessary to enlarge on, but only to suggest, the impracticability of such a scheme, when we regard the multitudinous affairs involved, and the almost infinite variety of their minute details."

In the case against the Basic Products Co. its counsel contended that section 6 of the Trade Commission act was unconstitutional "in so far as it authorizes investigations and compulsory disclosures of matters which are beyond the commerce power of Congress," and also, "in so far as it attempts to authorize a search or seizure by an administrative agency of the Government without charge or suspicion of wrong doing," and urged upon the court the necessity of so declaring it. However, the court said that while this contention was probably sound, it was not necessary so to do in holding the Commission was without the power to carry on the investigation which it had assumed in the instant case.

Ruling of the Court

Says Judge Orr: "An incident of such investigation is the ascertainment of trade secrets. It is plain that the cost of manufacturing a patented product to which the manufacturer has the exclusive right may be a trade secret, a species of property of great value. This is also true of refinements of method in producing the same. The act prohibits the disclosure of trade secrets. The assumption that no such disclosure will be made disappears before the expressed intention to give the information to the Navy Department. We have then, a contemplated search and seizure, and a contemplated taking of private property for public use, without due process of law, which are violative of the Fourth and Fifth Amendments of the Constitution."

And on another point the court remarked: "It never was intended that the extent of a free man's duty to perform should be determined by those who demand performance."

Exports of Cement From United States

According to data compiled by the statistical division of the United States Bureau of Foreign and Domestic Commerce, the exports of domestic cement during the calendar year 1919 were 2,463,573 bbl., valued at $7,513,389.

Improved Apparatus for Determining Light Oil in Gas

By E. H. Bird

FOR some time the common method for the determination of light oil in coke-oven and illuminating gas has made use of a simple train of absorbing bottles. The method originally adopted by the Koppers Co.[1] specified a train of ten bottles. This has proved to be an efficient procedure and probably will always find use on account of the simplicity of the apparatus required. In a series of tests on this apparatus, when operated according to specifications, it was found to have an efficiency of 99 per cent.

For plant control tests, however, any such bottle train is objectionable on account of the excessive time and attention required to keep it in good order and to empty and refill it for each test. The oil-soaked stoppers easily slip out, the glass connections and bottles are easily broken and the rubber connections quickly wear out. For plant laboratories having regular light oil determinations to make, these are obvious disadvantages and there is too much opportunity for erroneous results due to some little carelessness in keeping the rubber parts renewed and in making the connections tight.

Double Coil Scrubber

The Koppers Co. laboratories undertook the problem of developing a more compact apparatus of adequate absorbing capacity. The work resulted in the invention of the "double coil scrubber,"[2] which has been in use in a number of laboratories for about two years. This apparatus is compact and substantial, having no glass parts, and is, at the same time, easily portable.[3] It provides for intimate contact between oil and gas, and may be emptied by turning a single valve, and refilled through a single opening.

Though designed for the absorption of light oil from coke-oven and illuminating gases, the apparatus may be used for the absorption of any constituent of a gas soluble in a liquid-absorbing medium, provided the absorbent will not attack the metal from which the apparatus is made. For instance, it is well adapted to the absorption of gasoline from natural or casinghead gas. A detachable cooling jacket provides for absorptions at temperatures other than atmospheric.

Design of Scrubber

The apparatus, as shown in Fig. 1, consists of two concentric vessels 13 and 14, made of sheet copper, each of which contains an absorbing coil shown at 4 and 8 respectively. The inner vessel 13 has an outlet pipe 10 at its lower end which is controlled by the valve 9 with handle 20. The outer vessel 14 has an outlet at the valve 12. The gas inlet pipe 1 leads downward into the inner vessel 13 and terminates in a jet 2, through which the gas passes into the coil 4. This jet is provided with an aspirator pipe 3, which forms the oil inlet of the coil. The inner chamber has a gas outlet which connects by a pipe 5 with a second jet 6, which connects with coil 8 and has aspirator pipe 7. The apparatus is filled with absorbing oil through the connection 16. The outlet gas connection from the apparatus is shown at 15. When it is desired to maintain the absorbing oil at other than atmospheric temperature, the apparatus can be jacketed. Fig. 2 shows the apparatus provided with a galvanized iron jacket and connected with a gas meter.

Operation of Apparatus

The valve handle 20 and the filling pipe 16 are opened and the valve 12 closed. About 3,000 c.c. of absorbing oil is poured into the chambers. This brings the oil level just below the outlets of each coil. The filling connection and the valve handle 20 are then closed, the inlet pipe 1 connected to the gas-sampling line and the outlet to a suitable gas meter. The gas is passed through the absorber at a definite rate, 2 cu.ft. per hr. being suitable for benzolized gas and 4 cu.ft. per hr. for debenzolized gas. The gas first passes through the inlet pipe 1 into the jet 2, from which it bubbles through the coil. In passing through this coil it is held in intimate and prolonged contact with the oil in the coil. The aspirator action of the jet is such as continually to draw fresh oil in through the aspirator pipe 3. The oil with which the gas comes in contact is expelled at the upper end of the coil. The gas then passes through the coil in the outer chamber in a similar manner and passes out to the meter. After the expiration of the absorption period the valve 9 is opened and the contents of both vessels drained from valve 12. The vessels will drain in a short time, but it is best to rinse out the apparatus by pouring in a little fresh oil in the opening 16 and shaking. The oil is then subjected to

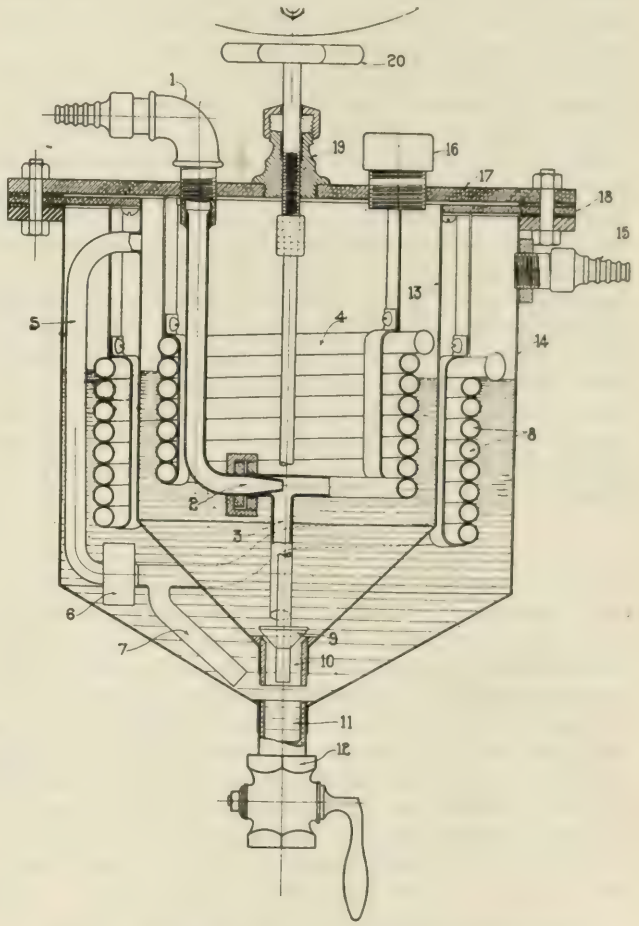


FIG. 1. SECTION OF DOUBLE COIL SCRUBBER

[1] F. W. Sperr, Jr., Met. & Chem. Eng., vol. 17, 1917, p. 550, of article entitled, "Laboratory Methods for Benzol Recovery," pp. 548-555; 586-588; 642-647.

[2] Patented by F. W. Sperr, Jr., and A. A. Kohr, U. S. No. 1,316,602.

[3] Weight of the apparatus without cooling jacket is 23 lb.

the standard steam distillation for the determination of the light oil.

The gas comes in good contact with the oil during the total length of the two coils, which is 20 ft. When the chambers are filled with the proper amounts of oil, about 70 per cent of it is contained in the outer vessel. As this is the last oil to wash the gas, the per cent enrichment does not rise so high as to cause inefficient absorption unless too large quantities of gas are scrubbed. The second chamber, in which the oil is kept separate from the first, is a necessary part of the apparatus, since no matter how thorough is the contact of oil and gas in the first chamber some light oil is lost. This loss is practically nothing at the start of the test, but increases with the enrichment of the oil. The much larger volume of oil in the outer chamber and the previous treatment in the inner chamber allow sufficient gas to be passed before appreciable losses begin to occur.

When the gas is passed through the absorber at a rate exceeding 6.5 cu.ft. per hr., a portion of the gas bubbles out of the aspirator pipes and therefore does not get as thorough contact with the gas as it should. A rate of 4 cu.ft. per hr. is recommended for testing debenzolized gas and 1 to 2 cu.ft. per hr. for benzolized gas. Five in. (water) of pressure is required to operate the apparatus unless suction is used.

This apparatus has been tested in the laboratory as follows: A measured amount of coke-oven light oil, all of which distilled under 200 deg. C., was vaporized uniformly into a current of air and passed through the absorber at a constant rate. A bottle train absorber was attached after the coil scrubber, and the light oil absorbed in this determined by the standard methods and the percentage not absorbed by the coil scrubber calculated. The whole apparatus was operated under suction in order that there should be no back pressure on the coil scrubber. The air was passed through a meter merely to keep the rate constant and to aid in vaporizing the light oil uniformly. One cu.ft. of air carried 1.5 c.c. of light oil (0.396 gal. per 1,000, imitating a coal gas rich in light oil). Three liters of absorbing oil were used in each test.

Efficiency

The efficiency of the apparatus was found to vary with the amount of light oil passed into it and with the rate of gas flow. In some cases, in order to get a measurable amount of light oil in the bottle train, fresh oil was put in the coil scrubber for two or three successive tests, the light oil in the bottle train only being determined after the last test of the series. The per cent enrichment of the oil in the two chambers of the absorber was also determined. On account of the much larger quantity of the oil in the outer chamber, the per cent enrichment is quite low until the oil in the first chamber is nearly saturated.

TESTS AT 2 CU.FT. PER HR.

Test Nos.	C.c. Light Oil Vaporized in Each Test	Per Cent Saturation Inner Chamber	Per Cent Saturation Outer Chamber	C.c. Light Oil in Bottle Train	Per Cent Efficiency of Coil Scrubber
1, 2 and 3	30	2 42	0 22	0.0	100.0
4 and 5	45	2 70	0 706	2.6	97.1
6 and 7	60	2 93	1 12	7.6	93.7

Obviously, the efficiency might also be determined by ascertaining the percentage of light oil absorbed. By such a method, however, the effects of distillation losses are undoubtedly exaggerated. For instance, a distillation loss of 3 per cent of the light oil absorbed in the scrubber would have a much greater effect on the efficiency figure than a distillation loss of 10 per cent of the light oil in the bottle train. Figures obtained for the efficiency of the apparatus by this second method will be given here for what they are worth. By means of blank tests, factors for distillation

FIG. 2. DOUBLE COIL SCRUBBER WITH COOLING JACKET AND CONNECTED WITH GAS METER

loss with different quantities of light oil were determined and applied in the use of this method. Even these corrections are somewhat uncertain on account of the exaggerated effect of small losses. After the application of these factors, the efficiency of the apparatus was found to be the following:

	Per Cent
Tests 1 to 3	98.2
Tests 4 and 5	96.0
Tests 6 and 7	90.0

Tests made at 4 cu.ft. per hr. showed the absorption to be less complete at that rate. When 45 c.c. of light oil was vaporized at that rate, an efficiency of 92.5 per cent was indicated.

It will be seen from the foregoing tests that in testing unscrubbed coal gas an absorption efficiency of practically 100 per cent should be obtained if an amount of gas is used containing about 30 c.c. of light oil. The efficiency with the gas volume containing 45 c.c. of light oil is 97 per cent, which is satisfactory for all plant control processes, and it is recommended that in testing unscrubbed gas the amount of light oil absorbed should not exceed 45 c.c. Tests on unscrubbed gas can be made at a rate of 2 cu.ft. per hr. Debenzolized gas can safely be run at 4 cu.ft. per hr.

The Koppers Co. Laboratories,
Mellon Institute, Pittsburgh, Pa.

Revival of Salt Industry at Inagua, Bahama Islands

American capital operating under the name of the Inagua Salt Co., Ltd., will be responsible for a revival of the salt industry of Inagua, Bahamas. The work is already under way and it is estimated that Inagua will soon be exporting 3,500,000 bushels of salt a year to the United States. The company proposes using several light-draught, three-masted auxiliary schooners for handling this export. Motor trucks and railway trucks will be employed for taking salt to shipping points.

Synopsis of Recent Chemical & Metallurgical Literature

Corrosion of Condenser Tubes.—The fifth report of the Corrosion Committee, presented by GUY D. BENGOUGH, R. M. JONES and RUTH PIRRET at the spring meeting of the Institute of Metals, is confined to the corrosion of condenser tubes (mainly 70:30 brass), and is a study of the practical problems of corrosion in condensers under service conditions, employing either sea water or fresh water. It is divided into four sections.

The first section deals with what has been called the diagnosis of condenser tube corrosion. The procedure to be followed in withdrawing and preparing a tube for examination is described, also the symptoms or appearances within the tube which correspond to each of the five main types into which the practical problems of corrosion under fresh-water or sea-water conditions have been classified. The importance of additional information concerning (*a*) the water supply and (*b*) the corroded tubes toward elucidating the cause of corrosion is shown and emphasized. This information, which is specified, has rarely been obtainable in the past, particularly as regards the water supply, and this may partly account for the lack of appreciation of the importance in corrosion troubles of the conditions existing within the plant. These conditions frequently vary very much from time to time, and it is shown that although the conditions which favor accelerated corrosion may be present for but short periods at irregular intervals, and consequently may not be easily detected, the effect on the tubes may still be very serious. Also in certain cases it is shown that accelerated, localized corrosion may persist after the initiating conditions have disappeared.

The second section is devoted to a consideration of certain features in the structure of condenser tubes, since an appreciation of these is of great value in following the mechanism of the types of corrosion studied later. Attention is principally directed to the presence on the tubes of a surface layer consisting of structureless and highly distorted metal. This layer has undoubtedly a greater resistance to corrosion by saline and fresh waters than the underlying crystalline metal, so that whenever this layer is penetrated corrosion will proceed at an increased rate. The layer has been stripped from a number of tubes of different composition. Its thickness is usually of the order of 0.01 mm., and indications have been obtained that its composition may be somewhat different from that of the underlying metal.

In the third section the five main types of brass condenser tube corrosion are considered separately in detail.

Type I. General Thinning.—This type may be considered as an accelerated form of the complete corrosion which normally occurs in saline solutions, in so far as the tube is gradually and uniformly reduced in thickness. The rate of ordinary complete corrosion is too slow to be of any serious consequence in practice; laboratory experiments with running sea-water have shown that a period of fifteen to twenty years may elapse (even presuming that the rate of corrosion is uniform and does not decrease with time) before a tube is reduced 50 per cent in thickness from this cause. Tubes almost always fail in practice by local action of some kind long before ordinary complete corrosion has seriously reduced the thickness of the tube. Rapid general thinning, however, is essentially a fresh-water phenomenon and is usually associated with the presence of free acid in the water supply. The results of tests on ten samples of tube of widely different composition in hydrochloric acid of concentration 3 parts in 100,000 at ordinary temperature show that in six weeks all tubes had lost from 2 to 4 per cent in thickness. That such a very dilute acid should reduce the thickness of a tube so much in such a short time at ordinary temperature is ample evidence of the serious effect of acid in the water supply upon the life of condenser tubes. Proper neutralization, preferably at the source of contamination, is an effective remedy for this trouble, but considerable difficulty may be experienced in detecting the acid, especially if, as is generally the case, it enters the water supply only intermittently. Regular and frequent tests of the water must be made when this type of trouble occurs.

Type II. Deposit Attack.—The principal cause of pitting which is the most frequent source of trouble in condensers is ascribed to what is termed "deposit attack." In the presence of sodium chloride solutions the cuprous oxide formed on a brass surface gradually changes to cuprous chloride. The latter is usually swept out of a condenser tube by the circulating water, but under various conditions may adhere at different parts of the tube surface. When such adherence has occurred, conditions now allow of the further gradual change of the insoluble cuprous chloride under the influence of oxygen to soluble cupric chloride and cuprous oxide. The action of cupric chloride solution on brass is very rapid, as may be gathered from the fact that a piece of brass tube 2 in. long, placed in a strong cupric chloride solution at ordinary temperature, was completely disintegrated and partially replaced by a pseudomorph in copper in two days. The action involves the oxidation of the copper and reduction of cupric chloride to cuprous chloride; redeposition of copper from solution by the zinc also occurs. In the presence of air cuprous chloride will again be converted to cupric chloride and the attack on the brass continued. Thus the action is both recurrent and local. Foreign bodies, and particularly colloidal bodies, lying in the tube have an injurious effect by serving as loci for the adhesion of cuprous chloride and by preventing the diffusion of cupric chloride. Observations on the incidence and distribution of pits in condenser tubes are shown to agree with the results which would be expected to follow from the above explanation of the mechanism of pitting. Attention is drawn to the importance of keeping tubes clean and as free as possible from foreign bodies as a means of preventing deposit attack.

Type III. Layer Dezincification.—An account is given, preliminary to the consideration of this type of corrosion, of the mechanism of so-called dezincification. The conclusion is reached that true parting of zinc and copper in a 70:30 brass does not occur but that the so-called residual copper is always redeposited copper. Dezincification is therefore only apparent and

not real, and the term is always subsequently employed by the authors in this sense.

The layer type of dezincification, which is characterized by disintegration of the brass tube and redeposition of copper over large areas, has been found to occur under both marine and fresh-water conditions. Several ways in which such action may occur are indicated. Under fresh-water conditions it is often associated with acid water, particularly if the acid is not too dilute and the access of oxygen is not very easy.

Type IV. Plug or Local Dezincification.—This type of local corrosion may be regarded as a form of deposit attack, as it always proceeds beneath a deposit and is stimulated by the presence of foreign bodies. It differs, however, in many ways from Type II. So far as is known it occurs only in sea water (or diluted sea water), and is always associated with adhering white salt consisting of colloidal zinc oxychloride (also containing some carbonate). It is readily reproducible in the laboratory, as it occurs spontaneously on the surface of 70:30 brass tubes after immersion in seawater at elevated temperatures (40 to 50 deg. C.) for a few days; and is hence rather more amenable to experimental study than the previous types of corrosion. It is shown that the production of the right concentration of zinc in the liquid layer adjacent to the corroding brass surface plays a large part in the formation of the characteristic white oxysalt, and that interference with the production of this condition, e.g. by lowering the zinc content of the brass or by raising the zinc content of the sea water, is sufficient to prevent its occurence. The dezincifying action is thought to be due to a small concentration of hydrochloric acid contained within the colloidal white salt. The difference in behavior of different batches of 70:30 tube—some always showing local dezincification, others never—persists after annealing or pickling, or both, and the reason for the difference in behavior is still not clear.

Type V. Water-Line Attack.—In the case of a brass tube only partially immersed in sea water, increased corrosion (compared to that of the immersed portion) takes place, not at the water-line as is commonly supposed, but above it, and sometimes as much as 2 cm. above the surface. Further, the attack is not uniform but is concentrated at areas where salt deposits have formed and is coterminous with the area covered by the deposits. Narrow bands of salt connect the seawater with the deposits. This type of corrosion is obviously a special form of deposit attack, taking place under the most favorable conditions inasmuch as the attack beneath the deposits is much more severe than in any of the previous types of corrosion. This type of attack may occur at the inlet end of condenser tubes when entangled air clings to the surface of the tube and is prevented by eddying effects from being swept away by the water-flow.

The fourth section of the report contains an account of preliminary work on the electrolytic protection of condenser tubes. The particular question investigated was that of the efficiency of electrolytic protection in preventing deposit attack, i.e. attack by cupric chloride solution. A piece of 70:30 brass tube made cathode to strip iron in a normal cupric chloride solution is very distinctly attacked, despite the small current passing from the solution to the brass. It is considered that an electric current slows down but does not necessarily inhibit corrosion of a cathode. By raising the current density sufficiently it is possible that all corrosion even in a cupric chloride solution may be prevented. Experiments have shown, however, that a current as large as 20 to 25 amp. per 1,000 sq.ft. is insufficient to prevent a 70:30 brass tube from being rapidly corroded by such a dilute solution of cupric chloride as a one-twenty-fifth normal solution. Some suggestions are made whereby the usefulness of the electrolytic protection process may be extended by special manipulation of it in the early part of the life of a tube, with the object of forming a thin continuous layer of calcium carbonate over the surface of the tube.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Manufacture of Cement in Electric Furnace.—The ground constituent materials are introduced into an electric furnace the upper part of which consists of a vertical shaft while the lower part contains the electrodes. During their passage through the shaft, the materials are heated and are finally melted in the lower part of the furnace. The molten product is tapped at intervals and cooled suddenly by water or by air. (1,332,422; MAURICE L. BOILLOT and JEAN DAUDIGNAC of Moutiers, France; March 2, 1920.)

Solvent for Acetylene.—The use of cement in the mixture used as fillers for acetylene gas containers is desirable, but the free lime present in the cement reacts with the acetone in an objectionable manner. This difficulty may be avoided by adding to the acetone a quantity of ethyl acetate (or other ester of an organic acid) sufficient to react with the lime in the cement:

$$Ca(OH)_2 + 2CH_3COOC_2H = Ca(OCOCH_3)_2 + 2C_2H_5OH.$$

For example, the filler for a standard acetylene container such as is now used may be composed of:

Portland cement	8 lb. 8 oz.
Kieselguhr	8 lb. 8 oz.
Asbestos fiber	15 oz.
Water	28 lb.
Charcoal	1 cu.ft.

This mixture is introduced into the tank, allowed to harden and thoroughly dried. If the cement contains 1 per cent of free lime, i.e., 1.4 oz., about 3.5 oz. of ethyl acetate should be added to the acetone before adding this to the tank. (1,332,525; HENRY S. SMITH of New York and GEORGE O. CURME, JR., of Pittsburgh, Pa., assignors to the Prest-O-Lite Co., Inc.; March 2, 1920.)

Sulphur Retorts.—In these patents, two retorts somewhat resembling a Kelly filter press in design are described. They consist essentially of a cage into which the sulphur bearing rock is introduced and a housing into which the cage moves when charged. Steam is admitted and the cage rotated. The molten sulphur collects in the shell, from which it is discharged through a valve. (1,332,537; FRANK W. BECRAFT and ALBERT L. GENTER of Salt Lake City, Utah, and 1,332,542; WILLIAM E. CLIFFORD of Salt Lake City and THOMAS H. GREEN of Springfield, Ill.; both assigned to United Filters Corporation; March 2, 1920.)

Sodium Permanganate.—The oxidation of sodium manganate by means of chlorine is catalyzed by the addition of $Co(OH)_3$, which has the additional function of decomposing hypochlorites according to the equation:

$$2NaClO = 2NaCl + O_2$$

Thus, by using an excess of chlorine the free alkali present may be converted into sodium chloride. This prevents decomposition of the permanganate:

$$4NaMnO_4 + 4NaOH = O_2 + 2H_2O + 4Na_2MnO_4$$

Since the formation of hypochlorites and consequently of chlorates is prevented, the solution contains principally sodium permanganate and sodium chloride, which may be separated by crystallization. (1,330,032; ROBERT E. WILSON of Cambridge, Mass.; Feb. 3, 1920.)

Process of Concentrating Liquids.—It is possible to concentrate solutions without heating above 100 deg. F. by adding anhydrous sodium sulphate to the solution heated to the point of maximum solubility of sodium sulphate. Upon cooling crystals of the hydrated salt (Glauber's salt) separate and thus remove a considerable amount of water from the solution. Other anhydrous salts may be employed in the same manner. (1,330,016; GEORGE T. WALKER of Minneapolis, Minn., assignor to Colonial Chemical Co.; Feb. 3, 1920.)

Extracting Thorium From Monazite Sand.—The following procedure is suggested by OTTO N. BERNDT of Chicago: 500 lb. of monazite sand, which has been concentrated by means of a magnetic separator to remove ilmenite and other magnetic constituents and contains about 9 per cent thorium oxide, is treated with about 475 lb. of fuming sulphuric acid stronger than 66 deg. Bé., containing preferably about 5 per cent excess sulphur trioxide. The mixture is heated for a period sufficient to decompose the sands and to convert the thorium into an insoluble compound, the heating preferably being at such a rate that a temperature of 200 to 230 deg. C. is reached in between 3 to 4 hr. At this point the rise in temperature becomes more rapid, due probably to heat evolved by the reacting mass in substantial amounts, attaining a temperature of 300 to 350 deg. C. in from one-half to one hour. The reaction mass becomes greenish-yellow in color and is in stiff plastic state, capable of being further stirred. At this point external heating is stopped and the mass is permitted to cool for several hours while being stirred and is removed from the baking pot or digester. The product is a thick pasty mass weighing about 950 lb. The mass removed from the digesters is treated in suitable tanks with a sufficient quantity of water, preferably about 900 gal. for the above amount. A slight agitation of the solution which has a slight acidity will keep the insoluble thorium compound in suspension, while the heavier siliceous residues will settle to the bottom. The suspension of the thorium compound may be decanted and filtered, the thorium compound remaining as a residue on the filter in a greatly concentrated state and suitable for further purification. (1,329,747; assigned to Lindsay Light Co.; Feb. 3, 1920.)

Production of Cyanides.—This invention relates to an improved form of furnace for carrying out the fixation of nitrogen according to the Bucher process (U. S. Pat. 1,120,682; Dec. 15, 1914.) Briquets are formed of sodium carbonate, pulverized coke or charcoal and finely-divided iron. These are fed into a vertical retort and are treated counter-currently with nitrogen while heated to about 1,000 deg. C. As cyanide is formed, it fuses and binds the briquets together upon reaching the relatively cooler zone below the furnace. Here an eccentric rotating device breaks fragments from the bottom of the column. The broken material passes to a shallow cooler, from which it is delivered at a temperature but little above atmospheric. (1,329,721 and 1,329,722; WILLIAM D. MOUNT of Saltville, Va., assignor to Nitrogen Products Co.; Feb. 3, 1920.)

Cement From Low-Grade Carboniferous Material.—Certain materials such as oil shale, lignite and cannel coal can not be economically used as fuel because of the large amount of fixed carbon which is retained by the argillaceous ash. ROBERT W. LESLEY of Haverford, Pa., has found that this ash is a suitable material for the manufacture of portland cement in combination with calcareous or other ingredients. The carboniferous material is first destructively distilled in suitable retorts, ammonia and other valuable volatile products being recovered from the vapors. The fixed gases assist in heating the kiln referred to later. The ash from the retorts is mixed with limestone and subjected to a clinkering process in a gas or oil fired rotary cement kiln. The fixed carbon in the ash supplies a portion of the heat required in the operation. The hot gases from the kiln serve to heat the retorts for the distillation of further quantities of material. (1,323,294; Dec. 2, 1919.)

Dinitrochlorbenzene and Sulphur Black.—The nitrating agent employed is a mixture of 2,800 lb. H_2SO_4 (66 deg. Bé.) and 610 lb. $NaNO_3$. This is heated to 25 deg. C. in a jacketed cast-iron kettle and 400 lb. of chlorbenzene is added slowly, keeping the temperature between 45 and 50 deg. C. After the total quantity has been added the temperature is allowed to rise to 60 deg. C. The mixture is then heated to 115 to 120 deg. C. until nitration is complete. Upon pouring into water, the dinitrochlorbenzene separates. The product contains about 90 per cent of the 1.2.4 form and 10 per cent of the 1.2.6 form. It may be converted directly into sulphur black without first preparing dinitrophenol: 100 lb. of the product is heated with 500 lb. H_2O and 55 lb. NaOH, forming sodium dinitrophenate. A fused mixture of 210 lb. Na_2S crystals and 102 lb. S is then added and, after an hour, the mixture is heated under pressure for 12 hr. at 120 deg. C. The sulphur black is then precipitated by waste acid from the nitration step. (1,330,074; RICHARD HEYDER of Forest Hills, N. Y., assignor to Williamsburg Chemical Co., Inc.; Feb. 10, 1920.)

Silicon Carbide.—The formation of vapors of silica and silicon during the operation of a carborundum furnace results in an increase in the ratio of silica to carbon in the upper part of the furnace and the product is not uniform. OTIS HUTCHINS of Niagara Falls obtains a uniform product by using a mixture below the resistor core which contains proportionately more silica than that above the core. Thus, the lower portion may contain 100 parts C to 194 parts SiO_2, while the upper portion may contain 100 parts C to 170 parts SiO_2. (1,331,435; assigned to the Carborundum Co.; Feb. 17, 1920.)

Current Events
in the Chemical and Metallurgical Industries

The Shawinigan Industries

A joint meeting of the American Section of the Society of Chemical Industry with the New York Sections of the American Chemical Society and the American Electrochemical Society was held in Rumford Hall on Friday evening, April 9. Dr. H. W. Matheson, general manager, Canadian Electro Products Co., outlined the growth of one of the most interesting and promising electrochemical centers in America—Shawinigan Falls, Que.

Hydro-Electric Developments

Shawinigan Falls is on the St. Maurice River, about twenty-two miles north of the mouth of the river, and about equidistant from Montreal and Quebec. At Shawinigan Falls the river drops 150 ft. and is capable of developing about 250,000 hp. The Shawinigan Water & Power Co. installed two 5,000-hp. waterwheels and generators about 1900. In 1910 the plant had grown to 60,000 hp. and the present capacity is 200,000 hp., the latest installation being five direct-connected generating units, each complete with its double runner horizontal turbine, developing 20,000 hp. at the normal operating head of 150 ft. and a speed of 225 r.p.m.

The St. Maurice valley is one of the finest waterpower sites in the world. Two hundred miles above Shawinigan Falls, the great La Loutre dam (1,800 ft. long, 70 ft. high) impounds the headwaters of the river, forming a lake 360 square miles in area. When full, this reservoir contains enough water to generate one billion kw.-hr. in the existing hydro-electric plants, and thus serves to regulate the power output during periods of low water. Other hydro-electric plants are located at Grand' Mere and Gres Falls, so that the total power developed amounts to about 320,000 hp. at present, with 1,100,000 hp. estimated as the future capacity of the St. Maurice valley.

General Industrial Situation

Of the total power developed, 130,000 hp. is required by the chemical and electrochemical industries at Shawinigan Falls. Among the plants using large quantities of electric power may be mentioned:

The Northern Aluminum Co., which started in 1901 as the Pittsburgh Reduction Co., produces 60 tons of aluminum (pig, wire and cable) per day, using Louisiana bauxite. About 800 men are employed.

The Belgo Canadian Pulp & Paper Co. has a capacity of 165 tons of groundwood pulp, 100 tons of chemical pulp and 90 tons of paper per day.

The Canada Carbide Co. has a plant covering about fifteen acres. The furnaces require about 40,000 hp. and operate on three-phase, 30-cycle and three-phase, 60-cycle power, producing about 200 tons of calcium carbide per day. Coke is obtained from the Montreal Heat, Light & Power Co.

The Shawinigan Electro Metals Co. began operations in 1915 and is now producing magnesium in stick and powder form and is making a careful study of magnesium alloys.

The Canadian Carborundum Co. will soon require 20,000 hp. for the manufacture of carborundum, aloxite and ferrosilicon.

The Canadian Ferro-Alloys Co. uses 6,000 hp. in the preparation of ferrosilicon and ferrochrome.

The Canadian Electrode Co. supplies the other companies with amorphous carbon electrodes.

Acetone From Acetylene

The most interesting portion of Dr. Matheson's paper was devoted to the work of the Canadian Electro Products Co. in producing glacial acetic acid and acetone from acetylene. A brief résumé of the process will be found in Chemical and Metallurgical Engineering, vol. 21, Oct. 29-Nov. 5, 1919, p. 575, and a more detailed discussion will be published at an early date. The process may be divided into five stages:

1. Production of acetylene from calcium carbide.
2. Production of mercuric oxide from mercury.
3. Production of acetaldehyde from acetylene.
4. Oxidation of acetaldehyde to acetic acid.
5. Conversion of acetic acid into acetone.

In the production of acetylene, the carbide was allowed to drop upon aluminum plates in the generators, thereby preventing frictional sparks which might result in explosions. In regard to the second step, the speaker said that the electrolytic oxidation process for the preparation of mercuric oxide had been discarded but no details of the new process were given. Explosions in the brine condensers used in separating the acetic acid formed in step 4 were traced to peracetic acid which is formed at low temperatures in mixtures of air, acetaldehyde and acetic acid.

In conclusion, the speaker predicted a steady growth for Shawinigan Falls as an industrial center, since it can sell power in competition with any country in the world (not excepting Norway and Sweden), is free from labor agitations and is well located for export trade.

Mechanical Engineers' and Chemists' Meeting

On Thursday, April 29, the midcontinent section of the American Society of Mechanical Engineers and the Oklahoma section of the American Chemical Society will hold a joint meeting.

During the morning session the routine business of each section will be attended to and officers for the coming year will be elected. In the afternoon and evening a series of interesting papers will be presented. Among those who have prepared papers are: Dr. C. K. Francis, Cosden & Co., Tulsa; D. E. Foster, Foster & Gilmore, petroleum engineers, Tulsa; Prof. Fred W. Padgett, Oklahoma University, Norman; J. E. Stillwell, Empire Gas & Fuel Co., Bartlesville; Prof. Hilton I. Jones, Oklahoma University, Norman; Arthur Frank, consulting engineer, Tulsa; Mortimer E. Cooley, dean of College of Engineering, University of Michigan; Ernest Hartford, secretary of the A. S. M. E.

Amalgamation, With Special Reference to Steaming of Amalgamation Plates

At the Nov. 15, 1919, meeting of the Chemical, Metallurgical and Mining Society of South Africa a sub-committee consisting of S. H. Pearce and J. E. Thomas reported on the practice of steaming amalgamation plates. In order to get an authoritative opinion questionnaires were sent to all mill-manager members, and the answers, which were received from about half the members to whom questionnaires were sent, were used as a basis for the committee's remarks.

A diversity of opinion exists as to the desirability of steaming; some hold that because of the danger to the health of the workmen the practice should be prohibited, others that it is a necessary operation. The question resolves into one to be considered from the point of saving of labor and the health of the workmen.

Under certain conditions amalgam will accumulate on plates and its removal is laborious unless steam is used to soften the deposit. Depending upon its hardness, the deposit may be removed by scouring or may require the use of chisels. The conditions which affect the quantity and quality of the deposit of amalgam may be roughly divided into two classes, provided such deposits as are allowed to accumulate for the purpose of regulating output are excluded.

Factors Affecting the Class of Deposits

One class of deposits is due to the conditions of the plate—whether hard or soft—the grade or slope of the plate, the frequency of dressing. If a comparatively large amount of amalgam is left on the plate, more mercury can be used in dressing and the plate will remain soft and in good receptive condition longer than a comparatively bare plate under similar conditions. Such plates are scraped lightly and produce when steamed a large return. This method gives a high return by amalgamation with a minimum of labor but holds back gold. A similar condition of the plate may be obtained with the retention of a minimum amount of amalgam, but to obtain this result there are required more frequent dressing, hard scraping every day and probably also a thorough scouring every other day. This results in a high amalgamation return but requires a maximum of labor. Steaming would not be advocated under these conditions. A variation is found in less frequent scouring but in place of steaming a thorough monthly clean-up.

A second class of deposit is due to conditions over which the operator has little, if any, control. These include design of plant and peculiarities of the ore. In the case of a plant with launders of insufficient grade a high water-to-ore ratio is necessary and the plate area is unnecessarily large; on the other hand, modern plants with correct or probably excessive launder grade are economical in plate area. These conditions affect the grade of plate, 18 per cent being necessary in one case and 8 per cent in the latter. Apart from overcrowding of the plate areas, the steeper slope causes difficulty in control of plate condition. With a bare plate there is nothing to overcome the tendency of the mercury to run off the plate and it is necessary to choose between leaving a deposit on the plate and very frequent dressing. In either case the amalgam will harden more rapidly near the top of the plate and its removal will require more labor whether by steaming or by other means.

The degree of alkalinity of the mill water also affects plate accumulation in that an excess of lime hardens the amalgam. In some mills variation in the acidity of the rock make it difficult to regulate the alkalinity, and in these cases a scrape made in the usual way leaves a considerable quantity of amalgam, which may be removed by steaming. The fineness of the gold is also a minor factor. Coarse gold particles produce an amalgam that is easily removed, but the opposite is true where fine particles are present, and these if present in large proportion tend to produce an amalgam containing a higher percentage of gold and show a greater tendency toward accumulation.

Effect of Steaming Amalgamation

Dealing with the facts as they appear, the committee was of the opinion that steaming can be considered only as a means of saving labor, making it possible to remove plate accumulations with the least difficulty, as otherwise in the absence of a mechanical device a large amount of labor would be incurred in most instances.

As regards the effect of steaming amalgamation plates on the health of the workman, there is no doubt that, as with many other ailments, idiosyncracy plays a very large part and certain men suffer from some sort of indisposition after taking part in the operation. In many instances there is probability of mercurial affection, but in at least as many others it is equally probable that the indisposition is due to overexertion and poor health. It seems probable that the practice of eating meals with unwashed hands is far more dangerous as a means of conveying mercury into the system.

The precautions to be observed consist of:

Ample ventilation of plate-houses.

Exhaust steam from plates to be led outside of building.

Selecting men for the work who are known to be immune.

Division of the work to prevent overexertion.

Provision of wash basins, mouth washes, etc.

The report of the committee was followed by a discussion in which members and visitors took part. In the discussion additional points were brought out by those in favor of and opposed to the steaming of amalgamation plates.

List of Commercial Organizations in the United States

A revised edition of a publication that has proved to be a useful desk book among persons engaged in domestic trade has just been issued by the Bureau of Foreign and Domestic Commerce. It is designated Miscellaneous Series No. 99, "Commercial and Industrial Organizations of the United States," and supersedes the first edition issued in 1917. The publication gives the title and secretary's address of practically all active interstate, national, and international commercial organizations, classified both alphabetically and by industry. City commercial organizations are arranged by states, with the address of the secretary and data as to number of members, annual income, and date of annual meeting. The present edition is a complete revision in all particulars, only those associations which made reply to the Bureau's request for information being included.

Washburn's Testimony on Government Nitrogen

Charging that less than 1 per cent of the cost of fertilizer could possibly be given to the farmers as a benefit from operation of the Government plant, even if all the estimated saving could successfully be transferred to the ultimate price of fertilizer, Frank S. Washburn, president of the American Cyanamid Co., opposed before the Senate Committee on Agriculture the War Department's proposal to operate the cyanamide plant at Muscle Shoals. Mr. Washburn objected also to the proposal that the further financing of these plants be accomplished by selling sodium nitrate now held in reserve by the Government.

Criticism of Nitrate Program

Starting on the assumption that nitrates and ammonium compounds are not interchangeable sources of nitrogen for fertilizer or industrial chemical use, Mr. Washburn undertook to demonstrate that we had a large surplus capacity for ammonia production at the present time and that increase in this capacity as proposed for Muscle Shoals would only make it necessary to increase our dependence upon Chile for nitrates. He argued that every increase in the output of ammonia for fertilizer use must be accompanied by a corresponding increase in consumption of nitrates, since otherwise a properly balanced plant food will not be obtained. Mr. Washburn presented a very complete history of the nitrogen fixation developments in this country from the first work in 1907 at the Canadian cyanamide plant through the proposals made to the Government about the same time up to the Muscle Shoals hydro-electric company proposal in 1916. Various recommendations to the Ordnance Department and the Government's committees on nitrogen supply and other activities extending into the first six months of the war period were set forth at length in an attempt to discredit altogether the War Department policies. It was charged that work on the Haber process had resulted simply in wasting $13,000,000 without developing any successful plant or even a successful process. The cyanamide company had placed at the disposal of the War Department convincing evidence that this would be the result, but "the committee did not even accept the offer of the company of these proofs."

No Market for Cyanamide

Mr. Washburn claimed that the results from the cyanamide plant at Muscle Shoals had been 100 per cent satisfactory, the cheapness, purity of the product and capacity of the plant all being greater than expectations. He stated that if this plant had run three years under the contract and the agreements between the War Department and the Air Nitrates Corporation, the Government would have saved not only all of its costs and investment in the plant but a considerable sum in addition. On the other hand, the present result to the company after payment of taxes, losses, etc., is that there is nothing left. He denied that his company was interested in any negotiations to purchase this plant from the Government, as at the present time he believed that the real problem was how to find a market for the product from this plant. Cyanamide nitrogen, characterized as "the cheapest form of nitrogen," is available to the extent which the market now demands in this form, and operation of the Government plant throws upon the market an additional supply to the detriment of private interests, with no advantage to the Government.

Classifying the various sources and kinds of nitrogen for fertilizer supply, Mr. Washburn came to what he considers "the crux of the situation," which is the fact that ammonium sulphate cannot replace sodium nitrate in fertilizers. This is because only the nitrates are assimilated by the plants directly and the ammonia compounds must first be nitrified by bacterial action, which is very slow in the spring of the year when the benefit of fertilizer on plant growth is most important. He also claimed that in other industrial chemical uses the ammonium sulphate should not be regarded as in any sense a possible substitute or source for a substitute of nitrates.

With reference to the manufacture of nitrates at Muscle Shoals, he claimed that even if the plant was fully amortized and that no charge were made for power, yet it would not be a profitable proposition for the Government to continue operations there, as the market is not available for the product. He insisted that $38,000,000 more would have to be spent by the Government to complete the project at Muscle Shoals and that it was altogether out of the question to economically accomplish the additional development necessary under the War Department proposal with present costs.

Alternate Plan Proposed

Asked what alternate plan he proposed, he recommended that the plant be kept in condition ready for use in production of explosives in case of war, and that the Government hold itself in readiness to sell the plant to private interests whenever market conditions justified this. He insisted that no one would be willing to buy the plant at the present time but that the plant would probably not become obsolete in the near future, as the processes and equipment were already too fully standardized to permit this.

Estimated Requirements of Fixed Nitrogen

The charts which were presented to support the above conclusions were based upon projecting the normal increases in demand for nitrate and ammonia before the war up to 1930. For this latter year Mr. Washburn estimates a demand for 875,000 tons of sodium nitrate, 775,000 tons of ammonium sulphate or its equivalent in cyanamide and that surplus ammonia capacities would be available as follows: (*a*) assuming only a normal increase in pig iron production, 125,000 tons of ammonium sulphate surplus; (*b*) assuming that one-half the beehive ovens were converted to byproduct ovens an additional 165,000 tons of ammonium sulphate; (*c*) assuming full conversion from beehive to byproduct ovens a still further amount of 165,000 tons ammonium sulphate per year, and finally, (*d*) assuming that the Government Muscle Shoals plant is operated, 200,000 tons of ammonium sulphate additional surplus. The total demand and surplus thus estimated for 1930 are 2,325,000 tons computed as ammonium sulphate equivalent. Another chart estimated the world nitrogen resources in 1919 as 1,500,000 tons of nitrogen, of which about 900,000 tons finds ready market, the remainder being surplus capacity. This surplus capacity is shown by the charts as just equivalent to the sum of the capacities of the Haber and the cyanamide processes, which are given as 300,000 tons each per year. Projecting this curve to 1930, it was estimated that the demand for nitrogen in that year would amount to 1,280,000 tons of nitrogen, which is less than the present capacity for nitrogen production as estimated.

Portland, Oregon, a Shipping Point for Phosphate Rock

To facilitate the shipment of phosphate rock in bulk from the United States to Japan, Portland is erecting bunkers with a capacity of 20,000 tons, on its newest municipal terminals. These will be completed late in July or early in August. The new bunkers are to be equipped with mechanical conveyors for unloading the rock from the cars, in which it is brought from Idaho, into the storage bins. It is then loaded directly into ships for ocean transportation. The bunkers will be capable of loading a vessel of any size with a full cargo in one day.

Portland had an advantage over Seattle in a differential of one dollar in the rail rate from the producing center to the seacoast. The advantage of Portland over San Francisco lay in the fact that lumber is desired for shipment in part cargo lots with phosphate rock to balance the cargoes. As rock is exceedingly heavy, a vessel loaded with it alone would be down to the load line before all her cargo space was filled. It is held, therefore, that the ideal cargo is a combination of about 4,500 tons of rock and enough lumber to fill the hold. Lumber for export to the Orient is available at Portland in almost unlimited quantities.

Phosphate rock, consisting largely of calcium phosphate, is in great demand in Japan. Furukawa Co., Ltd., of Kobe, Japan, which has booked the largest amount to date for export, controls several large plants in Japan for crushing the rock and converting it into superphosphates.

Chemical Activities at Yale University

At present all the chemical work of the Academic Department and Sheffield Scientific School are consolidated under one head, thus doing away with much duplication of courses and equipment.

Plans are now under consideration to build a centrally located chemical laboratory to take care of the needs of the entire university. It is planned to build the new laboratory large enough so that all of the courses can be carried on under the same roof. Special emphasis will be given to the industrial side of chemistry, and the new laboratory will be well equipped for this purpose.

In order to further the work of organic chemistry in its application to the industries, a series of lectures by the following men has been arranged, for the students of this year: Dr. C. L. Reese, research director, E. I. du Pont de Nemours & Co.; Dr. C. G. Fink, head of research laboratory, Chile Exploration Co.; Dr. W. S. Landis, chief technologist, American Cyanamid Co.; Dr. Hyle, research director, Upjohn & Co., Kalamazoo, Mich.; Dr. C. R. Downs of The Barrett Co., Dr. C. O. John of the Bureau of Chemistry, Washington, D. C.

Exhibition of American Products in Buenos Aires

A cablegram from Commercial Attaché Julius Klein, at Buenos Aires, states that the American Chamber of Commerce in that city has requested the American National Expositions, Inc., to hold its proposed exhibition of American products in November and December of 1920 instead of March, 1921. This request has been agreed to, according to information received from the directors of American National Expositions, Inc.

War Department Releases Sodium Nitrate

An indication of the seriousness of the shortage of fertilizer raw materials was the action of the Senate on March 31 in allowing the immediate consideration and passage of a bill authorizing the Secretary of War to lend soda to fertilizer distributers or users. The rules of the Senate require that a resolution of that character must be referred to a committee. In this case the Committee on Agriculture had jurisdiction.

Quite contrary to custom the committee agreed immediately to report the bill favorably and the measure was passed without a dissenting vote. The text of the resolution is as follows:

> That in order to meet the existing emergency in the shortage of fertilizers, the Secretary of War is hereby authorized to turn over to agricultural fertilizer distributers, or users in this country, such quantity of nitrate of soda held as a reserve supply by the War Department as in his opinion can be spared consistently with the military needs of the Government, such stocks so turned over to be replaced by such fertilizer distributers or users with an equivalent amount of nitrate, the turning over and replacement being under such guarantees as the Secretary of War may prescribe.

The resolution had been approved prior to its introduction by both the War and Agricultural Departments.

Oil-Shale Plant to Locate at De Beque

The Shale Oil & Refining Co. of New York City has recently signed a contract with the Gas Machinery Co. of Ohio for the equipment of the first unit of a plant to produce gasoline from shale. The company has a large tract of oil-shale lands in Colorado, and is planning to erect its plant at De Beque, Col., to distill the shale. A contract is to be placed next month for a refinery.

The first unit will handle from 300 to 400 tons of shale per day which, it is estimated, will yield about 300 to 400 bbl. of oil. The Wallace process of distillation will be used, and eight retorts are to be installed. The plant is expected to be in operation about next September, and it is estimated that it will cost in the neighborhood of $250,000.

This is the first attempt to utilize the oil shales in this country on a commercial scale, and with the demand for oil ever on the increase this development will be watched with much interest.

Research on Alunite

The metallurgical research department of the Utah State School of Mines, in co-operation with the U. S. Bureau of Mines, has been doing considerable work recently on the massive low-grade alunite deposits from Piute County, Utah. Experiments have been made with the idea of economically obtaining potash from the ores by a simple roasting-lixiviation process. The object of the tests is to determine:

1. The roasting temperature best adapted to a high recovery of potash by subsequent lixiviation.

2. The size of crushed ore which on roasting at the most desirable temperature gives the best extraction-crushing economy combination.

3. Whether there is a loss of potash by volatilization during roasting operations.

Further tests on a large scale are now under way. These tests are to be carried on with the object in view of recovering the alumina as well as the potash.

Meeting of Electric Furnace Association

The Electric Furnace Association held a meeting at the Massachusetts Institute of Technology on April 8 at which the subject of adequately trained electric furnace operators was discussed. The symposium was led by Acheson Smith, president of the Association, who pointed out the tremendous growth of the electric steel industry, and the inability of steel producers to get a sufficient supply of trained electric furnace operators. The number of electric furnaces operating in the United States and Canada has increased from 22 in 1913 to 363 in 1920. The weight of electric steel castings has increased from 9,207 gross tons in 1913 to 108,296 gross tons in 1918. The following table shows the comparative production of crucible and electric steel in the United States and the growth of electric steel since 1913:

Year	Production of Steel Ingots and Castings by Crucible Process, Gross Tons	Electric Furnace, Gross Tons
1913	121,226	30,180
1914	89,869	24,009
1915	113,782	69,412
1916	129,692	168,918
1917	126,716	304,543
1918	115,112	511,364

The figures for alloy steels for the year 1918 may also be of interest:

Process	Ingots, Gross Tons	Castings, Gross Tons	Total, Gross Tons
Open hearth—basic	1,013,913	10,724	1,024,637
Open hearth—acid	323,913	29,191	353,104
Bessemer converter	41,286	23,430	64,716
Crucible steel	54,370	64	54,434
Electric steel	287,885	3,076	290,961
Total	1,721,367	66,485	1,787,852

"The possibility of using the electric furnace in the production of brass and other non-ferrous metals has just begun to be appreciated, and it is only recently that a considerable number of electric furnaces have been used in this field. At the beginning of 1919 there were possibly fifty-eight electric furnaces producing brass, while at the beginning of 1920 there were at least 146 electric furnaces engaged in this work. The results already accomplished indicate that the application of the electric furnace in this field has been highly successful and the demand for more furnaces will follow rapidly."

Demand for Skilled Melters

This great increase in the use of electric furnaces has led to an unsupplied demand for skilled melters and assistants. Discussion of Mr. Smith's paper developed the fact that colleges and universities could not be expected to supply this demand, for it is not their function to turn out men skilled in operating details. It appears to devolve on the electric-steel industry to train its own personnel from either technical graduates or intelligent skilled labor; or upon the manufacturers of electric furnaces to furnish service to the metal industries in the form of men trained by the manufacturers themselves. In the latter case the Electric Furnace Association might take official action in the establishment of a training school.

Officers Elected

Officers of the Association for the ensuing year were elected as follows: President, Acheson Smith; vice-presidents, C. H. Booth and H. L. Hess; secretary, C. G. Schluederberg; treasurer, F. J. Ryan; directors for two years, F. J. Tone and H. G. Weidenthal.

Personal

James Bradley, formerly of the Atlas Powder Co., is plant supervisor of the Du Pont dye and intermediate plant at Lodi, N. J.

Dr. Benjamin T. Brooks is chemical engineer for the Mathieson Alkali Works, with headquarters at the newly established New York office, 25 West 43rd St.

W. E. Burkhard, formerly chief chemist of the Baker-Adamson Co., is chemical engineer at the Perth Amboy Chemical Works.

A. S. Eastman has been placed in charge of chemical control at the Calco Chemical Co., Bound Brook, N. J.

Prof. Ralph H. McKee, of Columbia University, has been consulting with officials in Washington on various chemical matters.

Edwin Mullen, returning from the Army, has been made superintendent of the Camden Works, General Chemical Co.

Walter B. Murphy has been transferred from the Frankford plant of The Barrett Co. to the main offices in New York, where he will take up his new duties as manager of industrial relations.

H. C. Parmelee, editor of Chemical & Metallurgical Engineering, left New York April 7 for an extended trip. He attended the spring meeting of the American Electrochemical Society in Boston and is attending the meeting of the American Chemical Society in St. Louis, Mo. From there he will go west to Omaha, Denver, Salt Lake City and San Francisco. He expects to be gone about two months.

Dr. Charles L. Parsons, secretary of the American Chemical Society, will sail shortly for Europe. He expects to attend the meeting of the International Union of Pure and Applied Chemistry, which will be held in Rome in June. In addition he will visit a number of chemical plants in Italy, Switzerland, France, Belgium, Germany and England.

Charles F. Rand was elected chairman of the Engineering Foundation at a special meeting held March 25. He succeeds Dr. W. F. M. Goss, resigned.

W. Kilburn Scott was a recent caller at the nitrate division of the War Department in Washington.

Obituary

Arthur L. Ormay, illustrator-in-chief of the McGraw-Hill Co., died at his home in Brooklyn, March 23. Mr. Ormay was born in Hungary, May 25, 1881. After the usual preliminary education he entered the Polytechnic of Budapest, from which he was graduated in June, 1905, with the degree of M.E. He came to the United States the following year and shortly afterward joined the staff of *Engineering News* as draftsman and letterer. He stayed with this paper for about three years. He then went to John Hill with a proposal to establish a drafting department to do the work of the papers of the Hill group, which at that time consisted of the *American Machinist, Power,* and *Engineering and Mining Journal.* The consolidation of the McGraw and the Hill companies in 1917, after Mr. Hill's death, broadened Mr. Ormay's duties and responsibilities, as he then had ten technical papers to serve. He was given the title of illustrator-in-chief, which he held at the time of his death.

In addition to his other talents, Mr. Ormay was noted for his pen-and-ink sketches of persons. One of his best was a large likeness of Mr. Hill, which was finished shortly before Mr. Hill's death. This portrait displays an execution and artistic talent of a very unusual quality.

Current Market Reports

The Non-Ferrous Metal Market

New York, April 12, 1920—There have been few changes since last week.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent.	32@33
Antimony, wholesale lots	11.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	62.25
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	8.75
Zinc, spot, New York	9.00
Zinc, spot, E. St. Louis	8.60

OTHER METALS		
Silver	oz.	$1.26
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f.o.b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	103.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled, (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	26.50
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless bronze tubing	34.50
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	22.00@23.00
Aluminum, sheet scrap	21.50@22.75
Aluminum clippings	24.75@26.00
Copper, heavy machinery comp.	14.25@14.75
Copper, heavy and wire	14.25@14.50
Copper, light and bottoms	13.00@13.50
Copper, heavy cut and crucible	15.50@15.75
Brass, heavy	9.50@10.00
Brass, casting	9.00@ 9.25
Brass, light	9.00@ 9.25
No. 1 clean brass turnings	8.75@ 9.25
No. 1 comp. turnings	11.25@11.50
Lead, tea	5.75@ 6.00
Lead, heavy	7.75@ 8.00
Zinc, scrap	5.25@ 5.75

The Iron and Steel Market

Pittsburgh, Pa., April 9, 1920.

The outstanding feature of the iron and steel market situation is the wide variety of opinions held by those in the trade both as to the actual condition today and as to the prospects. The condition as to production, which is large, is held in some quarters to indicate that prices must decline, and in other quarters to prove that steel will be still scarcer when expected additional demand develops. As to the future, not merely of steel but of industry generally, there are those who predict a "panic," though precisely what is meant by the term is not defined, next August or September, there are others who predict something of the sort a year hence, or some time in 1921, and still others who insist there is no basis for predicting any panic at all, except that if one lives long enough he is likely to see almost anything.

The monthly steel ingot report of the American Iron and Steel Institute shows that in March 3,296,799 gross tons of steel ingots were produced by thirty companies which in 1918 made 84.03 per cent of the country's total. Counting the number of working days in the month and year and allowing for the producers not reporting, this indicates that during March steel ingots were produced at the rate of 45,200,000 tons per annum. Similarly indicated rates were 44,200,000 tons in February and 40,650.000 tons in January. For the last four months of 1919 no monthly reports were made. Even the January output was larger than had been expected in December, and the increase from January to March was 11 per cent.

The manufacturing difficulties that were foreseen in December—shortage of coke and coal, winter weather, etc.—were all experienced, and the works probably did not operate at much higher percentages of their capacity than had been expected, but it now appears that capacity of the industry as a whole was underrated, and this means that the March production rate can be improved upon very materially. Until quite recently the country's steel ingot capacity was regarded as being 49,000,000 to 50,000,000 tons, according to estimates quite generally accepted. On this basis, however, the March production, with all the obstacles to efficient operation, would be more than 90 per cent of capacity. The disposition now is to regard capacity, under favorable working conditions, as nearer 55,000,000 tons. On a 55,000,000-ton rating the March output would be 82 per per cent of capacity, and that seems to be too low a percentage, in view of the conditions, just as 90 per cent seems too high.

Outlook Good for Fullest Employment of Steel Mills

Shipments of finished steel products from mills were slightly in excess of the production, as a little progress was made toward reducing the large accumulations of January and February caused by car shortage. Receipts by consumers were in turn heavier than shipments, because belated shipments were arriving. Thus the receipts of steel were very large indeed. All the surface indications are that the steel was all absorbed and passed into actual ultimate consumption. If that really was the case, there are very strong probabilities that steel will be as scarce in future as of late, if not scarcer, for it was common everyday consumption that absorbed the great bulk of the steel. Very little steel went to railroads and relatively little went into large construction works. In future it is quite certain the railroads must have much more steel, and certainly there will be much more steel, eventually, consumed in construction work. From this viewpoint the outlook is for the fullest employment of steel mills for a long time to come, and for the minimum prices now asked, those of the Steel Corporation, to rise, even though the maximum prices, now secured for early deliveries, may fall part of the distance by which they are separated from the minimum prices.

The experience of a few weeks, however, can hardly be accepted as sufficient to prove the case, especially when the case is such an important one. When steel was so extremely scarce for several months, a few weeks of heavy shipments without a surplus becoming visible is hardly a sufficiently long experiment. It is said that jobbers and manufacturing consumers have up to date accumulated no stocks, but there has hardly been time for a trustworthy canvass to be made, if indeed trustworthy information could be secured in all quarters. Nor would the absence of stocks in the hands of manufacturing consumers prove the entire case. Many of them make goods that are in turn handled by jobbers and retailers, whose stocks likewise have been low and may be in process now of being built up. The household, the carpenter's shop, the contractor's history, may have been getting material long desired.

In view of these considerations there are those in the steel trade who now argue that when so much steel can be made, and is being pushed out into business, a relaxation in the pressure of buyers will quite possibly occur at an earlier time than the broader demands, of railroads and investment builders, are expressed in actual orders. The one might occur in a few weeks, the other might not come for months, perhaps not until next year.

The American Sheet & Tin Plate Co. announces that early next week, presumably about Tuesday, it will open its order books for second half business in the case of manufacturing consumers and third quarter in the case of jobbers, at the following prices: Blue annealed sheets, 10 gage, 3.55c.; black sheets, 28 gage, 4.35c.; galvanized sheets, 28 gage, 5.70c.; 100-lb. tin plate, $7 per base box, Pittsburgh, plus rail freight to destination. These are the prices in the Industrial Board schedule that became effective March 21, 1919. The Steel Corporation subsidiaries have adhered to that price schedule in all particulars, and a fresh evidence is now afforded, though none was needed, that the

corporation has no intention of departing from its well-known policy as to prices.

As was the case with contracts for the present half year, the independent tin plate manufacturers in general will probably sell at the $7 price. The independent sheet manufacturers, with perhaps an occasional exception, now show no disposition whatever to observe the Steel Corporation prices. They have been selling up to date at a variety of prices, depending upon tonnage, time of delivery and the standing with the producer of the buyer. With nearly all mills the regular customer gets a lower price than the casual or chance buyer. Roughly speaking, prices of independent sheet manufacturers run from ½c. a lb. to 3c. or 4c. a lb. above the basis prices. The independents will sell only short distances ahead, as formerly.

Pig Iron

Substantially all the Connellsville furnace coke available for April has been disposed of, either by direct sales or by price adjustment under contracts calling for a monthly settlement. Except for two or three early transactions the coke has brought $11@$12, the Government limit ruling to the end of March having been $6. The high coke market has served to stiffen the position of merchant furnaces, but at the same time there has been little demand for pig iron. The valley market is quotable steady but quiet at former figures: bessemer, $42; basic, $41.50; foundry, $42, f.o.b. valley furnaces, freight to Pittsburgh being $1.40.

Ferro-Alloys

Ferromanganese for second quarter is firm at a minimum of $180, delivered, some producers quoting $200, while early deliveries command up to about $250. English is quoted at $200, c.i.f. Spiegeleisen continues to stiffen, being now quotable at $62 to $62.50, furnace, for spot, 19 to 21 per cent. Electrolyic ferrosilicon is held at $80, delivered, for 50 per cent and at $140 for 75 per cent. Bessemer ferrosilicon quotations are unchanged at $59.50 for 10 per cent, $62.80 for 11 per cent and $66.10 for 12 per cent, f.o.b. furnaces at New Straitsville and Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, April 12, 1920.

The tendency of these markets continues upward, especially in the alkalis and heavy chemicals. The coal-tar products are generally firm, owing to the scarcity of material in practically all lines. The present dock strike has crippled the spot market, which even before this trouble was in a bad way. No decline is foreseen for some time to come, particularly with the shortage of steel containers and the poor transportation facilities to be faced. This does not imply that if these conditions were more ideal the situation would be easier, for producers are unable to get the same percentage of production out of the same materials as they were formerly and output has fallen far behind the demand. The cost of labor alone in the production of most of the listed chemicals would be almost sufficient to maintain the present price levels.

PRINCIPAL PRICE CHANGES

	Today	Last Week	Last Month	Last Year
Alcohol, methyl	$3.50	$3.50	$2.50	$1.50
Barium chloride	180–200	140–150	160–170	76–80
Soda ash, light	2.75	2.50	2.50	1.50
Soda ash, dense	3.00	2.75	2.75	2.25
Sodium hydroxide	6.00	6.50	5.25	2.50
Sodium nitrite	.27	.30	.60	.17

General Chemicals

Under pressure of heavy demand and small supplies *alum, ammonia lump,* has been well sustained at 4@5c. per lb., while *potash lump* is fairly active at 7½@8½c. per lb. on contract. There were some small quantities of *ammonium sulphate* being sold on back contracts at 6c. per lb., but these have been filled and the present quotation ranges from 7@8c. Both grades of *sal ammoniac* remain practically nominal, as there is no material available on the spot market at present. *Oxalic,* crystals, has come up, being listed at 44@45c. per lb. for future and as high as 48c. is being asked for spot material. Stocks on this item are not dangerously low, but producers are having difficulty in keeping up with the present brisk demand. *Barium chloride* is tighter than it has been since the rapid rise of a week ago. Some material is changing hands in small lots and prices as high as $200 per ton are being asked for spot. A shipment is expected to arrive in this market soon, which ought to break the present high level. The Association price on *caustic soda* has been raised again recently to $4.50@$5.50 per cwt. But this is no indication of the market, as business is being transacted on a $6@$6.50 basis, with even higher prices reported for spot material. *Sodium nitrite* has come up again slightly and is now listed at 33@35c. per lb. for spot material. One large handler of this item is awaiting the arrival of a shipment and will sell at 22c. per lb. *Soda ash* is practically off the market, as there is no material to be had on the spot market and producers are so far behind in their contracts they cannot take any more business at present. Prices are nominal at $3.25@$3.50 per cwt. It is reported that manufacturers are sold out and refuse to quote on *sodium sulphide,* 60-62 per cent fused, prices ranging from 7@7½c. for future and 8@8½c. per lb. for spot, are nominal. The brisk demand on *copperas* has nearly exhausted the market of this item, and producers are unable to meet the demand. Quotations of $1.50@$2 per cwt. are practically nominal.

Coal-Tar Products

This market remains practically unchanged, prices being sustained in all lines by scarcity of material. Demand is heavy and producers are unable to take care of all the business and are falling behind in their contracts. Spot market activity is confined to the scarcer items on the list, with only small quantities changing hands at extreme prices. To add to this the material in the hands of dealers is nearly exhausted and according to those engaged in this line there is no relief in sight.

Cresylic acid, 97-99 per cent, held firm at the former high level of 95c.@$1.10, while 50 per cent is still listed at 60@70c. per gal. *H* acid is still unobtainable except in small lots which are being sold as high as $1.90@$2 per lb. There is very little *napththionic* acid, crude, to be had. Prices are firm at the former levels of 65@85c. per lb. *Dimethylaniline* is still off the market. No quotations were heard, as there is no material being offered. *Nitrobenzol* is nominally listed at 14@19c. per lb., but there is very little material available at these prices and producers are completely sold out. *Paratoluidine* is in the same position, spot prices ranging from $2@$2.50 per lb.

Waxes

This market is in practically the same position as it was a week ago. Interest has fallen off slightly in refined *beeswax,* dark, which dropped from 39@40c. to 38@39c. per lb. Large supplies of Japan grade are reported in the primary market, but buyers seem fairly supplied, a condition that has held this grade in the same position as was previously reported, 19@20c. per lb. being the quotation received.

Crude Rubber

The recent jump in exchange has steadied this market to some extent. Dropping prices have stopped and quotations remain at the levels previously reported. As yet buyers have not come back into the market due to a large extent to difficulty in obtaining tire fabric, which has considerably restricted the output of this industry. *Plantation* grades are listed as follows: *First latex,* 47½@48½c.; *brown crepe,* thin clean, 45c., and ribbed smoked sheets, 37@48c. per lb., with little trading in sight.

Vegetable Oils

This market has been generally weak during the period, there being very little activity evidenced. *Linseed oil,* raw, in car lots, came up from $1.74 of a week ago to $1.84, while boiled, in car lots, is listed at $1.87 per gal. for May and June. Prices ranging from $1.65@$1.70 for July-December delivery have been heard during the period. Other oils have been quiet, prices remaining firm with very little actual business transacted.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	3.50 – 4.00	4.25 – 4.50
Acetic, 56 per cent	cwt.	8.00 – 8.25	8.25 – 8.50
Acetic, glacial, 99½ per cent, carboy	cwt.	12.00 – 14.00	16.50 – 17.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 – .86	1.17 – 1.18
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05	.05½ – .07
Molybdic, C. P	lb.	—	4.25 – 5.00
Nitric, 40 deg	lb.	.07 – .07½	.07½ – .08¼
Nitric, 42 deg	lb.	.07½ – .08	.08¼ – .09½
Oxalic, crystals	lb.	.44 – .45	.46 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	—
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	16.00 – 18.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	—
Sulphuric, 66 deg., drums	ton	32.00 – 33.00	—
Sulphuric, 66 deg., carboys	ton	34.00 – 35.00	—
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P	lb.	—	1.35 – 1.45
Tannic (tech.)	lb.	—	.60 – .80
Tartaric, crystals	lb.	—	.69 – .74
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.35 – 3.50	—
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	—	.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03¼ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15½ – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14¾
Ammonium nitrate	lb.	.10 – .12	—
Ammonium sulphate	lb.	.07 – .08	.08½ –
Amylacetate	gal.	—	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	—	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride (nominal)	ton	125.00–135.00	180.00 – 200.00
Barium dioxide (peroxide)	lb.	.23 – .27	.28 – .30
Barium nitrate	lb.	.17 – .19	.20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		—	—
Blue vitriol (see copper sulphate)		—	—
Borax (see sodium borate)		—	—
Brimstone (see sulphur, roll)		—	—
Bromine	lb.	.85 – .90	—
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	.05 – .06	.06½ – .07
Calcium chloride, fused, lump	ton	22.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.35 – 4.50
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)		—	—
Caustic soda (see sodium hydroxide)		—	—
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.29 – .30	.31 – .32
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)		—	—
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		—	—
Epsom salt (see magnesium sulphate)		—	—
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)		—	—
Glycerine	lb.	—	.24½ – .26
Iodine, resublimed	lb.	—	4.10 – 4.30
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	.14 – .14½	.15 – .18
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	—	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	—	.13 – .14½
Magnesium sulphate, U. S. P	100 lb.	3.40 – 3.55	3.60 – 4.25
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.16 – .17	.17½ –
Phosgene (see carbonyl chloride)		—	—
Phosphorus, red	lb.	—	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.36 – .37	.38 – .42
Potassium bitartrate (cream of Tartar)	lb.	—	.56 – .60
Potassium bromide, granular	lb.	—	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.21 – .25	.28 – .30
Potassium chlorate, crystals	lb.	.15 – .16	.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	—	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.20
Potassium prussiate, yellow	lb.	.34 – .36	.38 – .41
Potassium sulphate	ton	$225.00 –240.00	—
Rochelle salts (see sodium potas. tartrate)		—	—
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake	ton	22.00 – 26.00	—
Silver cyanide (nominal)	oz.	—	1.25 –
Silver nitrate (nominal)	oz.	—	.77 – .82½
Soda ash, light	100 lb.	2.75 –	3.50 – 3.60
Soda ash, dense	100 lb.	2.90 – 3.25	3.55 – 3.65
Sodium acetate	lb.	.06¾ – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.40 –	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .40
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.05½ – .06½	.07 – .07½
Sodium borate (borax)	lb.	.08¼ – .08½	.09 – .09½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	4.50 – 5.50	6.00 – 6.50
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25¼ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.26 – .27	.33 – .35
Sodium peroxide, powdered	lb.	—	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04¼ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .z	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.15 – 1.40	1.60 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.07 – .07½	.08 – .08½
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 –
Zinc carbonate, precipitate	lb.	—	.19 – .20
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.11½ – .12½	.13 – .15
Zinc oxide, U. S. P	lb.	—	.19 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.42 — .48
Anthracine, 80% in drums (100 lb.)	lb.	.90 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.25 — 1.35
Benzidine, sulphate	lb.	1.20 — 1.25
Benzoic acid, U.S.P	lb.	90 — 1.10
Benzoate of soda, U.S.P	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .31
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .65
Beta naphthol, sublimed	lb.	.70 — .90
Beta naphthol, tech	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 — 1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 — .70
Dichlorbenzol	lb.	.08 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline (nominal)	lb.	—
Dinitrobenzol	lb.	.30 — .37
Dinitroclorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.34 — .36
Dinitrotoluol	lb.	.40 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine (nominal)	lb.	.55 — .65
H-acid (nominal)	lb.	1.90 — 2.00
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.10 — .12
Monoethylaniline	lb.	1.70 — 1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	08 — .09
Naphthaline, flake	lb.	.09 — .10
Naphthaline, balls	lb.	.10½ — .11
Naphthionic acid, crude	lb.	.70 — .85
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.40 — .50
Nitro-toluol	lb.	.20 — .30
Ortho-amidophenol	lb.	3.75 — 4.25
Ortho-dichlor-benzol	lb.	.15 — .20
Ortho-nitro-phenol	lb.	80 — 1.25
Ortho-nitro-toluol	lb.	.25 — .40
Ortho-toluidine	lb.	25 — .45
Para-amidophenol, base	lb.	2.50 — 3.50
Para-amidophenol, HCl	lb.	2.50 — 3.25
Para-dichlor-benzol	lb.	08 — .12
Paranitraniline	lb.	1.00 — 1.35
Para-nitro-toluol	lb.	1.35 — 1.50
Paraphenylenediamine	lb.	2.60 — 3.00
Paratoluidine	lb.	2.00 — 2.50
Phthalic anhydride	lb.	65 — .75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	12 — .25
Pyridin	gal	2.00 — 2.50
Resorcin, technical	lb.	4.25 — 4.50
Resorcin, pure	lb.	6.25 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.50 — .52
Salicylic acid, U. S. P.	lb.	.55 — .60
Salol	lb.	.90 — 1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.25 —	$0 31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.38 —	$0.39
Beeswax, refined, light	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal)...†	lb.	.43 —	.45
Japan	lb.	.19 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.11
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11¼
Paraffine waxes, refined, 133-135 m.p.	lb.	.12 —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.13½ —	.14
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.95 —	$19.50
Rosin E-I	280 lb.	19.75 —	20.00
Rosin K-N	280 lb.	20.25 —	21.95
Rosin W. G.-W. W.	280 lb.	22.00 —	24.00
Wood rosin, bbl.	280 lb.	15.50 —	18.50
Spirits of turpentine	gal.	..... —	2.30
Wood turpentine, steam dist.	gal.	..... —	2.75
Wood turpentine, dest. dist.	gal.	..... —	2.00
Pine tar pitch, bbl.	200 lb.	8.40 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl.	500 lb.	15.00 —	15.50
Rosin oil, first run	gal.	.92 —	.95
Rosin oil, second run	gal.	.94 —	.97
Rosin oil, third run	gal.	1.10 —	1.15
Rosin oil, fourth run	gal.	1.17 —	1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.32½ —	.33
Plantation—First latex crepe	lb.	.47½ —	.48½
Ribbed smoked sheets	lb.	.47 —	.48
Brown crepe, thin, clean	lb.	.45 —	.....
Amber crepe No. 1	lb.	.46 —	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.24¾ —	.25¼
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½ —	.19
Cocoanut oil, Cochin grade, in bbls.	lb.	.19½ —	.20
Corn oil, crude, in bbls.	lb.	.17¾ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.18
Cottonseed oil, summer yellow	lb.	.18½ —	.19
Cottonseed oil, winter yellow	lb.	.21 —	.23
Linseed oil, raw, car lots	gal.	1.84 —	.....
Linseed oil, raw, tank cars	gal.	1.77 —	.....
Linseed oil, boiled, car lots	gal.	1.87 —	.....
Olive oil, commercial	gal.	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15¾ —	.17½
Palm, Niger	lb.	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½ —	.22
Peanut oil, refined, in bbls.	lb.	.27 —	.28
Rapeseed oil, refined, in bbls.	gal.	1.64 —	1.70
Rapeseed oil, blown, in bbls.	gal.	1.64 —	1.68
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15½ —	.16

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal.	1.30 —	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$38.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	—	..
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal)	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	55.00 —	65.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.08½
Graphite, crucible, 88% carbon content	lb.	..... —	.09
Graphite, crucible, 89% carbon content	lb.	..... —	.09½
Graphite, crucible, 90% carbon content	lb.	..... —	.10
Graphite, crucible, 91% carbon content	lb.	..... —	.10½
Graphite, crucible, 92% carbon content	lb.	..... —	.11
Graphite, crucible, plus 92%	lb.	..... —	.12½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine, nominal	lb.	1.45 —	
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	180.00 —	240.00
Spiegeleisen, 16-20% Mn.	gross ton	60.00 —	65.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage: for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Dixie Brass & Fdry. Co., 6th Ave. North, between 12th and 13th Sts., is in the market for portable electric welding outfits, lathes, drill presses, and general machine shop, iron and brass foundry tools and equipment.

California

EL MONTE—The city has awarded the contract for the construction of a sewer system and Imhoff septic tank, to McNeil & Barnett, 234 South Center St., Orange, at $41,813. Noted March 17.

OAKLAND—The Palmolive Co., 42 4th St., Milwaukee, Wis., is having plans prepared for the construction of an oil mill. Estimated cost, $500,000. Lockwood, Greene & Co., 38 South Dearborn St., Chicago, engrs. Noted March 3.

SACRAMENTO—The Southern Pacific Ry. Co., 65 Market St., San Francisco, is having plans prepared for the construction of a brass foundry, here.

SAN FRANCISCO—The Natl. Carbon Co., Brannan and 8th Sts., has awarded the contract for the construction of a 4-story, 175x275-ft. warehouse, etc., to Hannah Bros., 142 Sansome St., at $362,500.

WILMINGTON—The Vegetable Oil Products Co., Wilmington, Del., is negotiating for a site upon which to build a refinery, the first unit of which will cost about $300,000. Edward G. Mueller, dir.

Connecticut

BRIDGEPORT—The Harvey Hubbell, Inc., Bostwick Ave., plans to build a 4-story manufacturing plant on State St. Estimated cost, $175,000.

MERIDEN—The Miller Bros. Cutlery Co., 464 Pratt St., has awarded the contract for the construction of a 4-story, 50x90-ft. manufacturing plant addition on Pratt St., to the J. H. Grozier Co., 721 Main St., Hartford. Estimated cost, $50,000. Noted March 17.

Illinois

CHICAGO—B. Kuppenheimer & Co., 423 South Franklin St., is building a 3-story factory building at 20th St. and South Karlov Ave. Estimated cost, $500,000.

CHICAGO—The Troco Nut Butter Co., 30 North Michigan Ave., has awarded the contract for the construction of a 4-story, 100x112-ft. factory at 37th and Iron Sts., to E. W. Sproul Co., 2001 West 39th St. Estimated cost, $250,000. Noted March 31.

WOODRIVER—The Standard Oil Co., Syndicate Trust Bldg., St. Louis, Mo., plans to construct a lubricating oil plant in addition to the other large projects, at its plant, here.

Indiana

TERRE HAUTE—The Columbian Enameling & Stamping Co. has awarded the contract for the construction of a 1-story, 155x240-ft. factory, to Roehm Bros., Denning Bldg. Estimated cost, $100,000.

Kansas

SCOTT CITY—The city will receive bids about May 1 for the construction of a sanitary sewerage system and a sewage disposal plant. Estimated cost, $75,000. Ruckel Eng. Co., Hutchinson, engr.

Kentucky

LOUISVILLE — The Visible Measure Gasoline Dispenser Co., 700-800 West Breckinridge St., plans to build a 2-story factory addition at 8th and Breckinridge Sts. Estimated cost, $25,000. G. Cunningham, genl. mgr.

Maryland

ASBESTOS—Arthur E. Van Bibber, 6337 Drexel Rd., Philadelphia, Pa., has purchased the plant of the Baltimore Roofing & Asbestos Mfg. Co., here, and plans to use same for the manufacture of linoleum and roofing.

BALTIMORE—The Amer. Sugar Refining Co., 117 Wall St., New York City, has awarded the contract for the construction of a sugar refinery including several 5- to 8-story buildings at Locust Point harbor front, to Stone & Webster, 117 Wall St., New York City. Estimated cost, $8,000,000.

BALTIMORE—S. W. Wiley & Co., Inc., analytical and consulting chemists, 7 South Gay St., is having plans prepared for the construction of a 3-story, 50x122-ft. chemical laboratory at 900-904 North Calvert St. Estimated cost, $150,000. W. G. Beecher, Frederick Rd., Catonsville, archt.

CURTISS BAY (Baltimore P. O.)—The Prudential Oil Co., Inc., 310 Keyser Bldg., Baltimore, will soon receive bids for the construction of a 1-story, 72x129-ft. oil refinery on 3rd and 4th Aves. Estimated cost, $25,000.

DUKES (Adelina P. O.)—The West Virginia Pulp & Paper Co., 200 5th Ave., New York City, will build 50x90-ft. and 100x120-ft. additions to its plant. Work will be done by day labor. Noted March 23.

Massachusetts

BROCKTON—George L. Falk, archt., 63 Main St., will soon award the contract for the construction of a 3-story, 55x160-ft. dry kiln building on Cherry St., for the Miller Tree Co. Estimated cost, $50,000.

CAMBRIDGE—The Prest-O-Lite Co., Inc., 30 East 42nd St., New York City, is having plans prepared for the construction of a few 1-story, 25x100-ft. acetylene plants. Estimated cost, $80,000.

CHICOPEE—The Fiske Rubber Co. has awarded the contract for the construction of 2-, 3- and 5-story factory additions, to Fred T. Ley, 19 West 44th St., New York City. Estimated cost, $150,000.

WEST SPRINGFIELD (Springfield P. O.)—The Gilbert & Barker Mfg. Co., Cold Springs Ave., has awarded the contract for the construction of 12 buildings, including a 2-story, 80x400-ft. brass foundry, 1-story, 40x80-ft. zinc building, 2-story, 164x200-ft. sheet metal building and a 1-story, 14x63-ft. testing building, to Tucker & Lewis, Inc., 101 Park Ave., New York City. Estimated cost, $1,000,000. Noted March 10.

Michigan

DETROIT — Albert Kahn, archt., Marquette Bldg., will receive bids until April 15 for the construction of a 1-story, 175x282-ft. factory on Mt. Elliott and Strong Aves., for the Detroit Pressed Steel Co., 1800 Mt. Elliott Ave.

DETROIT—The Wolverine Auto Painting & Trimming Co., c/o Atwood & Trysell, archts., 603 Temple Bldg., is having plans prepared for the construction of a 2-story, 90x100-ft. enameling plant at Herbert and Martin Sts. Enameling and painting equipment will be installed in same. Estimated cost, $25,000.

GOODELLS—The Brass & Aluminum Fdry. Co. is in the market for a brass furnace.

MILAN—The Amer. Furnace & Fdry. Co. has awarded the contract for the construction of a 1-story, 75x200-ft. foundry along the Michigan Central R.R., to Thomas Gotts. Estimated cost, $50,000.

Minnesota

RENVILLE — The Bd. Educ. plans to build a 2-story, 80x240-ft. junior and senior high school. A chemical laboratory will be installed in same. Estimated cost, $300,000. Croft & Boerner, Palace Bldg., Minneapolis, archts. and engrs.

Missouri

MAPLEWOOD (St. Louis P. O.)—The Bowen Motor Car Co., Title Guaranty Bldg., has purchased a 21-acre site here and plans to build a plant for the manufacture of gasoline driven standard gage railway cars, on same.

ST. LOUIS—The Century Electric Co., 18th and Pine Sts., is building a factory. Estimated cost, $500,000. Noted Jan. 21

Montana

FORSYTHE—The Bd. Educ. plans to build a high school. A chemical laboratory will be installed in same. Findlay & Ferner, archts.

New Jersey

NEWARK—The General Lead Batteries, 123 West 56th St., New York City, will build a 5-story factory at Lester Ave. and Chapel St. Estimated cost, $150,000. Work will be done by day labor. Noted Feb. 11

NEWARK—The Hanovia Chemical & Mfg. Co., Chestnut St. and the New Jersey R.R., has awarded the contract for the construction of a 3-story, 40x75-ft. chemical factory, to the Becher Constr. Co., 361 Grove St.

NEWARK—The Simms Magneto Co., North Arlington Ave., East Orange, has awarded the contract for the construction of a 2-story, 177x231-ft. addition to its present building on North Arlington Ave., to the Amer. Concrete Steel Co., 27 Clinton St. Estimated cost, $385,000.

NEW BRUNSWICK—The Trenton Porcelain Co., 803 East State St., has awarded the contract for the construction of a 1-story, 30x150-ft. porcelain plant, to F. R. Parker, 327 Calhoun St., Trenton. Estimated cost, $20,000. Noted Feb. 11.

TRENTON—The Cook Linoleum Co., East State St., has awarded the contract for the construction of a 1-story, 79x169-ft. plant addition, to J. H. Morris, Broad St. Bank, at $50,000.

TRENTON—The Nearpara Rubber Co., 79 Prince St., has awarded the contract for the construction of a 1-story, 100x125-ft. rubber plant, etc., to the Bethlehem Constr. Co., Bethlehem Trust Bldg., Bethlehem, Pa. Estimated cost, $150,000.

New York

ALBANY—The Albany Perforated Wrapping Paper Co., 1271 B'way., plans to build a 1-story addition to its plant. Estimated cost, $210,000.

BROOKLYN—The Keystone Varnish Co., 71 Otsego St., is having plans prepared for the construction of a 4-story, 50x100-ft. factory addition at 73 Otsego St. Estimated cost, $85,000. John E. Nitchie, 63 Park Row, New York City, archt. and engr.

BUFFALO—The Dept. of Pub. Wks. will receive bids until April 17 for the delivery of 80,000 lb. of liquid chlorine between May 1, 1920, and May 1, 1921.

BUFFALO—The Globe Belting Co. plans to construct a manufacturing plant at 1396 Clinton St. Estimated cost, $15,000.

BUFFALO—The Interlocking Reinforced Concrete Corp., East Ferry St. and the Erie R.R., has awarded the contract for the construction of a 1-story, 125x600-ft. factory, to J. Bellony, Builders' Exch. Bldg. Estimated cost, $25,000.

DUNKIRK—The Atlas Crucible Steel Co. plans to build a 70x200-ft. electric melting building, annealing buildings, etc., at its plant here. A 6-ton Heroult furnace, a 26-in. rolling mill and a 16-in. rolling mill, as well as other heating and annealing furnaces, etc., will be installed in same. This plant when completed will include three 30-pot furnaces, two 6-ton and one 3-ton Heroult electric furnaces, one 20-ton basic hearth furnace, hammers, rolling mills, wire mill, laboratory, inspection and shipping departments. Estimated cost, $1,800,000.

EAST SYRACUSE (Syracuse P. O.)—The East Syracuse Live Stock Rendering & Fertilizing Co., Inc., has purchased a site here and plans to construct a large packing plant on same. H. T. Riley, pres.

GOWANDA—The Eastern Tanners' Glue Co. plans to build an addition to its factory, here.

HAMBURG—The village is having plans prepared for the construction of a sewerage system and a sewage disposal plant. A $250,000 bond issue has been passed for the project.

LONG ISLAND CITY—Fahnestock Electric Co., Skillman Ave., has awarded the contract for the construction of a 2-story, 50x100-ft. factory at East Ave. and 8th St., to C. C. Woodruff, 213 16th Ave. Estimated cost, $52,000.

PYRITES—The De Grasse Paper Co. had plans prepared for the construction of a 1-story, 60x208-ft. machine room at its plant, here. Estimated cost $154,000.

THERESA—The Orleans Four Corners Dairymen's League Cooperative Association, Inc., is in the market for milk handling machinery, refrigeration system and milk-testing laboratory equipment.

TONAWANDA—T. J. Ballary, engr., will receive bids until May 5 for the construction of a filtration plant for the city. Estimated cost, $200,000.

Nevada

MINA—The Olympic Mines Co. plans to build a new mill on the site of the old one, which was destroyed by fire. The mill will have a capacity of 75 tons and will treat the ores from both the Olympic and the Loo mines. Estimated cost, $100,000.

North Carolina

HICKORY—The mayor has awarded the contract for the construction of a sewage disposal plant, to Tucker & Laxton, Inc., Charlotte, at $21,000.

North Dakota

HANKINSON—The Bd. Educ. will install a chemical laboratory in the proposed high school here.

Ohio

CINCINNATI—The Amer. Can Co., 120 B'way., New York City, plans to construct several 1- and 3-story factory buildings on Fergus St. Estimated cost, $1,000,000.

CINCINNATI—The Standard Silicate Co. has awarded the contract for the construction of a 2-story, 98x160-ft. and a 1-story, 49x80-ft. factory building on Paddock Rd., to the Fisher De Vors Co., 36 Blymyer Bldg. Estimated cost, $750,000. Noted March 17.

CLEVELAND—The Bd. Educ., East 6th St. and Rockwell Ave., plans to build a 3-story high school at the University Circle. Chemical equipment will be installed in same. Estimated cost, $5,000,000. F. G. Hogan, dir. U. R. McCormack, East 6th St. and Rockwell Ave., archt.

CLEVELAND—The Carbonized Steel Products Co., 331 East 140th St., has awarded the contract for the construction of a 1-story, 40x60-ft. factory, to the Sam Emerson Co., 1900 Euclid Ave. Estimated cost, $6,000.

CLEVELAND—The Euclid Fdry. Co., c/o Hulett & Stanton, archts., 226 West Superior Ave., has awarded the contract for the construction of a 1-story, 125x140-ft. foundry on St. Clair Ave. and the New York Central R.R., to the Complete Constr. Co., 226 West Superior Ave. Estimated cost, $100,000.

EAST CLEVELAND (Cleveland P. O.)—The Natl. Lamp Co. of the General Electric Wks., Nela Park, has awarded the contract for the construction of a 1-story, 100x220-ft. laboratory at Nela Park, to the Austin Co., 16112 Euclid Ave., Cleveland. Estimated cost, $100,000.

ELYRIA—H. A. Beck, Dir. of Pub. Serv., City Hall, will receive bids until April 26 for the construction of a filtration plant, substructures and appurtenant works, including coagulating basin, filtered water reservoir, rapid sand filter tanks, etc.

TRUMBULL—The Bd. Educ. R.F.D. 3, Youngstown, is having plans prepared for the construction of a 2-story, 91x150-ft. school on Churchill Rd. Chemical laboratory equipment will be installed in same. Estimated cost, $150,000. C. Cliffe, clk. Miller & Son, 408 Dollar Bank Bldg., Youngstown, archts.

WARREN — The General Fire Extinguisher Co. has awarded the contract for the construction of a 2-story, 100x200-ft. foundry, to the Foundation Co., 233 B'way., New York City. Complete foundry equipment will be installed in same. Estimated cost, $350,000.

Pennsylvania

HARRISBURG—The Harrisburg Water Dept. plans to install 6 additional filters, etc., at the filtration plant. S. F. Hassler, comr.

WHEATLAND—The Slick Knox Steel Co., c/o W. L. Ulmer, dir., Hippodrome Bldg., Cleveland, O., plans to construct a 1-story steel mill. Estimated cost, $300,000.

Texas

BRYAN—The city has awarded the contract for the construction of a sewerage system and a sewage disposal plant in the eastern section of the city, to F. L. Young, 306 Pershing Ave., San Antonio. Estimated cost, $35,844.

Wisconsin

CARROLLVILLE—The United States Glue Co. has awarded the contract for the construction of a 3-story, 377x500-ft. food manufacturing plant, to Paul Riesen's Sons, 1018 Humboldt Ave., Milwaukee. Estimated cost, $2,000,000. Noted March 10.

KOHLER—The Kohler Co. will build a 1-story, 100x290-ft. foundry. Work will be done by day labor.

MILWAUKEE—The Trapp Bros. Dairy Co., 86 Burleigh St., has awarded the contract for the construction of a 2-story, 70x110-ft. dairy on Burleigh St., to the R. Reisinger Co., 425 East Water St. Estimated cost, $75,000.

WEST ALLIS—The Allis-Chalmers Mfg. Co. has awarded the contract for the construction of a 1-story, 130x500-ft. foundry, to Klug & Smith, 40 Mack Block, Milwaukee. Estimated cost, $200,000.

West Virginia

CLARKSBURG—The city has awarded the contract for building an intake chamber and installing coagulating basins and equipment for pumping station, to the Richards Constr. Co., at $37,108.

Ontario

HAMILTON—T. B. McQuestin, Chn. of the Civic Gas Committee, has recommended that the city build a gas manufacturing plant. Estimated cost, $3,000,000. E. R. Gray, City Hall, engr.

KITCHENER — The Young Business Men's Association plans to construct a large hockey and skating arena. Chemical equipment required in connection with ice making will be installed in same. Estimated cost, $250,000.

Quebec

MONTREAL—The Barrett Mfg. Co., 2004 St. Hubert St., is having plans prepared for the construction of an addition to its tar products plant. Estimated cost, $32,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its fifth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive at St. Louis. Headquarters will be at the Hotel Statler.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Water Supply and Drainage in War Cantonments," Wednesday, April 21, at 4 p.m., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers Process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E., will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13, 14 and 15.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NATIONAL SAFETY COUNCIL, Engineering Section, will hold its spring conference in the Engineering Societies Building, New York City, on April 27.

THE NEW JERSEY CHEMICAL SOCIETY plans the following: Saturday, April 24, 2:30 p.m., visit to the plant of the Raritan Copper Co., Perth Amboy, N. J.; Monday evening, May 10, regular meeting; Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J., regular meeting and ladies' day.

THE NITROGLYCERINE MANUFACTURERS' ASSOCIATION will hold a meeting in Chicago, April 19 and 20.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its spring meeting at the Hotel Waldorf and the Hotel Astor, New York City, April 12 to 16.

Industrial Notes

HARRY J. WOLF, formerly associate editor of *Engineering and Mining Journal*, announces that he has resumed the general practice of mining engineering, with office at 42 Broadway, New York City.

THE ROESSLER & HASSLACHER CHEMICAL Co. announces that the main office has been removed to 709-717 Sixth Ave., corner 41st St., New York City.

THE OXWELD ACETYLENE Co., of Newark, N. J., and Chicago, has recently extended its manufacture of oxy-acetylene apparatus and equipments to include "Eveready" welding and cutting outfits. "Eveready" is a new name in the oxy-acetylene field, but the apparatus is not new, excepting for certain refinements of design, having been used extensively in the metal-working trades for several years under the name of "Prest-O-Lite" apparatus. The new name was adopted by the Oxweld company to suggest the ready convenience, adaptability and general-purpose uses of the equipment. The apparatus is designed for use exclusively with compressed acetylene in cylinders, thus providing the welder and cutter a compact and complete portable outfit.

CHARLES C. PHELPS has become associated with the Uehling Instrument Co., 71 Broadway, New York, combustion engineer and manufacturer of CO_2 recording equipment and other fuel economy apparatus. He is devoting most of his attention to research work in connection with the efficient combustion of fuel oil in boiler furnaces. Mr. Phelps graduated from Stevens Institute of Technology with the degree of mechanical engineer and has since spent several years studying power-plant problems. For five years of this period he was connected with the Ingersoll-Rand Co., manufacturer of power-plant equipment and pneumatic machinery.

JOHN A. KIENLE, formerly sales manager of the Electro Bleaching Gas Co., has been appointed general manager of sales of the Mathieson Alkali Works, Inc. This change was brought about by the severing of relations between the Mathieson Alkali Works, Inc., and its former sales agent, Arnold, Hoffman & Co., Inc. It is the intention of the Mathieson Alkali Works, Inc., to sell all of its products (caustic soda, soda ash, virginia soda, bicarbonate of soda, bleaching powder, liquid chlorine, chlorine solvents, etc.) direct to the consumer instead of through sales agents. Mr. Kienle has been placed in charge of the development of a complete sales organization. E. E. Routh, formerly manager of bicarbonate sales, has been appointed assistant to Mr. Kienle.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, April 21, 1920 *Number* 16

Standard Samples To Continue

IT IS with great regret that we learned that the House of Representatives and the Senate both declined to grant to the Bureau of Standards continuance of the fund for the preparation and distribution of standard samples. This small sum, amounting to $5,000 a year, was, as we have previously pointed out, really self-supporting, as the cash income from the work was more than $6,000 during the last fiscal year. In fact, credits for work done for state and Federal departments brought the total book value of the income up to over $10,000.

Despite this interruption of the appropriation, it has been decided by the Bureau of Standards to continue, at least in part, the standard sample work, and we congratulate that institution on this decision, even though we realize it had to be made with the understanding that certain other work would suffer correspondingly because of this burden being absorbed by the regular funds of the Bureau. In return for this self-sacrificing decision, the industries and our educational institutions owe a debt to the Bureau of Standards which should be recognized and met. Our metallurgical industries should in every way possible co-operate with the Bureau in securing the necessary irons, steels, brasses and other materials at a nominal expense to it, thus reducing the cost of preparation of the samples to a very minimum. The educational institutions should also co-operate by a very sparing use of the materials, refraining altogether from their use in student work except for purposes of research or in work of an advanced nature.

The cost and difficulty of preparing standard metal samples are little appreciated by those who have not given thought to this matter. It is an easy thing to ruin a sample of many hundred pounds after weeks of careful work had been put on it if for any reason a portion of it comes to have a slightly different composition than any other part of the mass. Very few institutions have either the facilities or the skill required for the painstaking work of this preparation. It is really a serious matter, therefore, when material prepared at great expense of time and skill is used unnecessarily by instructors as student samples. The Bureau quite properly declines to supply materials for such use when it has knowledge of the circumstances. It is suspected, however, that much use is being made of the materials without the knowledge of the Bureau, we would urge any who have unwittingly done this to discontinue such practice.

We trust that by another year Congress will come to appreciate the great importance and value of this activity and will appropriate for its continued growth in a measure commensurate with its work.

Iron Castings in Iron Molds

EVERY so often the question pops up, "Why are not permanent molds more widely used for iron castings?" The questioner may have in mind the great success of die casting as applied to white metal alloys or more recently to the more difficult aluminum bronzes; or he may have a recollection of having heard that such a procedure has been or could be applied to the iron foundry.

Perhaps the usual answer if the question were put to the "old-timer" would be that chill castings would have a heavy skin of white iron and the machine shop could do nothing with them. The answer would be entirely correct, and could be substantiated at any time by pouring a little of the iron regularly coming from the cupola and destined for green sand into a pig mold. The depth of the white-iron shell might even be intensified by filling a heavy deep iron cup. Examination of this sample when fractured would immediately show whether there was any possibility of a die-cast piece being machinable, a test used by OUTERBRIDGE for over thirty years. He it was who discovered and put to thorough commercial application a long time ago the fact that if the metal possessed the correct composition, either by original melting or by ladle additions of ferromanganese and ferrosilicon, such a chill cup would not produce even the thinnest skin of white iron, and a properly designed mold would give a commercial casting, soft and strong, very fine grained, almost steel-like in appearance after machining, yet having practically no combined carbon at all. He first set chill blocks in sand molded gear wheels, so that the rate of solidification could be so controlled that an accumulation of deep-seated cavities would not appear at the arm-junctions. From that point, progress naturally suggested a like practice on lathe beds, where dense sound iron is requisite.

If correct iron could cool against a series of blocks set in supporting sand without developing hard spots in the casting, there seemed no reason why the entire mold should not be made of iron, even to any necessary cores.

OUTERBRIDGE did it, and has made over a million castings in iron molds, machinable castings of exceedingly fine grain, free of dirt, sponginess and other defects, and having a marked increase in strength over the sand-cast metal. In this work the cores were withdrawn quickly to prevent seizure, but the casting cooled black in the mold.

This work at the Sellers foundry was kept a close secret for many years, with only bits of information leaking out from time to time. Therefore later work was along independent lines and without advantage of the accumulated experience at this particular foundry.

As an instance, CUSTER designed die-casting machines for soil-pipe fittings, which operated commercially for some time. This was before the days when the widespread introduction of molding machines had so largely reduced the labor expense on sand molds, and correspondingly dulled the spur to reduce molders' labor to the extreme minimum. Instead of using his molds once a day, CUSTER held the hot iron in the mold but a minimum of time necessary to maintain its form, when the cores were withdrawn, the mold opened, and the hot casting cooled in air. In this manner a single mold, operated by hydraulic power, could produce a hundred castings or more every shift. Such casting practice apparently allows a much wider range of chemical composition in the fluid iron than the Sellers method, since any cementite forming at the quick-solidifying surfaces is annealed into ferrite and temper carbon during subsequent slow cooling.

As is the case for die castings for white metal, such permanent molds are quite expensive to design and construct, much care being necessary to provide properly for gates, vents and traps. Unfortunately the molds, and especially the cores, are short lived. They ordinarily fail by surface disintegration, showing as a swelling, cracking and spongy layer of variable depth, which causes difficulty in shaking out the casting and ruins its surface appearance. This deterioration in the mold is caused by the well-known property which cast iron has of growing when heated repeatedly to redness. Yet so little known and so little under control is this fundamental property of the permanent mold that one metallurgist recommends the use of low-silicon white iron, which has less than the ordinary amount of growth, for molds which should never be brought in any part to a visible heat, while another experienced in bronze die-castings, whose working temperatures are comparable to that of iron, recommends the use of a close-grained iron with low combined carbon—a combination which is hard to get except by chilling high-silicon iron.

In the light of current literature and common information, the subject of iron castings in permanent molds offers an attractive field for experimentation and profitable application, either along the lines of casting in dies, with or without extraneous pressure, and with sand or metal cores, or of casting cylindrical pieces in centrifugal machines without molds, gates or risers of any kind.

How little it is applied today may be inferred from the fact that a large foundry producing 1,000 tons of automobile engine-parts every day makes but one part in permanent molds, and that in a centrifugal machine. At that its practice is to remove the castings, and cool in mica or ashes, and even this fails at times to produce machinable rings.

Even with all this in mind, one feels justified in saying that certain castings requiring a very fine grain, and uniform texture; free from blow holes, shrink holes and pipe; high strength and practically no combined carbon can be turned out in large quantity with a minimum molding expense in permanent molds in a manner unapproachable by any other known method. When this fact is widely known, the method itself will be intensively studied and widely applied by the largely increasing numbers of inquisitive metallurgists now questioning the sacred traditions of the iron foundry. Only men of this type would attempt what seems so bizarre, and almost foolish.

Research and Imitation Research

IN THE years past the fundamental schooling for industrial achievements was apprenticeship. The "old-timers" instructed the novices in the intricacies of the trade, which were considered as secrets to be revealed only to the apprentice. The guilds of the different industrial arts were comparable in a way with the unions of to-day, with the distinction that the former were solely protectors of the trade, while the latter are concerned chiefly with the problem of fixing higher monetary compensation for their members. The question of sound industrial progress through systematic technical improvement has received but scant attention by such organizations of workers.

It is only in recent years that systematic research work has been undertaken in order to further the progress of practically all branches of technical art; but, like any other innovation, it is liable to trespass the limits of actual usefulness, drift into mere duplication of effort or produce results hastily accepted as improvements at the cost of great expenditures in time and money.

The technical school of to-day feels that it can no longer confine its attention to an academic presentation of the theoretical intricacies of a particular subject; it must combine theory with as many practical applications as possible, with research work as the finishing touch for the technical graduate. Competition among the various schools has resulted in the establishment of research laboratories and courses in research at substantially all of the American technical institutions, and even as separate departments of the graduate school in the universities. Research work is very expensive, and the question arises as to whether the funds thus used might not have been applied in many cases to better advantage—in improving the salaries of the teaching staff, for example.

In the recently published report of the Carnegie Foundation for the Advancement of Teaching, the president, Dr. HENRY SMITH PRITCHETT, says:

"Much of that which has gone on in American universities under the name of research is in truth only an imitation of research and upon it great sums have been expended. College salaries also have been diluted enormously by the tendency of most college faculties and governing bodies to bid for students by extending the curriculum over the whole field of knowledge, a process which means great increase in the number of teachers and the consequent leveling down of salaries."

The need for productive research in pure and applied science is urgent, but we must not lose sight of the fact that not all students are endowed with the temperamental prerequisites of the research worker. On the other hand, industry must have technically trained men who are able to interpret and apply the results of research in the plant. Dr. PRITCHETT suggests that the universities take stock of themselves and "render a sincere and critical statement of the results obtained in education by the expenditures of the last twenty-five years." Is it not possible that such introspection would reveal the fact that we have placed too much stress upon the mere formalities of the "research course," without careful consideration of the needs of science and industry, the potentialities of the graduate student entering such work, and the capabilities of the faculty nominally in direction?

Alive to The Situation!

AMERICANS like to tell themselves and advertise to strangers that we are the most progressive, the most far-seeing and the most everything else you want to mention. That is to say, a certain egotistical minority do the advertising, and the rest of us believe we can see an ell, at least.

Yet nine out of ten of us cannot see an obvious event until it knocks us down and runs over us, despite the unheeded warnings of the active publicist or propagandist. We pay no attention to him because we don't trust him; because we feel there must be a sinister hidden influence somewhere; because we think he is trying to use us for the profit of himself or his applications; or because he is labeled as a plain crank.

So it is that nearly everyone buys on a rising market, few build when prices are low, and improvements in technology are left for the other fellow to develop. Nor will we give heed to plain economic tendencies until it is almost too late.

Picture the anguished consternation of the well-to-do professional man who has never been seriously inconvenienced by labor troubles finding that there are no accustomed trains to carry him the intervening miles from his home to his work. Labor troubles before have been impersonal things, perhaps inconveniencing the other fellow a bit and maybe slightly reflected in inflated prices. "But here! No trains! Is it possible that a few railroad switchmen have the whole country by the throat? Can a few bolsheviks hold up the nation and rob it with impunity? Somebody ought to be lined up against the wall and shot! Outrageous!"

All because the 8.17 is not running!

Steel Prices And Other Prices

WHEN during the war the Government began fixing prices it was held that a new system was inaugurated, that previously prices had been fixed in but one way, by "the law of supply and demand," except when the wicked trusts got in their work. Government price control ended, generally speaking, at the close of 1918, a few weeks after the Armistice, and an effort in the following March to regulate prices under Government auspices failed for a variety of reasons. Are prices now fixed by the law of supply and demand? One can hardly maintain that they are.

To point out proofs that prices are not now fixed by the law of supply and demand, however, is to develop some arguments that could have been used before the war to show that even then prices were not set by the "law" of supply and demand, which would make it appear that it isn't a law after all, but something cognate rather to a motto, a motto being something that one follows, if at all, only at his convenience.

For supply and demand to set prices would really mean in substance that the material to be sold is auctioned off day after day to the highest bidders, and that hardly occurs. It seems curious that we should have been talking so much about the law of supply and demand when so little evidence could be found of its actually being the controlling influence. One reason can be vouchsafed, that it represents the continuance of an idea after the circumstances that created it have disappeared in very considerable part. Imagine all products made by individuals, each man being his own manufacturing concern, with practically no capital investment in factory or materials, and a good many of the men jack of all trades so that they can shift from one class of goods to another. Then if the demand for gloves decreases the price falls until some of the men turn to making shoes, for which satisfactory prices are obtainable. The decline in gloves is arrested before anybody starves through inability to make enough gloves per day, at the low price prevailing, to buy him his bread and butter.

With the factory system this regulation cannot occur, and the factory system has been growing up for decades. If it does not hamper the operation of the old law of supply and demand, which would work in conditions like those just imagined, it at any rate would make a very unfortunate situation at times. This, indeed, it has done, and the fact that there have not been glaring cases in recent years does not indicate that experiences of the more distant past cannot be repeated, and on a larger scale. Those who lived through the industrial depression of 1893 to 1898 can readily recall the term so common then, "bankrupt competition." Numerous manufacturing concerns failed. Some of them had been promoted by country towns by a cash bonus, free land and exemption from taxation for a period of years. The promoter came along, was given possession of the factory merely in return for his promise that he would operate it and, presto, there was a manufacturer whose cost sheet had no blanks to fill in for amortization, obsolescence, depreciation, taxes or interest on investment. Respectable and responsible manufacturers, producing the same class of goods, paying taxes, conducting a legitimate business and entitled to thrive, were exposed to this "bankrupt competition."

Prior to the war competition was a factor in influencing commodity prices, and there was also the influence of manufacturers and sellers generally feeling that if they embraced an opportunity to make inordinate profits, when presented, retribution would likely come some time.

Selling prices now are made largely by what manufacturers think it right and proper to charge, and as there is a wide diversity of opinion among sellers, there is also a wide diversity of prices. In the steel industry, for instance, there is the United States Steel Corporation, which makes about 44 per cent of all the country's steel products, sedulously adhering to a certain schedule of prices, which chances to be the Industrial Board schedule that became effective March 21, 1919, and the independents all asking and securing higher prices, in some cases by half a cent a pound, in other cases by three or four cents a pound. If this were the result of the operation of any law of supply and demand, the Steel Corporation's products would be proved to be sonimous (word coined by CHARLEY SCHWAB) beyond ordinary powers of conception. Go into a hardware store, make a collection of tools all made of much the same material, brass, steel, etc., and by quite the same classes of workmen, and inquire how present prices compare with those of 1915. Some of those tools will be found to have advanced two or three times as much as others. That is the difference in the psychology of the makers, not any difference in the cost of the raw materials and labor.

Readers' Views and Comments

Mineral Resources and Chemical Industries of the Southern States

To the Editor of Chemical & Metallurgical Engineering

SIR:—The writer has read with much interest the article by Andrew M. Fairlie on "Some Developed Mineral Resources and Chemical Industries of the Southern States," in your issue of Feb. 18. Considerable attention is there devoted to the Southern phosphate fields which are now developed. It is the purpose of this communication to call attention to an as yet undeveloped phosphate deposit in the Southern States which is of peculiar interest.

I refer to the dahllite and collophanite found along the junction of the shaly limestone and Watanga shale in Johnson County, east Tennessee. This deposit was just noticed in 1915, when the Tennessee State Geological Survey made as detailed a report as the undeveloped condition of the field would permit. Such work as has been carried out up to the present time shows the presence of considerable amounts of phosphatic material containing 60 to 75 per cent tricalcium phosphate, as well as very large amounts of rock which is of a lower grade.

The economic importance of this bed is not so much as a source of phosphorus *per se*, but more especially its proximity to coal, coke, sulphuric acid and silica. Conditions are peculiarly favorable for the putting of this material into marketable form either as fertilizer or as elemental phosphorus. STUART W. MAHER.

Kingsport, Tenn.

The History of Mustard Gas

To the Editor of Chemical & Metallurgical Engineering

SIR:—In reference to the recent article on the History of Mustard Gas by Clarence J. West in your issue of March 24, 1920, Mr. West, as well as the authors of the controversy as to the discovery and commercial development of the reaction between ethylene and sulphur chloride, seems to have lost view of two extremely important points. One is that whatever the merits of the inventors and of the authors of the very large program of mustard gas to be manufactured (for home consumption, for it never reached the enemy), the only one of the Allies that manufactured and fired mustard gas was the French, and the other point is that whatever the merits of the Levinstein process the sulphur dichloride process furnished practically the whole of the mustard gas that was ever used against the Germans.

To be sure, this should not detract in any way from the merits of the Levinstein process, which doubtless would have become universal had the war lasted much longer, but, since the article purports to be a historical article, it should certainly mention that as a historical fact the sulphur dichloride process was the only one which was actually producing on a large scale in time to allow its product to be used against the enemy. In a series of confidential reports which I made to the Chemical Warfare Service I followed from February, 1918, until the armistice the progress which was being made by the plant of the Société Chimique des Usines du Rhone.

This plant started early in March with a production of two to three tons a day and was in July producing close to twenty tons a day. It was being duplicated at the time of the armistice, so that probably by December, 1918, the production of mustard gas by the dichloride process would have reached about forty tons. Early in June the first consignment of shells filled with mustard gas reached the French front and I believe about June 18 the first mustard gas shoot conducted by any of the Allies was carried out by the French.

I had occasion to mention this fact before at a meeting of the Société de Chimie Industrielle, an account of which was published in your journal[1], but evidently it seems to have escaped Mr. West's attention as well as, which is more inexplicable, the numerous reports to which Mr. West had access during his long and successful connection with the Chemical Warfare Service.

Mr. West's remarks regarding the sulphur dichloride process create the impression that it was never successfully worked even in the laboratory, when, as a matter of fact, it was practically the *only* process that was working in time to be of military use, the mustard gas made by other methods in France amounting then to only a few tons.

I hold no brief for the dichloride process. Besides the complicated and costly apparatus, it required considerable quantities of carbon tetrachloride. a solvent which was very scarce during the war, but when the matter is looked at historically the fact remains that it was the only one which was developed and running on an industrial scale when all others had just graduated from the laboratory or barely entered the semi-industrial stage. J. E. ZANETTI.

Columbia University,
New York City.

Need of Co-operative Educational Work in the Chemical Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—The reference to the American Cranberry Exchange, on page 511 of your issue of March 17, recalls a story which may or may not be familiar to the cranberry men, but which seems at any rate to have some advertising value.

A native of Cape Cod, in the course of conversations with an old French chef, happened to mention the cranberry. "Ah, ze crranberry," said the chef, "I know ze crranberry; you take heem and you stew heem, an' he make ze better apple sauce zan ze prune do."

If our cranberry-growing friends wish to make use of the story in advertising their product, I will cheerfully waive all proprietary rights.

FREEMAN F. BURR,
Geologist.

Augusta, Me.

[1] CHEM. & MET. ENG., vol. 21, No. 10, Oct. 22, 1919, p. 533.

CHARLES RIVER SKYLINE OF BOSTON

Boston Meeting of the American Electrochemical Society

Symposium on Colloids—Joint Meeting With the American Institute of Electrical Engineers—Discussion on Ferro-Alloys and Power for Electrochemical Industries—The Electric Brass Furnace

THE thirty-seventh general meeting of the American Electrochemical Society was held in Boston, April 8 to 11. In spite of unsettled business conditions, difficulties in traveling and lack of ample hotel accommodations, the meeting was one of the best attended for many years. There were over 300 members and guests registered. Animated and stimulated discussions of the pre-war type prevailed; these were characterized by the open-minded attitude of former days, which of necessity had dwindled during the war. Among the social features, the big Little smoker will linger long in the memories of all.

Meeting of the Board of Directors

At the meeting of the board of directors the treasurer's annual report was submitted. The liquid assets of the Society aggregate $17,000. The membership committee, C. G. Schluederberg, chairman, reported a present total of 2,307 members, as compared with 1,903 members on Jan. 1, 1919. Among the new business transacted, it was moved to circularize the membership and ascertain the opinion of the individual on the general adoption of the metric system in this country. President Bancroft appointed Messrs. Landis, Richards, Lash, Miller, Chaney and Tucker a committee of five to consider carefully the various proposals for the next meeting place of the Society and to report to the board not later than May.

Officers Elected at Annual Business Meeting

The annual business meeting was held in Huntington Hall. Upon the report of the tellers, the following officers were declared elected: President, W. S. Landis: vice-presidents, J. A. Mathews, L. E. Saunders and A. T. Hinckley; managers, Colin G. Fink, Acheson Smith and H. B. Coho; treasurer, Pedro G. Salom; secretary, Joseph W. Richards.

Technical Session—Thursday Morning

Prof. Henry P. Talbot of the Massachusetts Institute of Technology welcomed the members of the Society and dwelt briefly upon the ever-increasing importance of electrochemistry. The war has demonstrated most emphatically that "the ultimate defense of our country lies in the hands of electrochemistry."

The presidential address of the retiring president, Wilder D. Bancroft, dealt with the present aspects of contact catalysis theory. The action of infra-red radiation was discussed at length and the conclusion drawn was that until some proof is brought that a contact catalytic agent can act at a distance, we are justified in postulating that the reaction takes place in or at the surface. A corollary from this is that any substance which cuts down the rate at which the reacting substances reach the catalytic surface, or which prevents them from reaching it, will decrease the reaction velocity, and may destroy the catalytic action entirely.

The piling up of the reaction products will cut down the reaction velocity, if they prevent the reacting substances from coming in contact with the catalytic agent. This has been observed in the contact sulphuric acid process, where sulphur trioxide inhibits the reaction by sealing off the reacting SO_2 and O_2 from the platinum sponge.

Since reaction velocity is probably directly propor-

tional to the difference of chemical potential and inversely proportional to the chemical resistance, we can increase the reaction velocity either by increasing the difference of chemical potential or by decreasing the chemical resistance. When the reacting substances are adsorbed at the surface of a catalytic agent, there is a marked increase in the concentration and it has been suggested that this is the cause of catalytic action. As a matter of fact, the effect of concentration seems to be relatively unimportant in most of the cases studied hitherto. It is stated that oxyhydrogen gas has been found to be quite stable under pressures of 2,000 atm., which shows that the catalytic action of platinum on mixtures of hydrogen and oxygen must be due to something more than a change in concentration.

If we have selective adsorption of the reaction products, this will cause a lowering of the chemical potential of the resultants and will therefore increase the reaction velocity. It may even determine the direction of the reaction. Alcohol breaks down into acetaldehyde and hydrogen in presence of pulverulent nickel and into ethylene and water in presence of pulverulent alumina. Since nickel adsorbs hydrogen strongly and alumina adsorbs water, it seems natural to assume that the selective adsorption is the determining factor. However, this conclusion does not work well with the fact that the latter reaction is very much facilitated by the addition of steam.

If changes in the chemical potential are not the important factors in contact catalysis, the catalytic agent must change the chemical resistance in some way. There are two possible means for this, either more effective collisions between the reacting molecules or conversion of the reactive substances into an active form. While the conversion of a reacting substance into an active form may very well account for the effect of the solvent on reaction velocity in homogeneous systems, it must be shown what active form is produced and why one solvent produces more of it than another.

In conclusion, Prof. BANCROFT stated the study of organic reactions is by far the most likely to prove fruitful, and he listed tentatively sixteen problems which should be investigated.

Symposium on Colloid Chemistry

Dr. BANCROFT opened the quartet of papers discussing colloid chemistry with a résumé of phenomena having an electrotechnical aspect. So long as the suspended particles are all charged positively or negatively, they will tend to repel one another and will not coalesce unless the concentration is too high. Colloid solutions will be very sensitive to electrolytes having a readily adsorbable ion of the opposite charge from that which stabilizes the colloids. The formation of deltas is due primarily to the coagulation of the suspension by the electrolytes in the salt water. Migration of colloidal particles under electrochemical potential, cataphoresis and electrical endosmose, the functioning of a diaphragm, were discussed. Charged dust suspensions and their electrostatic precipitation were described in analogy to liquid suspensions.

SETTLING PROBLEMS

WILLARD A. DEANE, of the Dorr Co., spoke at length on "Settling Problems" and how these have been successfully solved.

The introduction of "continuous settling" has resulted in greatly increased application of sedimentation processes. The practical requirement of every settling problem involves two distinct processes, one clarification, the other thickening. The requirements for clarification are the minimum thickener area permissible with a continuous overflow of liquid of specified clarity. The requirements for thickening are a continuous discharge of thickened pulp of lowest permissible moisture content. In clarification problems the settlement of the finest particles is the governing feature. The settling properties of a pulp may be largely improved by a proper adjustment of conditions in processes prior to sedimentation.

Each settling problem is governed by specific conditions requiring independent study and analysis, and the most satisfactory solution often involves a study of processes and methods with a view of possible changes in certain conditions, so as to alter the physical character of the suspension and promote improved settling.

In the discussion of Mr. Deane's paper, the Chair, Dr. BANCROFT, called attention in particular to the author's description of the clarification of concentrated solutions. Deane's is the first good explanation he had seen to account for the fact that dilute solutions settle cloudy and thick or concentrated solutions clear. There is a sort of filtering effect taking place in the latter solutions, the coarser particles holding up the very fine ones. In the separation of cream from milk we have an upward filtering motion; and in a deep pan cream separates faster than in a shallow one.

GRAPHITIC ACID—A COLLOIDAL OXIDE OF CARBON

The third paper of the symposium was submitted by GEORGE A. HULETT and O. A. NELSON, of Princeton University, on "Graphitic Acid—A Colloidal Oxide of Carbon." After a careful survey of the investigations on graphitic acid carried out in the past, the authors reported on a series of experiments made to determine the relations of water to graphitic acid.

The translucent graphitic acid plates are made of an infinity of plates of excessive thinness. The relation of water to this substance and its variable properties are readily interpreted on the assumption that graphitic acid is a solid oxide of carbon with an exceptionally large surface covered with adsorbed water. The information available indicates formulas of the order C_3O or $C_{11}O_4$.

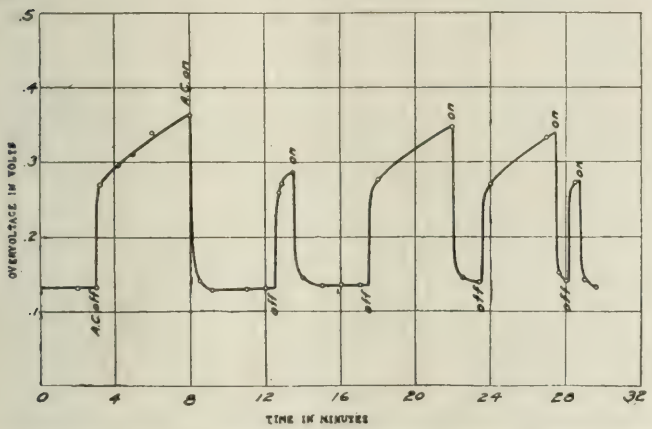
In discussing this paper, F. A. J. FITZGERALD referred to his years of investigation of a method of analysis for graphitic oxide without obtaining any positive results. He had made the best graphitic oxide from a sample lot of Irish coal; this oxide would swell up very appreciably during graphitization in the electric furnace. E. O. BENJAMIN called attention to the fluffy graphite that Mr. AYLESWORTH of the Edison Co. had obtained. The volume was about seven times that of any other graphite.

PROBLEM OF DETERMINING GRAPHITIC CARBON

W. A. SELVIG and W. C. RATLIFF, of the Bureau of Mines, Pittsburgh, Pa., reported upon a detailed investigation of the Problem of Determining Graphitic Carbon. No direct quantitative method for the determination of graphitic carbon in the presence of amorphous carbon has ever been developed before. Selvig and Ratliff tried out the Brodie and Staudenmaier methods ($H_2SO_4 + HNO_3 + KClO_3$) for the conversion of gra-

phitic carbon to graphitic acid on Alabama, Pennsylvania, Ceylon and Acheson graphites, and on mixtures of Ceylon and Acheson graphites with amorphous carbon in the form of anthracite and bituminous coal and coke. The Staudenmaier method (14 c.c. concentrated H_2SO_4, 6 c.c. concentrated HNO_3 and 18 g. $KClO_3$) was not applicable to substances containing relatively large amounts of amorphous carbon, as the reaction goes to explosive violence. Amorphous carbon in the form of anthracite and bituminous coal and coke when treated by the Brodie method (10 c.c. HNO_3 + 4 g. $KClO_3$ per ½ g. of sample) gave no graphitic acid in the case of the anthracite and bituminous coal. A slight amount of graphitic acid was, however, obtained from coke, this indicating the presence of graphitic carbon in coke. Graphitic acid cannot be made to come to constant weight by ordinary methods of drying, as the substance is very susceptible to varying humidity changes.

The Brodie method of conversion of graphite to graphitic acid can be hastened by a supplementary treatment with sulphuric acid and potassium permanganate. Carbon in the form of coal, coke, calcined anthracite,



SHOWING TYPICAL EFFECT OF ALTERNATING CURRENT ON OVERVOLTAGE

natural and artificial graphites gave varying amounts of CO_2 when treated with the Brodie mixture.

The graphitic carbon content as determined by conversion to graphitic acid by the Brodie and Staudenmaier methods and subsequent combustion gave low results as compared to direct combustion of the graphites. These differences were the least in the Ceylon and Acheson graphites and greatest in the Alabama and Pennsylvania graphites. They may be due to the differences in the physical characteristics of the graphites, such as flake structure. However, no satisfactory reason can be given why, when subjected to the same number of treatments with the same oxidizing mixture, Alabama and Pennsylvania graphites give a larger loss of carbon as CO_2 than do Ceylon and Acheson graphites.

Graphitic acid when treated with the Brodie mixture slowly gives off CO_2. It appears that when graphitic carbon is treated with oxidizing mixtures a series of oxidation products result, the end products being CO and CO_2. The maximum yield of graphitic acid is obtained under rather narrow limits as to temperature, time, and oxidizing reagents.

With Ceylon and Acheson graphite, in which the conversion of the graphitic carbon to graphitic acid proceeds at a comparatively rapid rate, the graphitic carbon content as estimated by the Brodie and Staudenmaier methods gave results which were within 5 per cent of the true graphitic carbon content. On the other hand, Alabama and Pennsylvania graphites, which required a prolonged treatment for conversion into graphitic acid, gave very low results, due, no doubt, to a larger loss of carbon as carbon gases resulting from complete oxidation to CO and CO_2. Carbon in the form of coke and partly calcined anthracite coal, though finely ground, required more treatments than pure graphitic carbon in the form of Ceylon and Acheson graphites.

The action of oxidizing mixtures on different forms of carbon offers an extended field for further scientific investigation.

In the discussion, Mr. FITZGERALD suggested that the methods as outlined by the authors might be applied to advantage to the different grades of carbon and graphite anodes on the market today.

Overvoltage—Dry Cells—Storage Battery

"The Effect of an Alternating Current on Hydrogen Overvoltage" was the title of a paper by H. M. GOODWIN and M. KNOBEL, of the Massachusetts Institute of Technology. They studied the overvoltage of hydrogen on platinum, lead and copper cathodes when alternating current was superposed on the direct electrolyzing current. The effect of varying the alternating current was also studied, the effect of its frequency and the power factor. The effects seem in general to be due to the oxygen liberated on the cathode by the reverse wave of the alternating current. The magnitude of this depolarization appears to be independent of the electrodes and of the current density, and determined primarily by the ratio of alternating to direct current used. The effect increases slightly as the frequency decreases, but results would indicate that it is practically independent of the power factor.

H. D. HOLLER and L. M. RITCHIE reported their observation of a marked difference in potential of manganese dioxide electrodes made of natural ores and the chemically prepared oxide, the former giving twice the voltage and varying as a logarithmic function of the hydrogen ion concentration. The prepared oxide showed no relation to the hydrogen ion concentration. The cause of this difference has not been investigated. At least a portion of the polarization of a dry cell during discharge may be explained as being due to a layer of electrolyte on the surface of the electrode impoverished in hydrogen ions.

A careful investigation of "The Reactions of the Lead Accumulator" was reported upon by Prof. D. A. MACINNES. The research was carried out by himself and L. Adler and D. B. Joubert at the Massachusetts Institute of Technology and the University of Illinois. The amount of sulphuric acid consumed during the discharge of a lead accumulator was measured in order to determine whether 2 or 1 g. equivalents of acid disappear per Faraday passing and in order to decide between Gladston and Tribe's formula for the chemical reaction or that advanced by Fèry. The result was intermediate of the two. Careful chemical analyses of the oxide formed during charging show it to be certainly PbO_2. The chemical potential of the oxide on the positive plate was also found identical with that of chemically prepared PbO_2 and electrically precipitated PbO_2. The author suggested tentatively that intermediate oxides, for example Pb_3O_4, or basic compounds, for example $(PbO)_4.PbSO_4$ may be formed during discharge.

Arc Images in Chemical Analysis

The final paper of the Thursday morning session was that of William Roy Mott on "Arc Images in Chemical Analysis." Mr. Mott has been conducting a long series of highly interesting tests at the laboratories of the National Carbon Co.

Mr. Mott reproduced upon the screen some of the most characteristic arc images.

Dr. Bancroft, in discussion, complimented the author and ventured to say that the day was not far off when all analytical laboratories would be equipped with an arc image-testing outfit. Dr. Fink referred to the fractional separation of rare earths by the arc process and the comparative simplicity of this process as against any of the wet processes. Letters of commendation were received from Prof. Leonard of Wisconsin and Dr. Hillebrand of Washington.

Thursday Afternoon at Cambridge

Luncheon was served at the Walker Memorial Building of Massachusetts Institute of Technology, Cambridge, and an opportunity was afforded the members to inspect the splendid new buildings.

A New Cyanide

A technical session was held at the Institute from 2 to 4:30. The first paper was that of the incoming president, W. S. Landis, on "A New Cyanide" (see Chemical & Metallurgical Engineering, vol. 22, No. 6, Feb. 11, 1920, p. 265).

In discussion, L. E. Saunders of the Norton Co. gave a brief account of his early experiments on cyanamide and cyanide carried out in the electric furnace. With barium salts he had obtained fairly high efficiencies. The barium cyanide-cyanamide mixture was fused together with soda ash; the output of NaCN was high enough to offer commercial possibilities, but basic patents interfered.

Carbon in Iron

Dr. T. D. Yensen, of the Westinghouse Research Laboratory, presented a paper on a highly efficient method of determining very small amounts of carbon in iron.

The ordinary method of determining carbon in iron and steel consists in burning the sample with free oxygen, absorbing the CO_2 by means of KOH and weighing the KOH bulb before and after. In order to eliminate the errors due to absorption and weighing, the new method substitutes freezing out the CO_2 with liquid air and allowing it to expand into a known volume and noting the increase in pressure. In order to differentiate between the carbon existing as adsorbed CO or CO_2 and that existing in combined form, the method involves two heatings, one to 600 deg. C. in vacuo, and the other to 1,000 deg. or higher in oxygen. Extra precautions are also taken to eliminate errors due to other sources, so that by this method carbon can, if necessary, be determined with an accuracy of ± 0.0001 per cent.

Dr. Yensen's vacuum method gave rise to much favorable comment and was generally conceded to be one of the greatest advances in carbon analysis. Dr. A. S. Cushman of Washington pointed out that one of the great advantages of the Yensen method lay in the fact that we could now readily determine separately the three kinds of gases present in iron and steel: (1) blow-hole gas; (2) gas held in solid solution, and (3) "combined" gas, i.e., nitrides, carbonyls, carbides, etc. Nitrogen has a very deleterious effect on the quality of the steel; and furthermore, the effect of nitride nitrogen is distinct from that of dissolved nitrogen.

Other papers presented during this session included "The Influence of Enclosed Slag on the Corrosion of Wrought Iron," by L. T. Richardson, and "The Embrittling Effects of Cleaning and Pickling Upon Carbon Steels," by S. C. Langdon and M. A. Grossman, abstracts of which will be published in subsequent issues of Chemical & Metallurgical Engineering.

Electrolytic Calcium—Chromium—Bronze

P. H. Brace, of the Westinghouse Co., submitted an account of experiments on "The Electrolytic Production of Calcium," in which a new modification of Goodwin's moving-cathode cell was developed. Pure calcium chloride, properly dehydrated, was found to be the most satisfactory electrolyte. The product contained 1.08 per cent of chlorine and very small quantities of carbon.

"Electrolytic Chromium" was the title of a highly interesting paper contributed by George J. Sargent, of New York.

Brief allusion was made to the history of the deposition of chromium, including some unpublished work done by Skillman at Cornell University. Details were given of the electrolysis of various mixtures of chromic sulphate and chromic acid, showing that the yield of chromium from chromic acid solutions is greatly increased by the addition of chromic sulphate. Tabulated records were included of experiments with rotating cathodes, as compared with stationary cathodes, and investigations of the most favorable temperatures, and strengths of solution and mixtures, and current densities. Some theorizing was indulged in concerning the deposition of chromium with two different valences, 3 and 6, from chromic acid, chromic sulphate plating solutions. Very good deposits of chromium were obtained from chromic acid solutions containing small amounts of chromic sulphate. Low temperatures yielded fair ampere-hour efficiencies at comparatively low current densities. A deposit up to 1.25 cm. thick was obtained. The chromium plating is extremely resistant to corrosion by air, moisture, and many chemicals.

During the discussion of the paper, Dr Bancroft, under whose direction the research had been carried out, emphasized that the quality of the chromium deposit was very much dependent upon the current density. Attempts were made to produce a chrome-steel surface on iron by heating the plated iron in hydrogen. But very high temperatures were required to bring about good alloying and the scheme did not prove to be practical. F. S. Weiser, of Waterbury, suggested that a chromium-plated nickel wire might be used in place of the nickel-chromium alloys.

"Bronze Plating" was investigated and reported upon by Prof. F. C. Mathers and Stanley Sowder, a student of his at Indiana University. They found that bronze can be deposited from a bath containing potassium hydroxide 5 per cent, potassium cyanide 0.5 per cent, ammonium stannic chloride 0.38 per cent and potassium copper cyanide 1.5 per cent. Satisfactory corrosion of bronze anodes is obtained, using a temperature of 40 to 50 deg. C., and current density of 0.4 amp. per sq.dm. (3.75 amp. per sq.ft.).

Refractories; Their Physical Characteristics

The Research Laboratory of the Carborundum Co. presented two papers on refractories by M. L. HARTMANN and O. A. HOUGEN.

SPALLING LOSSES

The first paper was on "Spalling Losses" and covered comparative tests of the resistances of twelve different kinds of refractory bricks exposed to rapid cooling by an air blast after heating to 1,350 deg. C. This cooling was repeated up to ten treatments with nine bricks, while three were completely disintegrated at the seventh, fourth and third treatments. The results of all tests are summarized in the following table:

	Spalling at End of	Per Cent
1. Bonded carborundum (carbofrax C)	10th cooling	0.3
2. Bonded carborundum (carbofrax A)	10th cooling	6
3. Bonded carborundum (carbofrax B)	10th cooling	8
4. Grade A fireclay	10th cooling	9
5. Recrystallized carborundum (refrax)	10th cooling	12
6. Bauxite	10th cooling	43
7. Zirconia (natural)	10th cooling	53
8. Grade B fireclay	10th cooling	65
9. Grade C fireclay	10th cooling	90
10. Chrome	7th cooling	100
11. Silica	4th cooling	100
12. Magnesia	3d cooling	100

From five to ten bricks were used in each test. These were purchased in the open market and undoubtedly do not give absolute results for the various types of refractories. The general order of magnitude of spalling is probably correct, however.

COMPARATIVE COLD AND HOT ABRASION TESTS

The second paper was based on "Comparative Cold and Hot Abrasion Tests." These tests were made on different kinds of refractory materials, at ordinary temperatures and at 1,350 deg. C., by a carborundum cutting wheel under a constant pressure, and measuring the depth abraded in a given time. The results are summarized in the following table. While the figures are only roughly quantitative, they indicate the general relative resistances of these materials to abrasion.

TESTED HOT (1350 DEG. C. AT START)
(5-MINUTE PERIOD)

	Abrasion Inches
1. Bonded carborundum (carbofrax C)	0.01
2. Bonded carborundum (carbofrax A)	0.01
3. Bonded carborundum (carbofrax B)	0.03
4. Bauxite	0.04
5. Zirconia (natural)	0.06
6. Recrystallized carborundum (refrax)	0.07
7. Grade C fireclay	0.07
8. Grade B fireclay	0.09
9. Grade A fireclay	0.11
10. Chrome	0.27
11. Magnesia	12.50
12. Silica (lime bonded) spalled too badly for measurement.	

In discussing these two papers, F. A. J. FITZGERALD, of Niagara Falls, referred to the change in crystalline structure of certain bricks, in particular magnesite, which would naturally effect the spalling tendency. Furthermore, since the heat conductivity of the various bricks tested is widely different, the carborundum wheel test for abrasion does not seem to be satisfactory. Possibly a sand-blast test would be more reliable. Messrs. RICHARD, SAUNDERS and BANCROFT also participated in the disscusion.

The Smoker

The smoker was a distinct success. It was held in the laboratory of Arthur D. Little, Inc., beginning with a general inspection with incidental "exercises," which we shall describe later, and concluding in the assembly and lunch room. The tour began in the chemical museum on the main floor. This contains a large number of rare and interesting specimens as well as an illuminating exhibit of successive raw, intermediate and finished products of a great variety of industries. It is also so arranged as to show many things that could and should be done, for profit as well as for the improvement of human conditions, provided only the necessary research were undertaken and carried to a definite conclusion. It would be hard to find a better demonstration of the achievements of research on the one hand or of the amazing lack of initiative in industry to accomplish results that are at once available and greatly needed by this very means.

After a look through the administration offices the guests entered the basement, inspected semi-commercial scale apparatus and saw the experimental paper mill in operation, making A. D. L. filter paper; the entire plant being operated with distilled water. Following this the research laboratories, library and analytical laboratories were all visited, except the extraction room in which over-night work was in process. Then ensued a kind of competitive examination in olfactics, or of the nose efficiency of persons present.

AN EXAMINATION IN OLFACTICS

In one of the large rooms four tables were placed upon each of which were twelve similar bottles, corked and labeled with numbers. Each contained cotton wool moistened with 2 c.c. of an odoriferous body, and blanks were provided with spaces for the person's name and answers to be filled in. The key, which was known only to a committee of the staff, was: 1, almond extract; 2, kerosene; 3, oil of lime; 4, turpentine; 5, amyl acetate; 6, acetic acid; 7, carbon tetrachloride; 8, Worcestershire sauce; 9, carbolic acid; 10, ethyl alcohol; 11, oil of sassafras, and 12, vanilla extract. Nearly 80 per cent answered three-quarters of the numbers correctly, seven made only one mistake and only one, Dr. Alcan Hirsch of New York, gave the right answer to all twelve. He received the prize of a gold-headed silk umbrella. Some of the errors were interesting. Carbon bisulphide, iodoform and eucalyptol were mistaken for phenol, lactic acid for alcohol and acetic acid, menthol for turpentine and a majority thought sassafras was wintergreen. One wrote after No. 10 (alcohol), "familiar but cannot remember."

HUNTING WITH A CAMERA IN NEW BRUNSWICK WOODS

At about 9:30 the company repaired to the assembly room, where, after some lusty singing by the assembled 200 guests and some original songs by an employee of the laboratory written in the trenches in France, Lyman Underwood, a biologist of the faculty of the Institute of Technology, gave an illustrated talk on hunting with a camera in the New Brunswick woods. It was a very lively and interesting address and it made nearly everybody want to go and do likewise without delay. In introducing Mr. Underwood a member of Dr. Little's staff told a chemical story that should be profitable to those young men who want to study chemistry and nothing else. It seems a chemist of this sort was invited by an astronomer to look through his telescope with a field of a nebula in focus. "Huh!" exclaimed the chemist as a multitude of suns appeared, "the damned thing's colloidal!"

Refreshments were served at 11 o'clock and the occasion was acknowledged to have been one of the best smokers ever.

Symposium on Electrically Produced Alloys

The Friday morning session was a joint session with the American Institute of Electrical Engineers, and was held in the Copley Plaza Hotel. Dr. H. E. HOWE, of the National Research Council, introduced the subject with a brief discourse on "The Fundamental Problems in Alloys Research." A good deal of investigation is required, Dr. Howe said, in order to complete the published data on standard alloys. Likewise the testing of non-standard alloys should be undertaken and detailed physical and chemical properties tabulated and published. The corrosion problem is a very large one and has only been partly solved. Phase rule diagrams of ternary alloys are badly needed; very little has been published in this line. The effect of occluded gases on metals, specific heats of many metallurgical compounds, and best alloys for die casting are some of the other important problems that await solution. In conclusion Dr. Howe referred to the newly organized Alloys Research Association, which will devote its efforts initially to an informational service.

MANUFACTURE OF FERRO-ALLOYS IN THE ELECTRIC FURNACE

"The Manufacture of Ferro-Alloys in the Electric Furnace" was the title of a paper presented by C. B. GIBSON of the Westinghouse Co.

He stated that the demand for ferro-alloys is governed, to a large extent, by the requirements of the iron and steel industry. As specifications for ordinary, tool and alloy steels, and also castings, are becoming more rigid, the steel maker is depending on ferro-alloys to meet these requirements. The alloys in general use for deoxidizing are ferromanganese, ferrosilicon, etc. The alloys used for imparting to steel certain properties are ferromanganese, ferrochromium, ferrotungsten, ferromolybdenum, ferrovanadium, ferro-uranium, ferrotitanium, ferrozirconium, etc. After discussing briefly the specific uses of these alloys, the author gave some data in regard to power and raw material consumption in the manufacture of some ferro-alloys.

In laying out new furnace installations, or in planning to improve the operating conditions of existing ones, a careful study is essential of the problems relating to the bus and cable layout. Relatively the problems involved in 25-cycle installations, for the same size furnace, are not as serious as for 60-cycle, for the reason that maximum energy that can be fed into a constant voltage circuit at different frequencies is inversely proportional to the frequency. In other words, where a 10,000-hp., 60-cycle furnace is about the limiting size for a well-designed furnace and bus layout, 22,000 hp. is the corresponding size for a 25-cycle furnace.

In the discussion of Mr. Gibson's paper it was pointed out that the United States had two serious competitors in the ferro-alloy field—Canada and Norway. Dr. BANCROFT asked whether it was possible to predict at this time whether 25- or 60-cycle current is going to win out. Mr. Gibson replied that at present it was difficult to say; similarly, the limiting size of furnace cannot be predicted today; 3,000-kw. furnaces appear to be amply large. Dr. RICHARDS referred to the blast furnace as a competitor of the electric furnace and believed it to be possible to make 50 per cent ferrosilicon in the blast furnace if oxygen-enriched air were used. Dr. FINK in reply stated that highly concentrated electrical energy was usually cheaper than highly concentrated chemical energy and 50 per cent ferrosilicon made in the blast furnace would be comparatively costly.

DEVELOPMENT OF FERROVANADIUM METALLURGY

Another paper of the symposium was presented by B. O. SAKLATWALLA, general superintendent of the Vanadium Corporation of America, on "The Development of Ferrovanadium Metallurgy." The speaker referred to the modern introduction of vanadium into large-scale metallurgical practice, in armor plate and special steels. He described the methods of reducing vanadium compounds to metal by silicon in the electric furnace; by the alumino-thermic process, and finally by carbon.

In the discussion of Mr. Saklatwalla's paper GEORGE M. BERRY, of Syracuse, brought up the question of the future supply of vanadium and its steadily increasing cost. According to Mr. Saklatwalla there is only one deposit of importance, that of Peru.[1]

The supply has not been able to keep pace with the demand. Replying to Mr. GILLETT'S question, it was brought out that the percentage of carbon in the new carbon-reduced ferrovanadium is no higher than that of the former aluminum-reduced ferrovanadium (carbon derived from the lining). As to the somewhat higher silicon content found by Mr. Berry in the new product, Mr. NORRIS of the Vanadium Corporation stated that there is no objection to this silicon content in electric-steel manufacture, since the silicon can be slagged off readily. In the crucible process there might be difficulty in keeping the silicon content of the tool steel down. Others participating in the discussion were Messrs. BANCROFT, FINK and RICHARDS.

MANUFACTURE OF STELLITE

Mr. ELWOOD HAYNES of Kokomo, Ind., contributed an account of the present day manufacture of stellite, the well known tool steel. He referred also to many of the very remarkable physical and chemical properties. Dr. S. A. TUCKER of the Chemical Foundation inquired regarding the high price of the alloy and ventured to state that the present limited use of the alloy was due to its cost alone. Dr. FINK referred to Mr. Haynes' difficulties in the past in attaining uniform results when the alloy was made in an oil- or gas-fired furnace. Today, however, stellite is made in the electric furnace and the product is absolutely uniform in quality, strength and hardness. Dr. RICHARDS added that when making armor plate by the open-hearth process, 50 per cent of the chromium is lost.

FERROSILICON AND OTHER SPECIAL ALLOYS

"Ferrosilicon" was the subject of a paper by F. A. RAVEN, of the Canadian Ferro-Alloys, Ltd. Ferrosilicon is one of the most important of all ferro-alloys. The paper included a very interesting account of the various grades of ferrosilicon; description of the older and modern processes of manufacture; methods of grading; various applications of the alloys; and discussion of the electric furnaces best adapted to alloy manufacture.

RALPH M. MAJOR, of the Driver Harris Co., Harrison, N. J., gave an illustrated talk of the manufacture of nichrome, climax, invar and other special alloys made by his company.

In the discussion Dr. BANCROFT described the nichrome tubes that were used by the Government dur-

[1] See *Eng. and Mining J.*, April 3, 1920, p. 814.

ing the war for heating and activating nut charcoal. Messrs. TUCKER and WEISER discussed the forgeability, hardness and resistance to wear at elevated temperatures of the alloy nichrome. Mr. MAJOR said that there was not yet very much data available along these lines, but that tests are under way. Nichrome will stand about as much wear, when hot, as steel. It can be made very hard by working but not by heat treatment.

The Anaconda Copper Mining Co.'s experience in the electrical production of ferromanganese was related by E. S. BARDWELL, of the Great Falls staff.[2]

HIGH-SPEED STEEL

Of the complex alloys made in the electric furnace, high-speed steel is among the most important. A detailed account of its manufacture was presented by ROY C. MCKENNA, president of the Vanadium Alloys Steel Co. By the electric-furnace process the vanadium content of high-speed steel can easily be maintained within much narrower limits than by the crucible process. The average power consumption of a 3-ton heat of high-speed steel melted in a 3-ton Heroult furnace is 1,000 kw.-hr.; 40 lb. of carbon electrodes per heat; 80 heats per lining.

In discussing Mr. McKenna's paper, Mr. NORRIS reported that ferrovanadium with 20 per cent silicon had been successfully used in the electric furnaces. F. W. BROOKE, of Philadelphia, emphasized the importance of deoxidizing the slag before adding the ferrovanadium. Formerly too little attention was paid to this point.

"The Electrolytic Production of Ferrocerium" was described by Dr. ALCAN HIRSCH, of New York. The raw materials for cerium are the residues of the gas mantle industry. These are purified and the cerium salt is introduced into a fused bath. During electrolysis the current and voltage is carefully controlled and regulated. The metal is cast into small 8-in. molds. This is next alloyed with iron (30 per cent) or magnesium or copper. The ferrocerium is used in the manufacture of pyrophoric lighters. Dr. Moldenke has tried it out as a deoxidizer for steel, producing a very soft product, practically free from gas and with little internal shrinkage. The magnesium-cerium alloy is used for miners' lamps, where the flame effect is more desirable. Tests made on copper bars showed that the addition of a small percentage of cuprocerium to the molten copper increased the ultimate strength of the rolled or drawn metal from 25,000 lb. per sq.in. (without Ce) up to 26,740 (with Ce addition); elongation 28.4 and 33.5; and reduction in area, 23.6 and 37.8 respectively.

The paper was discussed by Messers. GILLETT, BULLOCK, BENJAMIN, FINK and BRAID.

"The Magnetic and Electrical Properties of Iron-Nickel Alloys" was the title of an A.I.E.E. paper submitted by Dr. T. D. YENSEN, of the Westinghouse Co. He reported upon a series of careful experiments on the permeability and hysteresis loss of Fe-Ni alloys, a paper which will be abstracted in a subsequent issue of CHEMICAL AND METALLURGICAL ENGINEERING.

W. S. LANDIS
New President of the American Electro-Chemical Society

ELECTRICAL PROPERTIES OF TITANIUM ALLOYS

Prof. M. A. HUNTER and J. W. BACON, of the Rensselaer Polytechnic Institute, investigated "The Electrical Properties of Titanium Alloys." They found that the addition of titanium to iron improves the magnetic quality of the iron. Alloys of titanium with nickel, copper, nickel-iron and nickel-copper were made. The resistances of these materials are only moderately high for additions of titanium up to 5 per cent. Beyond this point the alloys are exceedingly hard to draw.

Dr. YENSEN, in discussing Hunter and Bacon's paper, referred to experiments he had carried out on ferro-titanium alloys. His results seemed to show that there was no advantage in using titanium. In general better results were obtained with silicon and aluminum than with either titanium or boron.

Exhibit of Electrically Produced Alloys

In conjunction with the symposium a very attractive and instructive display of the various alloys produced in the electric furnace and electrolytic cell had been arranged by R. P. HOMMEL. Among the novelties were sheets of electrolytically deposited brass (¼ in. thick) and brass-plated steel submitted by GEORGE HOGABOOM; a large sample of silicon-zirconium from the Electrometallurgical Co., Niagara Falls; and rods of ductile aluminum silicide (tensile strength 30,000; elongation 5 to 6 per cent) submitted by the Alpax Laboratories of Cleveland.

Fixation of Atmospheric Nitrogen

C. FRANCIS HARDING and K. B. MCEACHRON, of Purdue University, gave a detailed account of their experimental studies of the fixation of atmospheric nitrogen by the silent electric discharge (Paper published in the *Journal*, A.I.E.E., April).

Power for Electrochemical Purposes

The Friday evening session was likewise a joint session with the American Institute of Electrical Engineers. That most vital of all topics—power—was discussed by many of the chemists and engineers assembled. President C. TOWNLEY of the Institute presided. JOHN L. HARPER opened the discussion with a paper on "Power for Electrochemical Purposes." He confined most of his attention to developments, both past and future, in the eastern section of the country. Here was a potential power of 1,900,000 kw. At Niagara today there were 500,000 kw. developed.

ELECTRIC-FURNACE POWER FROM THE STANDPOINT OF THE CENTRAL STATION

E. A. WILCOX, in his dissertation on "The Electric-Furnace Power From the Standpoint of the Central

[2]This paper was published in full in this journal April 14, 1920, p. 681.

Station," reviewed the entire situation in detail. He believed that a small electric furnace operating rapidly is preferable to a slow large unit. Furthermore, frequent heats mean less floor space. Electric-furnace power has many advantages: large blocks, no close regulation of service voltage as is required in lighting service, and more constant and steady demand and supply than interurban car or street car service. As a rule three-phase power is to be recommended.

Power Problems From the Standpoint of the Furnace Operator

Wallace G. Berlin, of High Bridge, N. J., discussed "The Power Problems From the Standpoint of the Furnace Operator." He talked chiefly of the power requirements when melting cold charges in the steel furnace.

In the open discussion, F. Hodson, of Philadelphia, recommended the installation of graphic meters very highly and considered it poor practice to overload the furnace. Mr. Benjamin urged a wider use of off-peak power for various electrolytic processes. Dr. Hering strongly favored the use of small furnaces at high speed on account of the much higher economy. Mr. Gail referred to the frequent unsatisfactory tariff contract. H. A. Winne said that a series of electric furnaces could be operated at a time very cheaply if a fixed schedule was adhered to. Mr. Hess favored the cold charge for the highest quality electric steel.

Automatic Control of Arc-Furnace Electrodes

"Automatic Control of Arc-Furnace Electrodes" was the title of J. A. Seede's paper. He described and illustrated the regulator he invented at the Schenectady works and referred briefly to numerous installations which had been operating satisfactorily for the past ten or twelve years. In contradistinction to the Thury regulator, which is of the intermittent control type, the Seede regulator is of the continuous control type. Provisions are made in case power is shut off completely. The close regulation obtainable was strikingly demonstrated by a series of charts from a curve drawing instrument connected into the circuit of an electric alloy steel furnace.

Other Papers

Harvey A. Winne of Schenectady presented a paper on "Reactors for Electric-Furnace Circuits."

C. T. Maynard described the plant of the Rumford Falls Power Co. in Maine, and pointed out the many advantages of this "Location for a New England Electrochemical Plant." About 35,000,000 kw.-hr. per year are available for immediate use as continuous primary power and about 40,000,000 kw.-hr. per year more of secondary power.

F. F. Fowler presented a discourse on "The Water Powers of the Pacific Coast." He discussed in detail the coastal rainfall, cause of present power shortage, Columbia River power development (estimated price, $15 per hp.-yr. on the basis of immediate sale of all the power), availability of raw materials, etc. Puget Sound is today the most favorable locality. In California the net minimum cost is $32 with a power factor 95 per cent and a load factor of 100 per cent.

The final paper of the symposium was that of Dr. J. W. Beckman, of San Francisco, on "Power Developments in Scandinavia." Dr. Beckman showed how active has been the development of water power in Scandinavia, fostered by wiser legislation on the subject than in the United States.

Visits to Industrial Plants

On Friday afternoon the members were the guests of the General Electric Co. and an interesting and instructive tour was made through the River Works and the old Thomson Houston plant on Federal St., Lynn. Of special interest was the inspection of the Heroult electric furnace in the steel foundry which was in "full blast."

On Saturday afternoon the plant of the Huff Electrostatic Separator Co. of Arlington was visited. William E. McKee of the company had arranged a very striking display of some of the results obtained with the separator and demonstrated the actual working of the apparatus. Of special interest was the concentration of graphite from native Alabama and Pennsylvania ores resulting in a high-grade product "Electrophite," used in the manufacture of plumbago crucibles. Other noteworthy separations were those made on Florida sands resulting in a 98.5 per cent TiO_2 product on the one hand and a 97.8 per cent ZrO_2 product on the other; and separation of zinc from gold, silver, lead, copper and iron in complex ores.

Saturday Morning at Harvard University

In his address of welcome, Prof. T. W. Richards referred to Benjamin Thompson's (Count Rumford) activities and pointed out that his early lecture notes were still preserved at Harvard. The first paper on the program was that of Joseph W. Richards on "The Söderberg Self-Baking Continuous Electrode."

Briefly, this arrangement calls for a mechanism situated on a working floor directly above the furnace, which forms and feeds the vertical electrodes just as fast as they are consumed on the lower end by the furnace.

This paper aroused considerable interest and was admitted to be one of the most important of the meeting. A member of the Southern Ferromanganese Corporation pointed out that three of its electric furnaces are being equipped with Söderberg electrodes and that Mr. Swann is fully confident of success. The electrodes are 32 in. in diameter and will be in operation next month. In reply to questions put by Messrs. Tucker and Saunders, Dr. Richards stated that the electrical resistance of the hard-baked Söderberg electrode was the same as that of the ordinary electrodes of today. As regards the smoke due to the binder, pitch and tar, this does not vitiate the atmosphere of the foundry, since it is forced downward into the furnace and is there consumed. Furthermore, the baking of the Söderberg e'ectrodes proceeds so very slowly, about one meter per week, that there is very little smoke produced per unit time. As regards possible iron contamination from the metal casing of the electrode, it was found by actual test that in calcium carbide furnaces the product contained but 0.2 per cent Fe. If the Söderberg electrode were to be used for aluminum furnaces, an aluminum casing could easily be substituted for the iron casing.

Synthetic Electric-Furnace Cast Iron

Charles Albert Keller, director of Keller & Leleux of Paris, contributed an interesting illustrated account of the production of "Synthetic Electric-Furnace Cast Iron," substantially the same as was published in Chem-

ICAL & METALLURGICAL ENGINEERING, vol. 22, p. 83. In the disscussion of Mr. Keller's paper, F. W. BROOKE, of the Electric Furnace Construction Co. of Philadelphia, emphasized the difficulties in obtaining high carbon cast iron from melting steel turnings in the electric furnace.

STEP INDUCTION REGULATOR FOR ELECTRIC FURNACES

PHILIP B. SHORT, of the Westinghouse Co., presented a brief paper on a new "Step Induction Regulator for Electric Furnaces." The equipment consists of a combination induction type regulator, a selector switch, a transformer switch, a series transformer and a suitable panel for meters and switches. Photographs were shown of equipment recently designed for twenty electric zinc furnaces in Norway.

L. E. SAUNDERS congratulated the company upon the design and production of this new regulator and felt convinced that with the introduction of this regulator a great saving in cost of operation could be looked forward to.

EVOLUTION OF THE ELECTRIC BRASS FURNACE

The next paper, by H. M. ST. JOHN, of the Detroit Electric Furnace Co., on "The Evolution of the Electric Brass Furnace," gave rise to a very spirited discussion.

Mr. St. John divided electric furnaces applicable to brass melting into three groups and discussed the evolution of commercial types in each group.

The indirect resistance type, in which heat is generated in a resistor and transferred by radiation or conduction to the metal to be heated, resulted from the tendency of the first designers to copy combustion furnaces. Various resistors have been employed in the electric crucible furnace, but none have met with marked success. A recent addition to this group is the high-tension, high-frequency induction furnace in which the walls of the crucible itself are electrically conducting and serve to heat the contents during the period while the metal is still solid. By placing an incandescent resistor in the top of the furnace, crucibles may be dispensed with, and the design simulates that of an open-hearth furnace. One successful furnace employs an overhead granular resistor contained in a nearly circular refractory trough.

In the induction- or direct-resistance type the heat is generated by the direct resistance of the metal itself. These furnaces utilize the pinch-effect phenomenon, the latest modification being the vertical-ring induction furnace, which is recommended only for 24-hr. operation melting yellow brass.

With arc furnaces, the heat is transferred to the metal directly or indirectly by conduction or radiation. Volatilization and oxidation losses are high in the direct-arc type, so this has given way to indirect-arc furnaces which are either rocking or rotating for the purpose of maintaining uniformity of temperature throughout the molten bath.

A consideration of what the brass foundryman could expect from the use of electric furnaces brought out the following data in regard to energy consumption:

The consumption of electric energy under average conditions of 8- to 10-hr. operation is as low as 240-kw.-hr. per short ton for yellow brass, and 275 kw.-hr. per ton for red brass, in the induction or arc furnaces. In 24-hr. operation figures as low as 200 kw.-hr. per ton or less have been obtained. Less efficient furnace types use from 400 to 500 kw.-hr. per ton, depending upon conditions.

Messrs. FINK, WINDER, CROSBY, TUCKER, GILLETT, CONE, WEISER, BAILY, HERING and RICHARDS participated in the discussion. The main point at issue was the kilowatt-hour consumption per ton of yellow brass.

C. A. WINDER, of the General Electric Co., felt that Mr. St. John had not sufficiently emphasized the advantages of other than arc type brass furnaces. The low zinc losses of the resistance-type furnaces due to lower temperatures of operation, the cleansing action of the pinch and induction-type furnaces, reducing the oxide contamination to a minimum, besides effecting a uniform temperature in the alloy itself, were points well worth while considering. At present there seems to be a field for every one of the five types of brass furnaces. L. E. CROSBY, of Detroit, submitted figures of performance of the "rocking" furnace. At ten different installations, melting 60-40 and 70-30 brasses, the consumption of electrical energy amounted to 240 kw.-hr. and less for an 8- to 10-hr. day. At one of the brass foundries a six months' record (8-hr. day) showed an average of 215 kw.-hr. per ton of brass. Bronzes containing 92 per cent copper require more power. As regards uniformity of temperature of the molten brass in the rocking furnace, direct measurements indicated a variation of not over 3 deg. C. The furnace rocks every 40 seconds and therefore big differences in temperatures do not obtain. Furthermore, contamination by oxides is very slight since the atmosphere in the furnace is a reducing one (CO gas). The actual tonnage turned out by the rocking furnace today is about twice that of any other type of brass furnace. H. W. GILLETT, of the Bureau of Mines, Ithaca, N. Y., cited the performance of an induction furnace at the American Brass Co.'s plant: A ton of yellow brass was melted in 174 kw.-hr.; 240 kw.-hr. was certainly not impossible, as Mr. Winder contended; every brass furnace ought to do as well as that. Dr. CARL HERING, of Philadelphia, put in a plea for the induction type or pinch effect furnace. An important point besides power consumption is low loss of zinc; in induction furnaces this loss is very low. Then there is the self-regulating feature of the induction furnace, whereby the temperature of the metal is kept within narrow limits. As soon as the temperature rises too high a small zinc bubble is formed and the circuit is broken. There are about eighty-four induction type brass furnaces in operation today. Mr. CONE of *Iron Age* added that today there are about 300 electric brass furnaces in operation, including all types.

F. S. WEISER, of the Scovill Mfg. Co., regretted that there were not yet available reliable relative data on the performance of the different types of brass furnaces, giving the life of linings, cost of operation, metal losses, etc., in each case. T. F. BAILY, of the Electric Furnace Co., Alliance, Ohio, said that in the operation of his resistance furnace 285 kw.-hr. is required per ton of yellow brass.

Dr. RICHARDS, in commenting on metal losses, pointed out that a saving of 1 per cent of zinc during melting was equivalent to about 64 kw.-hr. (1c. kw.-hr.) and that the theoretical power consumption for melting brass was about 130 to 150 kw.-hr. Zinc does not boil out of brass until the melting point of copper is reached.

In discussing "The Melting of Lead Alloys" in the electric brass furnace, Mr. WINDER stated that the induction furnace could not handle alloys higher than 2 per cent lead on account of rapid deterioration of the furnace lining. Mr. GILLETT quoted results obtained by Clamer in the induction furnace, showing that good results were obtained with 6 per cent lead alloys. Mr. CROSBY referred to the experience of the Michigan Smelting & Refining Co. It is melting a 26 per cent lead alloy in a 2,000-lb. rocking arc type furnace with a maximum deviation of lead of 0.6 per cent Pb.

THE ELECTRIC FURNACE IN IRON AND STEEL METALLURGY

The next paper was presented by LEWIS B. LINDEMUTH, of New York, on "The Position of the Electric Furnace in Iron and Steel Metallurgy." He gave a detailed comparison between the physical and chemical characteristics and phenomena of the four steel-making processes, bessemer, open-hearth, crucible and electric-furnace. The advantages of the electric furnace he dwelt upon in detail and concluded that the electric furnace, when properly installed and operated, is metallurgically the best steel-making apparatus we have, and economically the cheapest.

In discussing the paper Dr. RICHARDS, of Lehigh University, ventured to predict that the day is not far distant when all steel will be finished in the electric furnace. As a piece of apparatus for refining or finishing steel, the electric furnace has no competitor. The duplexing and triplexing systems are gaining favor.

ELECTRIC ARC MELTING FURNACE AND THE CENTRAL STATION ELECTRIC COMPANY

"The Electric Arc Melting Furnace and the Central Station Electric Company" was the title of the next paper, presented by AUGUSTUS C. SMITH, of the Buffalo General Electric Co. Tests on arc furnaces with an Esterline graphic meter were made and very accurate records of the characteristic use of electrical energy were secured. Photographic copies of these graphic records were shown. Many of these reveal great surges which cause serious disturbances in the central station's lines. Mr. Smith pointed out, however, that with a certain amount of care in the operation of the electric furnace the surges can be practically eliminated.

In discussing Mr. Smith's paper Mr. COE felt certain that abnormally large surges could easily be eliminated by introducing automatic reactors into the circuit. Mr. NOYES outlined the very efficient system of the Detroit Edison Co. in supplying power to various electric foundries. Small substations are located at or near the electric foundry, and these substations are fed by 23,000-volt feeders, entirely separate from the lighting circuits.

ELECTRIC FURNACE AS APPLIED TO METALLURGY

A very valuable compilation of the literature of "The Electric Furnace as Applied to Metallurgy" was submitted by CLARENCE J. WEST, of the Arthur D. Little Laboratories. This compilation covers the years 1900 to 1919 and will be greatly appreciated by all students of electrometallurgy.

RESOLUTION OFFERED BY DR. RICHARDS OF LEHIGH AND VISIT TO THE T. W. RICHARDS LABORATORIES

In bringing the session to a close, Dr. RICHARDS of Lehigh offered a resolution embodying the hearty support of the American Electrochemical Society of the undertaking of the National Research Council in collecting and publishing its tables of critical physical and chemical constants, the Society recognizing full well the valuable aid to research and industry of tables of this kind. Dr. Richards of Harvard suggested that detailed references to all data be given; also references to values not included in the tables. Dr. Bancroft in reply assured the members that no effort would be spared in making the tables as complete as possible. The selection of the most probable value will in each case be left to an expert or group of experts. The National Research Council hoped to accomplish in the case of these tables what has been done in the past for atomic weight determinations.

Before adjourning for luncheon at Harvard Union Dr. T. W. Richards invited the members to visit his new laboratories, where measurements of highest precision are carried out. These laboratories are absolutely dust-proof and provisions are made throughout for the elimination of influences and effects that might give rise to inaccuracies in the use or operation of mechanical and electrical apparatus and instruments. There were buttons of the purest silver in the world, a large crystal of gallium and beautiful specimens of indium on display.

February Exports Show Decline

A decided drop in exports was the outstanding feature of the February foreign-trade statement issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

February exports amounted to $646,000,000, the smallest since October of last year, against $722,000,000 in the preceding month of January and $585,000,000 in February of last year. Exports during the eight months ended with February were $5,231,000,000, against $4,383,000,000 in the eight months of last year.

February imports amounted to $467,000,000, against $474,000,000 in January of this year and $235,000,000 in February a year ago. Imports during the eight months' period ended with February amounted to $3,235,000,000, against $1,933,000,000 a year ago. The imports during these eight months, representing two-thirds of the current fiscal year, exceeded by $140,000,000 the imports during the entire fiscal year ended with June, 1919.

Bronze Powder and Metal Leaf Industry in Japan

The statement that the Japanese bronze powder and metal leaf industry, which was making rapid progress before the war, grew phenomenally as a natural result of the cessation of their competitors, appears in an issue of *Commercial Osaka.* Several new companies were formed, including one having a monthly capacity of 100,000 lb. of bronze powder in addition to producing copper and aluminum powders and gold leaf.

Co-operation (!) During Reconstruction

The Société des Mines de Potasse de Sainte-Thérèse sent to the Portland Cement Werke Wetterau, of Langfurt a/M., a letter requesting an offer of cement and received the following reply: "It is agreeable to us to note by your request that France is in a state of economic dependence and we decline to come to her aid."—*The Review,* March 15, 1920.

T.A.P.P.I. BANQUET AT HOTEL ASTOR, APRIL 14, 1920

Fifth Annual Meeting of T.A.P.P.I.

Address of Welcome Given by George Sisson, President of the American Paper and Pulp Association—Presidential Address by Raymond S. Hatch—Election of Officers—Social Features, Including Banquet at Hotel Astor

THE fifth annual meeting of the Technical Association of the Pulp and Paper Industry was held April 13 to 15 in the Waldorf-Astoria, New York City. It was well attended and the program was well arranged and interesting.

Tuesday was devoted to meetings of the various standing committees, and registration of members and guests.

Society to Publish Journal

The first general session began on the second day. Raymond S. Hatch, president of the association, spoke of the growth of the society, which now numbers 535, and of the work it has accomplished. He also suggested the need of a technical journal controlled and operated by the association. This paper is to be devoted to the transactions of the association and to contain such technical information as pertains to the paper industry. The matter was favorably acted upon and referred to members of the finance and executive committees to devise ways and means of carrying out the project.

Address of Welcome

George Sisson, president of the American Pulp and Paper Association, delivered an address of welcome in which he emphasized the excellent work of the National Association of the Pulp and Paper Industry, and expressed the desire, on behalf of the American Pulp and Paper Association, to co-operate in every way possible to further the good work.

The rest of the morning session was taken up with reports of the committees and the election of officers.

Election of Officers

Officers elected for the ensuing year are: President, Raymond S. Hatch, the Hamersley Manufacturing Co., Garfield, N. J.; vice-president, Robert B. Wolf, Aeolian Building, New York, N. Y.; secretary-treasurer, Thomas J. Keenan, 471 Fourth Ave., New York, N. Y.; executive committee, Raymond S. Hatch, chairman; Robert B. Wolf; Henry E. Fletcher, Fletcher Paper Co., Alpena, Mich.; Frederick C. Clark, American Writing Paper Co., Holyoke, Mass.; Henry P. Carruth, Mead Pulp & Paper Co., Chillicothe, Ohio; Royal S. Kellogg, News Print Service Bureau, 18 E. 41st St., New York City; George E. Williamson, Strathmore Paper Co., Mitteneague, Mass.

Wednesday afternoon and all day Thursday were devoted to the presentation and discussion of the various papers, and to symposiums, the nature of which will be reviewed in a later issue of Chemical & Metallurgical Engineering.

Wednesday evening at 7 o'clock the members gathered for a reception in the Hotel Astor, followed by a banquet in the East Ball Room.

Judge Charles F. Moore, as toastmaster, spoke in the highest terms of the work done by the association for the paper industry, and of the appreciation by the men in the paper field of the chemical profession for its labors. He brought out the fact that the future success of the paper industry depended upon technical research, and that the very existence of the operators in the future depended upon the work of the technical men, and therefore the operators should support their work both financially and morally.

Herbert Hoover was to have been a guest of honor at the banquet, but owing to pressure of the many demands upon his time, he was unable to attend. He did, however, send his regrets and appreciation to T.A.P.P.I. and wished the association success in its work.

Dr. William H. Walker, of the Massachusetts Institute of Technology, gave a few reminiscences of his experiences in the early days of paper making and then explained a plan which M. I. T. is using to disseminate among the industry the vast store of information now collected and available in the institution.

Need of Vocational Education

Dr. Charles Baskerville, of the College of the City of New York, commented on vocational education and the dearth of trained men in this country of managerial capacity. He said that the three great factors of our prosperity are raw materials, money and men, and that although the country had the two former it lacked the trained men. Vocational education is a scheme to meet, in a measure, this situation. Dr. Baskerville also compared man to an instrument capable of development and not a mere receptacle of knowledge.

Howard S. Neiman, of New York City, told how T.A.P.P.I. protected the paper industry, and encouraged young men to go into the business.

Course Prepared by Vocational Education Committee

George Carruthers, president of Interlake Tissue Mills, Ltd., Toronto, Canada, said that 90 per cent of the managers of the Canadian paper mills were Americans. He laid special stress upon a new series of textbooks and correspondence courses now being prepared by the Vocational Education Committee of the Pulp and Paper Industry. This course aims to educate the men in the paper industry to a clearer insight of their own work and its relation to the industry as a whole, and also to fit them for more responsible positions.

Mr. Chipman, president of the Canadian Pulp & Paper Co., gave an outline of the meeting to be held in Canada and cordially extended an invitation for all present to come.

The Human Factor in Industry

John Stadler, of Belgo-Canadian Pulp & Paper Co., Ltd., Shawinigan Falls, Canada, the last speaker on the program, seconded Mr. Chipman's invitation, and then spoke of the human factor in industry. He did not consider this element as a commodity with a nominal market price, but something infinitely more vital with latent and potential capacities, upon which the development of the industry depended. Too much emphasis has been laid on the material side of the question and not enough on the human. He would bring the development of the man power of the organization to a higher plane through well-directed vocational education and co-operation with the management.

Crude Phosphate Situation in France

Agricultural science and intensive farming being highly developed in France, that country is a large user of superphosphate. In 1913 France consumed, in the manufacture of superphosphate, 1,100,000 tons of crude phosphate, which was obtained from the following sources: Algiers and Tunis, 795,000 tons; United States, 145,000 tons; and France, 160,000 tons.

During the years of the war France imported the following quantities of crude phosphate: In 1914, 787,000 tons; 1915, 346,000 tons; 1916, 321,000 tons; 1917, 258,000 tons; and 1918, 247,000 tons. The decrease in the use of crude phosphate was due to the lack of transportation facilities and to the fact that sulphuric acid was required as an essential in war industries. Prior to the war the annual production of superphosphate in France amounted to 2,000,000 tons, an amount sufficient for French consumption and for the export of 50,000 tons. During the war capacity for production of sulphuric acid was doubled. A greater part of this increase in productive capacity will ultimately be employed in the manufacture of the superphosphate, but this is not practical at the present time, as vessels and rail accommodation are lacking for the transportation of phosphate and also of pyrites and coal.

The French Government allocated the African phosphate production for the year 1919 as follows: France, 700,000 tons; England, 247,600; Italy, 355,000; Portugal, 14,700; Belgium, 3,600; Switzerland, 5,500; Spain, 734,600; making a total of 1,400,000 tons. But of the total amount allocated for French use, namely, 700,000 tons, only 200,000 tons were imported in the first semester, owing to the impossibility of securing vessels for transportation.

The needs of various European countries for crude phosphate in the year 1919 were estimated as follows, according to the *Fortnightly Review*, published by the American Chamber of Commerce, at Paris: France, 1,100,000 tons; Italy, 600,000 tons; England, 400,000 tons; Spain, 200,000 tons; Belgium, 100,000 tons; Netherlands, 100,000 tons; Portugal, 50,000 tons; Scandinavian countries, 40,000 tons; Switzerland, 10,000 tons; total, 2,600,000 tons.

Exports and Imports of Chemicals

Exports of chemicals during February were valued at $13,209,935, according to figures compiled by the Bureau of Foreign and Domestic Commerce. Some of the items making up that total, as well as revised figures for February of 1919, are as follows:

EXPORTS OF CHEMICALS

	Feb. 1919 Lb.	Feb. 1920 Lb.
Acids:		
Carbolic	27,372	97,534
Nitric	26,136	34,003
Picric	71	718
Sulphuric	767,792	2,025,311
Benzol	228,852	107,460
Calcium carbide	1,098,033	1,142,185
Copper sulphate	893,238	97,635
Wood alcohol	11,912	177,388
	Value	Value
Total sodas	$ 1,943,796	$ 1,706,556
Total chemicals	12,234,579	13,209,935
Total dyes and dyestuffs	2,018,642	2,461,797
Medicinal and pharmaceutical preparations	1,530,786	1,594,135

Some of the import figures, as compiled by the Bureau of Foreign and Domestic Commerce, are as follows:

IMPORTS OF CHEMICALS

	Value	Value
Chemicals:		
Free	$5,516,840	$11,878,274
Duty	3,896,713	4,725,832
Coal-tar products	400,345	350,174
Gums	2,012,186	4,363,893

Genesis of Ferrite

Contrary to Commonly Accepted Ideas, the Ferrite in Hypo-Eutectoid Steels Is Not Extruded as a Shell to the Outside of Austenitic Kernels, but Exists as an Aggregation of Crystals Essentially Discontinuous and Originating at the Low-Carbon Nuclei of Solid Solution Grains

By FEDERICO GIOLITTI

THAT α and β iron have an essentially different crystalline habit, and that the excess constituent in hypo-eutectoid steel does not collect at the periphery of austenite crystals in slowly cooled clean steel, can be demonstrated by direct observation of the various phases of formation of the ferrite itself, evidently the most direct and surest method of attacking the problem. Such demonstration appears necessary and is worthy of emphasis on account of the great practical importance of granular structure in steel and because so many erroneous ideas on its genesis appear in the literature. Especially, in the light of his own experiments, must the present author take issue with the eminent American Dr. Henry M. Howe in the latter's conclusions that ferrite is expelled to the outside of austenite grains on slow cooling, an idea developed at length in a paper entitled "Life History of Network and Ferrite Grains in Carbon Steel," published in the *Proceedings* of the American Society for Testing Materials, 1911, vol. 11, p. 271, and in his recent book on "The Metallography of Steel and Cast Iron."

I have presented reasons for believing that β iron crystallizes in rounded grains as compared to very flat plates, the normal habit of α iron, in an article entitled "Crystallography of Alpha and Beta Iron" appearing in CHEMICAL & METALLURGICAL ENGINEERING, vol. 22, p. 585 (March 31, 1920). In the present paper, the microscopic evidence further supports the hypothesis there set forth, but the primary purpose now is to establish my contention that ferrite meshes are essentially discontinuous chains of crystals and do not outline the original austenitic grain boundaries.

First Appearance of Ferrite

A few years ago the present author, with the aid of N. Boyer, conducted a series of experiments on a very well made, clean steel of the following composition:

	Per Cent		Per Cent
C	0.62	S	0.02
Mn	0.58	P	0.03
Si	0.07		

Some results of these experiments were presented at the time before the Academy of Sciences of Turin[1]. This steel had been forged into a bar 30 mm. square. Six blocks, 25 mm. long, were then cut off and suspended in a salt bath at 900 deg. C. for 1 hr. At the end of that time the fire was drawn and the bath slowly cooled, under constant stirring. When the temperature had fallen to 750 deg. C., one of the pieces was quickly withdrawn and quenched in water at room temperature, the second cube quenched when the temperature had fallen to 740 deg. C., and so on by 10 deg. steps, the sixth being withdrawn at 700 deg. C. All samples were then reheated in a lead bath at approximately 575 deg. C. to transform the martensite into sorbite.

When examined, the pieces quenched from 750 and 740 deg. C. were found to show sorbite and troostite, with no ferrite accumulations of microscopic size, which, indeed, could have been predicted. Fig. 1 gives the appearance at 160 diameters of the piece cooled to 730 deg. C. and then quenched[2]. Here are seen the first crystallites of ferrite which have separated out of austenite during the brief range from 740 deg. (the approximate temperature of germination of ferrite for this composition) and the quenching temperature, at which the normal process of growth of pro-eutectoid material was suddenly interrupted. As will become more apparent in the later specimens, it can be seen that even near the germinative point the ferrite separates in small isolated masses showing no disposition to segregate at the austenite grain boundaries when these grain boundaries do not contain any producers of oxidizing gases such as slag inclusions—an important reservation to which I will return later in this series of articles. The random location of the first appearing ferrite is all the more impressive when Fig. 1 is compared to Fig. 2 from Howe and Levy[3], which shows excess cementite extruded to a true meshwork at crystalline boundaries. Howe and Levy's metal contained 1.45 per cent C, 0.16 per cent Mn. It was heated under borax in a graphite crucible in an injector gas furnace for 50 min. to 1,200 deg. C., then transferred to a bath of fused KCl + NaCl at 930 deg., contained in a 4.5-in. graphite crucible held in an electric tube furnace. This temperature then was slowly lowered, taking 9 min. to pass from 960 deg. C. (above the germinative temperature) to 885 deg. C. (below the germinative temperature), at which latter point it was water-quenched, then reheated to 400 deg. C. to sorbitize the martensite ground mass. Apparently the conditions of formation allow close comparison of the crystalline habit of the pro-eutectoid constituent.

Quenching my steel at 720 deg. C. allowed the process of segregation to develop under normal conditions for a much greater interval. As shown in Fig. 3, the ferrite accumulates about nuclei of crystallization representing low-carbon localities and certainly not in characteristic contours surrounding granular kernels where, as a matter of fact, by the inhomogeneity of the solid solution, the last-solidifying material is *highest* in carbon. Instead, the ferrite crystals maintain an individual isolation, from which, however, there appears an incipient formation of acute projections due to the plate-like habit of α iron (in turn responsible for Widmanstättian structure, and the needle-like ferrite often observed in unannealed forgings, as discussed at some length in the article mentioned in the second paragraph

[1]Vol. 48, p. 1.

[2]All micrographs are etched with 5 per cent picric acid in ethyl alcohol except Fig. 8 which is etched with HNO_3 in amyl alcohol.

[3]"The Life History of Pro-Eutectoid Cementite," International Congress for Testing Materials, 1912, vol. 2, p. 1.

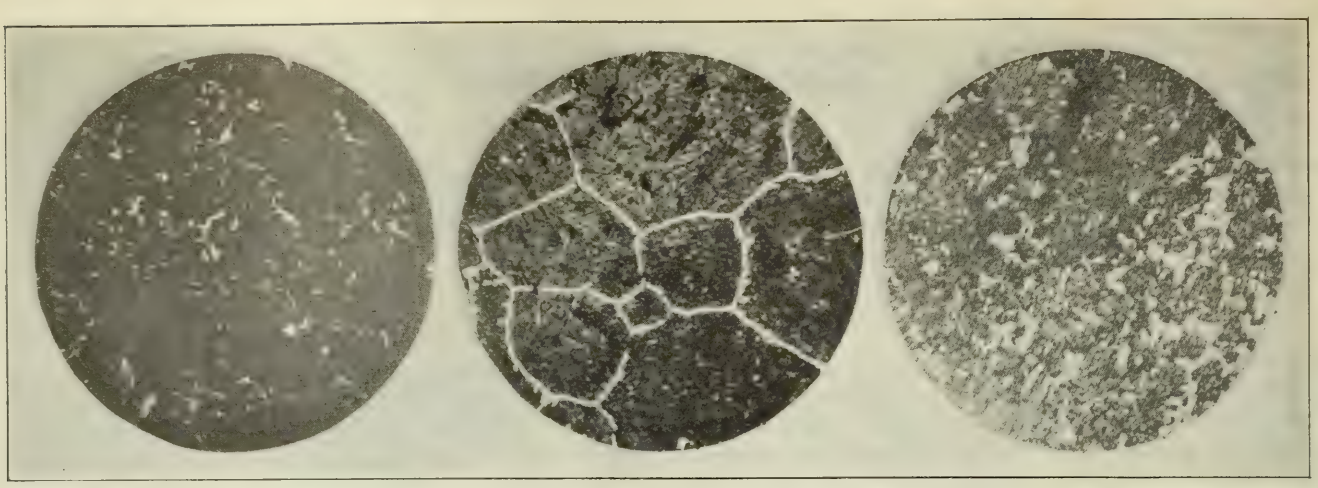


FIG. 1. Ferrite nuclei in 62-point carbon steel; quenched from 730 deg. C. × 160

FIG. 2. First precipitated cementite in 1.45 per cent carbon steel. × 50. (Howe and Levy)

FIG. 3. Ferrite nuclei, after further growth; quenched from 720 deg. C. × 160

of this paper). In this particular steel the first iron to precipitate came down as β iron, above the range MO of the iron:carbon diagram, at low-carbon spots containing considerably less carbon than the average analysis. On further cooling past the beta to alpha transformation, excess iron is precipitated as ferrite with its characteristic plate-like crystallization. Left to itself, such ferrite would appear in a rectilinear meshwork much like the warp and woof of woven cloth, but it is subjected to the additional attraction exerted by the pre-existing nodules of precipitated iron[4]. Its final form therefore is the resultant of these two forces —its own lamellar crystallinity, and the attraction of pre-existing accumulations of ferrite—and at the end the appearance is that of rough approximation of cell walls, much interrupted in their continuity.

Examination of Fig. 4 (quenched from 710 deg. C.) substantiates more clearly the above deductions. Here again are nuclei of ferrite, with their characteristic acute protuberances, but developed in size and distinctness owing to the longer interval of growth. Examined less in detail, but in general aspect, the disposition of the structural elements is such that the ferrite is placed in a manner to simulate the elements of a meshwork *with interrupted meshes* surrounding troostite-sorbite grains but partly isolated, an appearance more striking when examined at lower magification (Fig. 5).

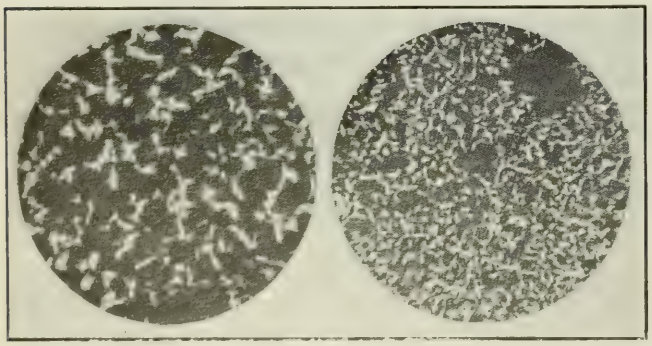


FIG. 4. Semblance of ferrite meshes in 62-point carbon steel; quenched from 710 deg. C. × 110

FIG. 5. Same steel as shown in Fig. 4, but at lower magnification. × 35

[4]That existing ferrite (or cementite) has a pronounced attraction for smaller quantities of nearby like material, even causing an apparent migration of 0.1 or 0.2 mm., is shown in my book on "The Cementation of Iron and Steel," when discussing the reasons for the presence of broad pearlitic zones in steels having a hypereutectoid case (Type II).

Further demonstration of the actuality of such "pseudo-meshwork" is unnecessary, considering the method of its birth—which has just been minutely analyzed—and the fact that the lighter areas are essentially and always have been separate granular crystallites. Furthermore, wide spaces always separate the elements of ferrite, which as a whole present extreme dissimilarity to cementite shells, which I admit are extruded to crystalline boundaries.

Continuing the passage through the transformation range will only cause ferrite grains to increase in size and develop their spinelike fringes, an inference confirmed by Fig. 6, quenched at 700 deg. C. A lower magnification (Fig. 7 at 70 diameters) shows the meshwork appearance to have progressed further, but to retain still its necessary genetic characteristics.

Confirmation by Reversing the Experiment

Entirely analogous results should be obtained by inverting the process, which can be handily done by quenching—after cooling to some definite temperature between Ar_3 and Ar_1—a partially cemented steel piece whose carbon content increases uniformly from about 0.30 to 0.80 per cent. This is evidently equivalent to fixing for examination in a single specimen a continuous variation in the time and temperature interval between beginning of ferrite deposition and its interruption.

The low-carbon edge of such a carburized steel is shown in 70-diameter microsection in Fig. 8. Originally it possessed

	Per Cent		Per Cent
C	0.19	S	0.03
Mn	0.52	P	0.03
Si	0.11		

and was cemented for 3 hr. at 1,000 deg. C. with CO and wood charcoal, allowed to cool slowly, reheated for 1 hr. at 900 deg. C. in a salt bath, cooled in the pot to 720 deg. C., quenched in water at room temperature, and finally tempered in a lead bath at approximately 575 deg.

Without repeating in detail the preceding discussion, it suffices to note that the structure as one proceeds from the high-carbon to the low-carbon regions develops all the characteristic facts established in what goes before. Low-carbon regions show wide markings of ferrite, resulting from an accumulation of roundish grains, while as the carbon increases, simultaneously appear more and

more suggestions of needle-forms as intersections of the plane of polishing with a plate or sheet of ferrite.)

That hypo-eutectoid steel slowly cooled through the transformation range contains an aggregation of disoriented crystalline granules of ferrite having forms resulting from the play of two different crystallizing tendencies is confirmed in almost daily observation by those working with such steels. One or two very definite instances may be cited.

Fig. 9 shows at 40 diameters the structure near the decarbonized edge of a 12-ton ingot of high-grade steel analyzing

	Per Cent		Per Cent
C	0.55	S	0.018
Mn	0.58	P	0.04
Si	0.26		

On account of a breakdown in the forge shop, the ingot remained in the heating furnace for four days at a temperature of about 1,150 deg. C., then was slowly cooled in ashes. Consequently, primary austenite was thoroughly well equallized in its carbon content during the long heating, and ferrite was allowed to segregate freely in the slow cooling.

Examination of the micrograph shows clearly in each ferrite crystal the morphological characteristics resulting from its habit and birth. Large masses of carbon-free material have formed near the decarburized region at the ingot surface. The sharp discontinuity at the inner surface of the carbon-free shell is but another exhibition of the strong tendency of insoluble material to collect about pre-existing masses of the same substance.

In later phases of segregation the individual crystallites have continued to place themselves side by side, constituting a chain-like ensemble imitating the threads of a mesh. The history of this ingot and the presence of large isolated ferrite masses preclude the separation of excess iron at austenite borders. The fact that no disturbing forces set up by slag inclusions were present in any of the steels experimented upon should, however, again be emphasized.

Another example of the separate morphology of β and α iron is shown in Fig. 10, at 65 diameters. This is from a 7-ton nickel-steel ingot for a gun-tube containing

	Per Cent		Per Cent
Ni	1.98	S	0.007
C	0.43	P	0.021
Mn	0.42	Si	0.22

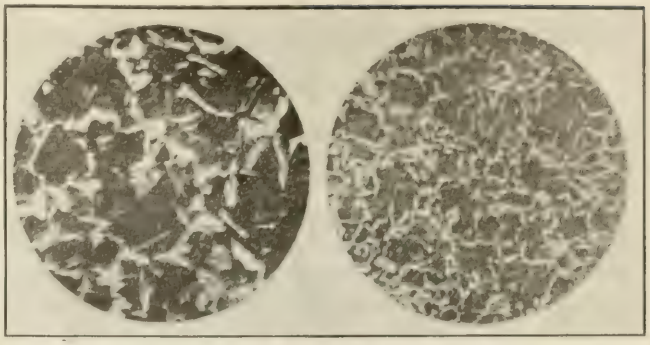


Fig. 6. Interrupted meshes in 62-point carbon steel; quenched from 700 deg. C. × 110

Fig. 7. Same steel as shown in Fig. 6, but at a lower magnification. × 45

which had been extremely carefully made and had undergone a heat treatment analogous to that just discussed. Further discussion of its obvious interpretation would be tiresome.

Conclusion

To summarize: The formation of the mesh-like structure in slowly cooled hypo-eutectoid steels is a fundamentally different phenomenon to that of the formation of the cementite shells in hypereutectoid steel, a conclusion in every way in accord with the well-known process of formation of non-homogeneous austenite from the molten metal. Whereas cementite actually segregates in sheets at the high-carbon interfaces between crystals of primary solidification, ferrite begins to separate in isolated masses in the central regions of austenite crystals at or near the points where the austenite began growing from the mother liquor, and where, subsequently, lacking the necessary heat treatment for perfect diffusion, the carbon must necessarily be lower than in its immediate surroundings. Only in the later progress of the segregation of insoluble ferrite do meshes appear resulting from the development of characteristic elongated fringes of α ferrite. This plate-like development of α iron is facilitated to an extent in direct proportion to the gradual disappearance of local variations in carbon concentration in the mother crystal. Thus long annealing gives a uniform diffusion and a more evident plate-like habit of α iron. Widmanstättian structure highly developed in coarse meshes is logically the end of the series as uniform austenite is reached.

Fig. 8. Ferrite growth completely revealed in cemented steel.

Fig. 9. Ferrite phenocrysts at decarburized surface of ingot. × 40.

Fig. 10. Pseudo meshwork of ferrite in nickel-steel ingot. × 65

Legal Notes

By Wellington Gustin

Law Regulating Contracts for an Approximate Amount Such as the Output for a Season

Does contracting the output of a plant or factory put the party under the legal obligation to operate the factory or plant under peril of breaching the contract for which he is liable in damage? What will the courts read into such a contract? What excuses may the party set up to relieve himself of responsibility? What is the meaning given to "season's output," "entire output," etc.? The answers to these problems may be found in the court decisions following:

Case of Kenan, McKay & Spier vs. Yorkville Cotton Oil Co.

In the latest case on the subject, Kenan, McKay & Spier, a Georgia corporation dealing in cotton linters, brought an action against the Yorkville Cotton Oil Co., a South Carolina corporation, in the Federal District Court, for breach of contract between the parties. By the contract the Cotton Oil Co. sold its "season's output of cotton linters, about 400 bales." It was said in the oil mill business the season began with August and closed with July, but it seems the period of active operations during which the most of the available seed is consumed covers only four or five months. It appears that the cotton oil company started up its mill in September and kept it running until the latter part of November, when it was closed down. In that time it turned out 155 bales of linters, all of which were delivered to the plaintiff dealer and paid for according to the terms of the contract. With the last shipment the cotton oil company wrote the dealers that owing to inability to borrow money for operating purposes it was forced to close down its mill for the season.

Upon objections to this action from the dealer the cotton oil company wrote the following: "We have shipped you our entire output, and, should we resume operations this season, we will ship you any further linters we make. We have nothing to add to this, and from our standpoint it closes the matter."

Following this letter the dealer brought suit in the state courts of South Carolina. Here a judgment against it was appealed to the Supreme Court of the state, and the judgment there affirmed. This court held that the cotton oil company was not bound to operate its mill in order to make the estimated quantity of linters, and that its obligation was discharged by the delivery to the dealer of all the linters actually produced. On the point the court said: "The buyer is bound to take the output, because he agreed to that. The seller is not bound to furnish more than the 'output,' because he has only agreed to furnish that much."

Losing on its point in the state court and there being a diversity of citizenship in the parties, the dealer brought the action in the Federal court. A judgment for the cotton oil company in the District Court was appealed to the Circuit Court of Appeals. (260 Fed., 29.)

This latter court said the complaint in this suit alleges bad faith, but there was nothing in the record to sustain it. Instead there was convincing and undisputed testimony that persistent efforts had been made by the cotton oil company to do business. The mill shut down solely for lack of money to keep it going. It appears that the company had little or no working capital, that its own borrowing power was exhausted, and that it had no assets with which to secure advances. It could not go on without ready money, and its inability to borrow was admitted. In this helpless condition it could not do otherwise than suspend operations, and hence it does not show lack of good faith in closing down the mill, said the court. Without showing lack of good faith on the defendant's part it cannot be said to have breached its contract.

Further the court said other facts seemed conclusive in themselves, in that the commercial products derived from the process of crushing cottonseed are oil, meal, hulls and linters, and the value of the last named product is barely 10 per cent of the whole. Hence it is not supposed that the defendant would go out of business in order to avoid the comparatively small loss on its contract with the dealer. Therefore the judgment of the District Court was affirmed.

Home Fertilizer & Cotton Oil Co. Case

The Supreme Court of Alabama was called upon to decide the point in a similar contract between plaintiff herein and the Home Fertilizer & Cotton Oil Co. (79 So., 367.) There the court said: "It is not possible to imply an obligation to make an article from an assumption of the limited obligation to sell, not a definite number of an article, but simply merely what the seller makes. . . . The seller having acted upon the buyer's promise to take his output, the buyer becomes bound to take what the seller has made, in reliance upon the buyer's promise, and the seller becomes likewise bound to deliver the output of his plant."

Case Between Plaintiffs and Dawson Cotton Oil Co.

In still another case, against the Dawson Cotton Oil Co. the latter was charged with shutting down its mill wrongfully and in bad faith for the purpose of evading its contract obligation. Of course, under such a condition there would be a breach of contract. However, the Court of Appeals of Georgia took occasion to say: "Of course, had the defendant discontinued the operation of his mill for some providential cause, or for any cause or causes not in any wise attributable to it, a delivery on the part of the mill of its output up to the time it ceased to operate would be all that the law would require."

Case of Brawley Against the United States

In the case of Brawley against the United States (96 U. S., 168) the U. S. Supreme Court said:

"Where a contract is made to sell or furnish certain goods identified by reference to independent circumstances, such as an entire lot deposited in a certain warehouse, or all that may be manufactured by the vendor in a certain establishment, or that may be shipped by his agent or correspondent in certain vessels, and the quantity is named with the qualifications 'about,' or 'more or less,' or words of like import, the contract applies to the specific lot; and the naming of the quantity is not regarded as in the nature of a warranty, but only as an estimate of the probable amount, in reference to which good faith is all that is required of the party making it."

Manufacture of Carbon Electrodes for Electric Furnace Purposes

A Description of the Raw Materials Used and Their Preparation, Calcining Furnaces and Plant Operation in the "Rammed Process" of Manufacturing Electrodes for Electric Furnace Purposes, With an Outline of Practical Deductions Obtained From Experimental Data

By WALTER L. MORRISON

CARBON electrodes for electric furnace work are divided into two classes: The graphite and the amorphous carbon electrodes. The amorphous carbon electrodes are again subdivided into two or more groups, depending on the process used in the manufacture. The method of manufacture covered in this paper is the so-called "rammed process" for the manufacture of electrodes.

The electrode is formed by ramming or pressing the material in a mold. The electrode after removal from the mold is allowed to cure, then is placed in a calcining oven and baked to remove the volatile matter. The raw materials used consist of carbonaceous products, and some form of binder such as tar and pitch.

Raw Materials

Pitch. The pitch used in the manufacture of amorphous carbon electrodes should be of the coal-tar variety, clean and of the highest quality. The pitch should contain at least 40 per cent fixed carbon, and the coke residue should be dense and tough. The so-called crude oil pitches and asphaltum pitches are not suitable for the manufacture of electrodes.

Coal-tar pitch is readily distinguished from the asphaltum pitch by odor or taste. A still better test is to volatilize a small portion of each in a crucible; the coal tar leaves a heavy, dense coke, while the asphalt leaves a very porous and friable coke, from which it is very hard to drive the last traces of volatile. Temperature during volatilization should not be too high; a good grade of coal-tar pitch loses nearly all its volatile matter at about 600 deg. F., while the asphaltum loses the last trace at a much higher temperature. The grade of coal-tar pitch used is that having a melting point from 150 to 200 deg. F.

The liquid tar used is also a coal-tar product. This material is the common unrefined product, having a fixed carbon residue of 25 to 35 per cent. This tar should be thoroughly dried before using to remove moisture. The coke residue is very similar to that of the solid coal-tar pitch, being dense and tough.

Coal. Anthracite coal is one of the best materials we have for the manufacture of amorphous carbon electrodes. This material is very dense and remains more or less so after calcination; especially is this the case with coals having a low volatile content.

The coal should be of the highest grade obtainable, high in fixed carbon, low in ash and as free as possible from other impurities. The fixed carbon should run 80 per cent or better and the ash should be under 5 per cent, preferably under 3 per cent. The writer has used coals running as high as 10 or 12 per cent with good results. When using inferior coals it is a good plan to mix some other suitable carbonaceous material of low ash content, such as petroleum carbon, or high-grade graphite, to lower the total ash content in the electrode.

Coke. The ordinary coke is not an essential material in the manufacture of large electrodes. Many attempts have been made to use the so-called petroleum or carbon residues from the manufacture of gas in which crude oil is used. Properly prepared petroleum coke works out very well in connection with anthracite coal.

The so-called petroleum carbon, which is very similar to lampblack, but having a higher volatile content, is extremely fine and porous. When a binder is mixed with this material, it absorbs such a large quantity to make a suitable mixture which will ram that on calcining the electrode will check. The electrode also has a tendency to spall when placed in service.

Foundry coke has been tried, but this material is so porous and of such high ash content that the conductivity is very low compared with other materials available.

Graphite. Graphite is an ideal material for the manufacture of electrodes, but unfortunately nearly all the natural graphite is so impure that it would have to go through a refining process, which would prohibit its use in an article which sells so cheaply as electrodes.

The artificial graphite is about the only solution of a graphitic material for electrode manufacture. However, experience has shown that the electrode made up from graphitic materials does not have as high an electrical conductivity as the amorphous carbon electrode which is subsequently graphitized, for example the Acheson electrode.

Much of the coal in the electric calcining process is converted into graphite, which adds greatly to the life and conductivity of the electrode. The graphite resists oxidation much more than the amorphous carbon.

Preparation of Raw Materials

Tar and Pitch. The tar and pitch are used in the molten state. The tar is heated in a large tank by means of a steam coil or steam jacket, to remove all traces of moisture and the lighter volatile oils. If this is not done but the tar added to the hot pitch without drying, it will cause the pitch to boil and perhaps take fire.

The ratio of tar to pitch depends a good deal upon conditions, the size of electrodes and equipment. Too large a quantity of tar should not be used, as the electrodes will not stand handling while warm in the green state. If all pitch be used, it makes the mixture too stiff to work properly or produce a uniform electrode. An all-pitch binder leaves the electrode extremely brittle while in the green state and is liable to break during the

cooling or curing. The temperature of the building has some influence upon the ratio of tar to pitch. During the winter months a higher ratio of tar should be used than during the summer months, unless the buildings are heated or are equipped with warming ovens or pits.

The fixed carbon or coke residue in the tar and pitch mixture should range between 30 and 40 per cent. The writer has obtained the best results with a mixture running 35 to 40 per cent fixed carbon. This is equivalent to one part tar to two or three parts pitch.

The tar and pitch are mixed in a large vat and kept molten by means of a steam coil. A measured quantity is then added to the ground carbon, which has been previously heated, and the whole mixed thoroughly.

Calcining Coal and Other Carbonaceous Materials. The purpose of calcining the raw materials is to lower the volatile content, thus preventing undue shrinkage, and check or mud cracks in the finished electrode.

There are several ways in which the calcination may be effected, viz., retorts, ovens, tubes and electric-resistance furnaces.

The main essential is to keep the material during calcination and subsequent cooling away from the air, as any oxidation raises the ash content. Also to carry the heat high enough to bring the volatile matter below 1 per cent, best results are obtained when the volatile is near 0.5 per cent or under.

The temperature necessary to carry out this operation is at least 1,300 deg. F., and preferably above 1,500 deg. F. The entire mass should be subjected to this temperature and results checked by pyrometers in the mass. Analyses should also be made from time to time in order to have the material under control and in the proper condition before going ahead with the process of manufacture. One of the best and most efficient methods of calcining is the use of the electric-resistance furnace.

Coal Calcining Furnace

There are two types of electric-resistance furnaces which are commercial, the vertical and the horizontal. The horizontal type is an intermittent furnace, being similar to the carborundum furnaces. The vertical resistance furnace is a shaft furnace and operates continuously. The coal is fed in at the top and after calcination removed from the bottom. The furnace is usually 20 to 40 ft. in height by 4 to 6 ft. in diameter. An iron shell of the proper dimensions is used. The upper part, in which the calcination takes place, is lined, while the lower part is unlined, to allow the cooling of the calcined mass before removal from the furnace, to prevent undue oxidation.

The current or kw. input into the furnace is regulated by drawing calcined coal from the bottom of the furnace, when the current becomes too high. This allows green coal to move down, thus increasing the resistance of the mass between the two electrode terminals.

Green anthracite coal has a very high electrical resistance, but as the volatile matter is removed the resistance drops very rapidly. The furnace works very satisfactorily, and with slight variation of current. The power consumed per ton of coal varies from 360 to 750 kw.-hr. depending on size of the installation and the amount of graphite produced.

There are two types of shaft resistance furnaces which can be used. One has two rings of carbon insulated from the shell and acting as electrodes to carry the current. The electrodes are spaced from 2½ to 5 ft. apart, depending on the voltage used. When operating with this type of furnace it is of advantage to have a transformer with several different taps to vary the voltage. The most desirable voltages would be 409, 609, 809, 1,009, the lower voltages being used for regular operation. The furnace has to be started with a good conducting carbon material. The upper part of the furnace is lined with a non-conducting material, with the exception of the carbon rings.

The other type of shaft furnace has an upper and lower central electrode. The lower electrode is fixed, the clamp and terminals being protected from the descending hot materials.

The upper electrode is movable and therefore allows a wider range of regulation, particularly when there is only one voltage available.

The calcination of coal requires a heavy current and low voltage. In normal operation the voltage should not exceed 60 volts, except in very large furnaces, to obtain the best results. The current density in the shaft between the two electrodes should be 5 to 10 amp. per sq.in. sectional area of shaft. This type of furnace has been developed to use with fine coal, the so-called slack, which is obtainable at a very low figure. This furnace will not work as satisfactorily on the lump coal as the furnace with the ring electrodes, on account of the more or less restricted openings in the shaft due to the central electrodes, which cause hanging in the shaft and irregular working conditions.

If fine slack or coal is used with the ring electrode furnace, the electric current has a tendency to pass so close to the lining as to cause a gradual reduction and deterioration of the lining by the excessive heat. This condition necessitates very frequent repairs, besides giving a poorer quality of coal when conditions get very bad. If the current be forced through the center of the mass, the excessive heating in the middle of the coal does no harm but is really of benefit, as it promotes the formation of large quantities of artificial graphite.

The calcining furnace during operation should be under laboratory control, frequent analyses being taken, to determine the status of the operation and detect any irregular working of the furnace. The best practice is to take at least one sample from each shift. A recording ammeter is also very useful to check up the furnace operation.

Construction of Molds and Dies

The design and construction of molds depends upon the process used in the manufacture. In the making of plain rammed electrodes which are not subjected to pressure other than the ramming, a split mold is used, which is constructed of light casting or heavy boiler plate reinforced with angles and held together with bolts. After the mold is rammed, the bolts are loosened and the electrode is removed. The electrodes made in this manner are those of special shapes: the square, hexagonal, etc., which are used without nipples for joining together. They vary in length from 6 to 9 ft. The electrodes which are not subjected to pressure after ramming are not nearly as good as the others. The split mold is not strong enough mechanically to withstand much pressure, such as is given the electrodes made in the one-piece mold.

The solid mold is of heavy construction and slightly with a binder, consisting of pitch and tar. The amount of taper from $\frac{1}{16}$ to $\frac{1}{32}$ in. per ft. on the diameter of the mold. The thickness of the walls is more or less an arbitary matter, since the material being subjected

to pressure does not act as a liquid nor as a solid. Furthermore, if the mold was designed to resist the pressure of a fluid and figuring on the pressures which are used, it would mean the use of an extremely heavy casting, which would be troublesome to handle. We usually figure from one-fifth to one-third the thickness required for a fluid, allowing a good factor of safety. The mold is made from 12 to 20 in. longer than the finished electrode desired.

The dies forming the female thread on the ends of the electrodes have a very low pitch and shallow thread. The diameter of the thread or nipple is approximately half the diameter of the electrode with which it is to be used. The pitch on the 18- to 24-in. diameter electrodes runs about one thread in 2 in., depth of thread $\frac{3}{4}$ to 1 in. There should be ample clearance for the nipple in the female thread, at least $\frac{3}{16}$ in., to allow for any blistering or slight imperfections which may occur either on the nipple or in the female thread during baking. The nipple can be made up in a heavy cast split mold which has been properly machined.

The dies forming the female threads in the ends of the electrode, after the mold comes from the press, are removed by screwing them out.

Calcining Furnaces for Electrodes

The large electrodes are so heavy and of such length that it is necessary to bake them on end. This requires the use of saggers, iron tubes, or a specially constructed furnace with chambers constructed very much like a large vertical muffle. The furnace should be so constructed as to obtain a uniform temperature throughout the entire length of the electrode. Pyrometer openings should be placed in several parts of the furnace, as well as in the retorts, to have proper control of the furnace.

Gas, oil or powdered coal may be used for firing the calcining furnace. The retorts or chambers should be large enough to allow at least 2 in. of packing material on all sides of the electrode.

Mixing

The calcined raw materials are ground so as to form a compact mass. This is best done in a dry pan, the material all passing through a screen. After grinding and sizing, the different sizes are warmed and mixed with a binder, consisting of pitch and tar. The amount of binder added varies from 15 to 20 per cent, depending on the kind and grade of materials used. There should be just enough binder to make the material adhere when molded into a ball with the hands. It is advisable to treat the mixture in a hot wet pan, to work out the air and get the tar completely worked around the particles of coal and petroleum coke. The mulling operation should require from 12 to 20 min., in order to make the toughest and most compact mass. If during the mulling the mass should become too dry, then more tar should be added. After some experience this is readily told by inspection. Too much tar should be avoided, as it causes undue shrinkage of the electrode and causes an excess pressure to be exerted on the electrode mold during squeezing, because the material has a greater tendency to flow under pressure and approaches the property of a fluid.

The pan should be sufficiently hot to keep the mass in a plastic condition; otherwise, when ramming, cavities are apt to exist in the electrode, also there is an imperfect bond between batches. The pan and rolls may be kept warm by means of a small gas or oil flame, and in no case should the pan or rolls be hot enough to volatilize the tar. The tar begins to boil or volatilize at about 500 deg. F. In making up the mixture for the nipples it is necessary to add a somewhat larger amount of tar, in order to produce a perfect thread. This is more or less a matter of experiment to determine the exact amount necessary, as conditions vary from time to time. After mixing thoroughly the material is placed in a mold for ramming.

Ramming

For the purpose of ramming, a bar or rod with an iron shoe secured to the end works up and down in the mold, the action being very similar to that of a stamp in a stamp mill. On the downward stroke you get the full weight of the stem and shoe. In designing this type of ram one must take into consideration the fact that the mold is constantly filling up. This calls for a special design other than the ordinary ram.

In order to maintain a constant height of drop as the mold fills up, a rack is placed on the stem and a pinion gear engages the rack, the pinion gear having several teeth omitted to allow the drop of the stem. Thus the height of drop will always be the same and can be varied by changing the size of pinion.

Another very simple ram is one having a round shaft with a shoe on the end and passing through two guides, a cable being secured to the other end. The ram is operated by a long-stroke double-acting steam cylinder, the slack and adjustment being taken care of by a small winch.

The shoe is specially constructed, having a tapered top to allow for passage of material and to be kept clear. The size and shape of shoe depend upon the electrode to be made. There should be a clearance of 1 to 2 in. between the ram and the sides of the electrode mold, for the passage of the carbon and pitch.

The mold is first warmed, then the inside surface oiled, the lower die placed in position, and the mold placed under the ram.

Material to a depth of 8 or 10 in. is placed in the bottom of the mold, then the ram is started. One man shovels in the mix while the ram is working. The shoes on the bottom of the ram have large conical points to prevent the formation of a joint in the electrode mass. After the mold has been rammed full, if the electrode is to be pressed, the mold is placed on a car, the upper die is placed in position, and the car is then moved to the press.

Pressing

The bottom plate of the electrode mold has an opening large enough for the passage of a die fastened to the plunger of the press. The electrode is subjected to pressure in three steps:

First, pressure is exerted on the bottom of the electrode, with the top of the mold resting against the top or upper platen of the press. This initial pressure is to allow sufficient space at the bottom of the mold for the removal of the electrode, or rather freeing from the sides of the mold in the last operation.

Second, an iron bushing of smaller diameter than the electrode is placed on the upper die, bearing on the upper platen when pressure is resumed. This exerts pressure on the top of the electrode as well as the bottom. During this second operation pressure is exerted on both ends to a maximum for the operation, and varies from 100 tons for an 8- or 10-in. diameter electrode up to 500 tons for 20- or 24-in. diameter electrode. These

represent the total pressure on the full cross-section of the electrode.

Third, pressure is exerted on the top of the electrode only, the mold resting on a plate. This loosens the electrode in the mold, as the mold is slightly tapered for this purpose. The pressure for this operation should not exceed that used in the second operation. If it should, the electrode must be sticking in the mold, due either to the use of too much tar or a careless oiling of the interior of the mold, or starting with the mold too hot, or a combination of these causes. The electrode should be of such composition that a hard, tough skin exists on the outside. When the electrode has become loosened, the mold is removed from the press, picked up by the crane and lowered into the pit. The bottom plate is removed, and the mold skinned off the electrode by hoisting the mold. In a short time the electrode is firm enough to withstand handling, is taken to the calcining oven, and packed for calcining.

Calcining

The electrodes are placed on end and packed in carbonaceous material, which is more or less porous to allow passage of the volatile gases from the electrodes. The material should be placed firmly around the electrodes, and they should also be covered to some depth.

The firing should proceed slowly, and after attaining a temperature of 600 deg. F. the furnace should be held at this temperature from two to four days depending on the size of the electrodes. This allows for the removal of the greater portion of the tar, which comes off slowly at this point, without injuring the conductivity of the electrode. The temperature may then be raised gradually up to 1,300 or 1,400 deg. F. and held at the upper limit till the coolest point of the furnace has reached 1,300 deg. The firing period requires usually from seven to ten days. The furnace is then cooled down, taking four to six days, making the total period of calcination fourteen to sixteen days.

If the temperature is raised too rapidly and before the volatile is removed from the electrode, the violent volatilization of the tar often causes fractures and splits, and very often a honeycomb structure which impairs the electric conductivity.

Surface checks on the electrodes are caused by poor mixing, high volatile content in raw materials or improper calcining. A few surface checks as a rule do not impair the electrical properties of the electrode.

Experimental Data

Electrodes having a high volatile content are not serviceable for electric-furnace work. The lower the volatile matter in the finished electrode, the better the performance in the furnace.

Electrodes were made from the so-called gas-house carbon, but these were found to be very unsatisfactory. In the first place, the carbon is so extremely fine it is like a sponge and absorbs large quantities of pitch before it is workable. After the molding operation it is very difficult to remove the electrode from the mold, as it has little mechanical strength and will hardly support its own weight. During the baking of the electrode the shrinkage was so bad as to cause large transverse cracks. The volatile in the finished electrode was also very high. The last of the volatile is very hard to remove and this is a property peculiar to all products derived from petroleum.

It has been suggested to make briquets of the gas carbon, using a pitch binder, and burn these at a very high temperature to form solid pieces of material as a base, which is subsequently crushed and sized and forms a basis for electrode material. This works out fairly well, but is very expensive, and makes the cost of the finished electrode much higher than when using other materials which have a better structure. The only reason for using the gas-house carbon is on account of its purity and its low ash content. For certain electrochemical work where a very pure electrode is required, it may find a use, but for ordinary smelting operations it is out of the question, on account of the cost of handling this material.

In preparing the coal for electrode manufacture, many different methods of calcination were tried and we finally resorted to the electric calcining furnace, which gave us a calcined coal running under 0.5 per cent volatile.

The first calcining operations of the electrodes were carried out by packing the electrodes in a horizontal position on a large hearth, using crushed coke, and covering the coke with mud to prevent oxidation. Several of the electrodes were lost due to transverse cracks and in some cases were completely severed during calcination.

The next batch of 10-in. electrodes was packed in 14-in. iron tubes and stood on end in the furnaces. All the electrodes came out without any breakage losses.

A furnace was then constructed with six chambers 25 in. x 56 in. x 10 ft. deep, using firebrick construction. These chambers were designed to hold 17-in. diameter electrodes x 8 ft. long.

Firing is done along the sides of the chambers, and works out very satisfactorily. Particular attention must be paid to the firing, and the success of this final operation depends upon the first four days' firing. During this period the temperature of the electrode chamber should not exceed 650 deg. F.

The shrinkage of electrodes during calcination is not very great in the case of rammed electrodes, and varies to a more or less extent, depending on conditions, as to mix used, total pressure used in ramming, and calcining. However, this is not such a vital point in the manufacture as the electrical conductivity, behavior when subjected to sudden changes of temperature and resistance to oxidation during service.

Many protective coatings have been tried to prolong the life of the electrode in service, but the writer has not found or heard of anything which works out very satisfactorily in furnace operation.

Portland, Ore.

British Output of Iron and Steel in 1919

The National Federation of Iron and Steel Manufacturers has issued the following return of the output of pig iron and steel in the United Kingdom during 1919. The figures are based upon returns, collected by the Federation, which, for the month of December, cover 93 per cent of the output in the case of pig iron and 96 per cent in the case of steel ingots.

Months	Pig Iron Tons	Steel Ingots Tons	Months	Pig Iron Tons	Steel Ingots Tons
January	664,000	718 000	September	574 000	718,000
February	625,000	734 000	October	445 000	438,000
March	684 000	758 000	November	630,000	693,000
April	653 000	668 000	December (approximate)	640,000	680,000
May	662,000	755 000			
June	612,000	631,000			
July	660 000	618 000	Total, 1919	7,370,000	7,885,000
August	521,000	474,000	1913	10,260,000	7,664,000
			1918	9,072,000	9,591,000

Technical Application of Hydrogen in Hydrogenation or Hardening of Oils

Principles Involved in Saturating Unsaturated Oils by Hydrogenation — Commercial Adaptability of the Method to Industrial and Edible Oils—Technology of the Process and a Schematic Outline of the Apparatus Used

By HARRY L. BARNITZ
Consulting and Construction Engineer

A VERY extensive use of hydrogen has developed in connection with the fat industry. By the introduction of hydrogen into fatty bodies and oils of low melting point these are converted into hard fats of higher melting point. In other words, oils which are composed of unsaturated acids, such as oleic acid and their esters, will combine with hydrogen in the presence of a suitable catalytic agent, forming a saturated compound

$$C_{17}H_{33}COOH + H_2 \rightarrow C_{17}H_{35}COOH$$
oleic acid + hydrogen → stearic acid

Fatty vegetable and animal oils may be described as consisting of a glycerine part and an acid part. The composition of the glycerine part is constant. The composition of the acid part varies from oil to oil, and is characteristic of any one oil, or of any one group of oils.

Several important vegetable and animal oils contain an acid part having the general chemical formula $C_nH_{n_2}O_2$. Among these we have cocoanut oil, palm oil, palm kernel oil, butter fat, lard, tallow, and various "butters" such as cocoa and mace butters. These oils and fats are characterized by the possession of a thick consistency; that is to say, they have high melting points, or, generally speaking, they are naturally "hard."

A considerable number of important vegetable and animal oils differ from those just discussed, in that their acid parts fail to correspond with the general formula stated, to the extent of two, four, six or eight atoms of hydrogen. For instance, in rape oil, and certain fish oils, two atoms are missing. Four are absent in the acid parts of cottonseed oil and soya bean oil. In linseed oil six atoms are missing, and as many as eight atoms are lacking in certain liver and blubber oils. These oils are characterized by the possession of a liquid consistency.

Saturating Unsaturated Oils

The acid parts of these oils are termed "unsaturated," for they are capable of picking up and combining with additional atoms of hydrogen. Under normal conditions, hydrogen, even in the nascent state, is quite without action on the fatty oils. To convert an unsaturated oil into a saturated oil has led to much investigation and it has been found that the addition of the hydrogen atoms can be effected if the oil is suitably treated with hydrogen in the presence of finely divided nickel, platinum or palladium. Each of these metals acts as a catalyst, and is left unaltered after the hydrogen has been taken up by the oil.

For the purpose of industry the world's supply of solid fats is deficient, while the supply of liquid oils is superabundant. Solid fats of vegetable origin are especially scarce. The hydrogenation process permits us to make good the deficiency by converting some of the superabundant liquid oils into hard fats.

Hydrogen has another advantage which is in some cases even more important than solidification effect. The saturation by hydrogen of the unsaturated bodies renders the oil much less likely to oxidize and rancidify.

Commercial Applicability of Hydrogenation Process to the Soap Industry

As an instance of the commercial applicability of the hydrogenation process, we may look for a moment at the soap-making industry. Tallow may be said to be the ideal substance for the soap manufacturer to work with, giving the necessary stiffness and texture to soap and yielding a firm soap such as we use daily.

Tallow, however, is expensive, and is obtainable only in limited amounts. Accordingly the soap manufacturer falls back upon some of the harder oils, such as palm oil, palm kernel oil and cocoanut oil. These oils are also expensive and are in increasing demand in other industries. If, on the other hand, the soap manufacturer tries to replace them with one or the other abundant naturally liquid oils, such as soya bean oil or whale oil, his product loses greatly in quality, and is apt to be a soft, sticky mass, unsuitable or unsalable as soap for many purposes. Hardening these oils before using them, he obtains a substance practically identical with tallow without affecting the yield from them of that valuable byproduct of the soap-making industry, glycerine. Therefore the hydrogenation process places at the disposal of the soap manufacturer a wide range of oils which otherwise would be next to useless for his purpose.

These remarks will also apply to the candle-making industry, which also calls largely for fats rather than oils.

Edible Synthetically Hardened Oils

Fats are now in demand for margarine and certain other edible compounds to a greater extent than can be conveniently met from natural sources of supply. It is certain that synthetically hardened oils will soon be extensively used for edible purposes throughout the world.

Great quantities of cottonseed oil at present are hardened. Increasing quantities of fish and whale oil, linseed, soya bean, cocoanut, palm kernel, palm and other vegetable oils are also being subjected to the process.

A word of explanation is no doubt desirable with regard to the hardening of cocoanut oil. This oil is just on the border line between liquid and solid fats, chang-

Copyrighted, 1920, by Harry L. Barnitz.

ing from a liquid to a solid state with fluctuations in temperature. All its acid part is not saturated, but contains portions of unsaturated acids. It is therefore capable of absorbing a certain amount of hydrogen, and so becoming harder than normally in this climate, but its melting point is not sufficiently raised to meet the requirement of a butter substitute which will stand summer temperature or the high temperature of countries in the torrid zone. To raise the melting point of the hydrogenated cocoanut oil to that required in lard or butter substitutes a small amount of hardened peanut or cottonseed oil is added, therefore contrary to widespread supposition cocoanut oil is not capable of being hardened by hydrogen to any great degree; in no sense comparable with hardening of such oils as cottonseed, soya bean, peanut and oils of this character. Cocoanut oil is almost saturated, as shown by having an iodine number of less than 10, while, for example, that of cottonseed oil is over 100. The iodine number is commonly used to express the extent to which hydrogen has been taken up by the oil in hydrogenation operations.

Characteristics of Hardened Oils

The characteristics of these hardened oils are white, tasteless, odorless substances of tallow-like consistency. They should all be identical, whatever may be the particular oil started with, and in theory and practice such identity seems to be attained, at least in the oils as freshly hardened.

It is customary to harden the oils at the soap works, or wherever else they are to be used or are otherwise employed, with but little interval between being hardened and being treated in industrial processes. The point of importance, therefore, is that certain oils will be hardened before shipment to this country. In the Orient and tropics the process is attracting considerable attention from the cocoanut and soya bean oil producers, the idea being that hardened oils may be shipped and carried without risking loss through leakage, which is a serious item in the shipment of liquid oils for long distances.

The technology of the process is dependent primarily upon two conditions—first, the careful preparation of the catalyst, and, second, the use of very pure hydrogen. A slight variation of procedure may quite readily result in an entire failure to harden the oil.

The catalyst ordinarily used on a commercial scale is metallic nickel prepared in a finely divided state by chemical precipitation. Once made, it must be kept strictly apart from certain other substances, notably air, moisture, sulphur, phosphorus, arsenic, carbon monoxide, chlorine, etc. These substances oxidize or otherwise react on the metallic nickel, and destroy its catalytic action, 0.1 per cent of H_2S being sufficient to destroy the catalytic action of nickel. Certain kinds of fish oils contain sulphur, and if this is not removed before attempting to harden these oils, the sulphur will quickly destroy the activity of the catalyzer. The action of these substances on the catalyst is exercised in three ways. First, it means that the hydrogen used must be very pure and free from moisture and sulphur compounds. Second, the oil to be hardened must be thoroughly free from moisture, which it usually contains when received. Third, in preparing the catalyst a stage is reached when it must be treated and handled out of contact with the atmosphere.

Technology of the Hydrogenation Process

When all the necessary conditions are complied with, the process is not difficult. The oil with the catalyst (usually the nickel catalyzer is employed in the proportion of 40 to 60 lb. per ton of oil) added is heated in an atmosphere of hydrogen inside a closed vessel termed the "converter." The oil and hydrogen are brought into intimate contact and at the end of 2½ to 4 hr. the absorption is found to be complete. The temperature at which the work is carried on is of great importance. For any given pressure of hydrogen inside the converter there is a definite temperature which must be reached before the absorption begins. At atmospheric pressure this temperature appears to be about 250 deg. C. In practice such a temperature would almost certainly result in the hardened oil being discolored. To avoid this, some temperature approximating 200 deg. must be used. The

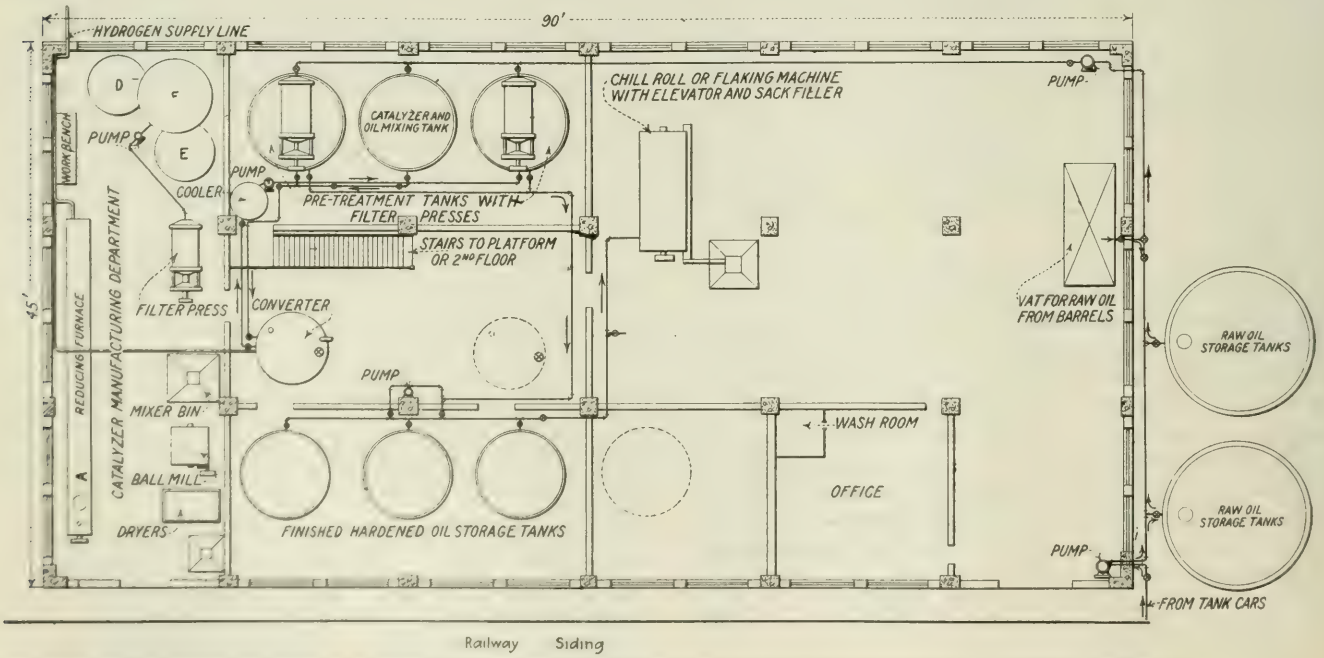


FIG. 1. DIAGRAMMATIC PLAN OF A 1,000 LB. PER HR. OIL-HARDENING PLANT

pressure of the hydrogen has to be increased above atmospheric as the temperature is decreased. A normal working condition is a temperature of 170 to 180 deg. C. in conjunction with a pressure of 70 to 80 lb. per sq.in. When the absorption is complete, the oil is run out of the converter, cooled, filtered, and allowed to solidify. A general diagrammatic plan of a modern oil-hardening plant of a working capacity for the treatment of 1,000 lb. of oil per hr., with provision for doubling the output, is seen in Fig. 1. The steam boiler and condenser for distilling the water is placed in the basement and is not shown in the plan.

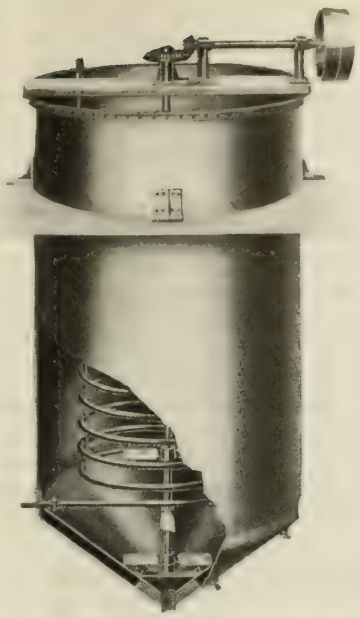


FIG. 2. PRE-TREATMENT TANK

Preparation of the Raw Oil

The characteristic of the raw oil to be treated may be thick, for instance, as cocoanut oil, therefore necessary means has to be provided for heating the oil before it is emptied into the storage tanks from the barrels and tank cars when received at the works and the oil in the storage tanks must be kept sufficiently liquid to be pumped on to the next stage.

The means provided for reducing and maintaining the oil in the liquid state consists of steam jets for heating the barrels—the tank cars usually have steam coils permanently installed with threaded connections to attach to the source of the steam supply at the works, the storage tanks have flat steam coils at the bottom. The oil in the barrels is first emptied into a vat and from this vat pumped into the storage tanks. From the tank car the oil is pumped directly into storage tanks.

Dessication of the Raw Oil

As the catalyst should not be brought into contact with moisture, it is necessary to extract the moisture from the oil by dessication. This is accomplished in the two pre-treatment tanks. First the oil is pumped from the storage tanks into the open circular pre-treatment tanks, Fig. 2, having conical bases and fitted with mechanical agitating gear and with steam-heating coils. The oil in them is freed from the moisture. The outlet for the oil is through a valve at the conical base. Steam, fluid level gages, and thermometers are fitted in connection with the pre-treatment tanks. The oil leaving the pre-treatment tanks is mixed with the catalyzer in the mixing tanks and is now ready to be brought into contact with the hydrogen in the converter.

Method of Preparing the Catalyst

There are several methods of preparation of the catalyzer, but the one to be described herein has perhaps been one of the most widely used. In general the catalyst employed is finely divided metallic nickel. It is received at the hardening plant in the form of nickel sulphate in crystals. Its preparation consists of making a solution of the nickel sulphate in tank *D* and another solution of sodium carbonate in tank *E*. Each of these tanks is fitted with an open steam jet to facilitate the preparation of the solution. They are erected over a third tank *F* provided with means for mixing the two solutions when they are turned into it. The result of this mixture is the precipitation of insoluble nickel carbonate and the passage of sodium sulphate into solution. Previous to the admission of the two solutions a quantity of finely divided refractory neutral material is placed in the mixing tank. In practice this material is usually kieselguhr. Its employment is to act as a carrier for the nickel. The mother liquor, the precipitate of nickel carbonate, and the kieselguhr are drawn off from the mixing tank and pumped through a filter press. When the filtering is completed the nickel carbonate and the kieselguhr are found consolidated on the filter cloths as cakes. These cakes are thoroughly dried in hot air driers, and then reduced to powder by means of a ball mill. The carbonate now has to be roasted or calcined in a furnace so as to reduce it to the form of oxide.

The next procedure is the very delicate operation of reducing the oxide to the metallic form. This is effected in a reduction furnace by heating at a certain temperature the oxide in contact with hydrogen, which must be entirely free from air. The furnace employed is either gas-, oil- or electrically-heated and varies in the internal mechanism. Fig. 3 is a diagrammatic sketch of one of the later improved types which is electrically heated

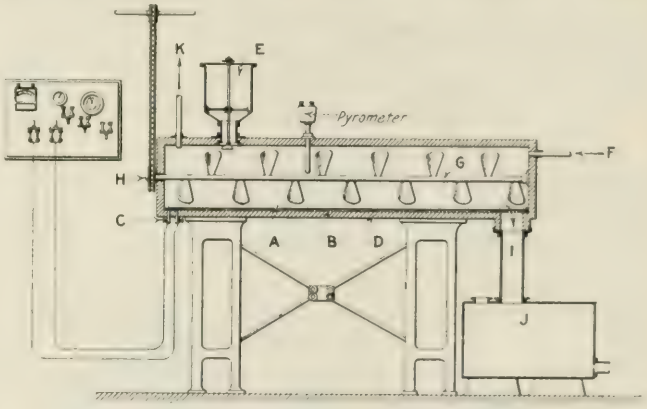


FIG. 3. DIAGRAMMATIC SKETCH OF CATALYZER FURNACE

and automatically controlled. The furnace *A* is cylindrical in form, and is closed at both ends. It is heated through the under surface at *B* by electrical connections at *C* and incased in heat-insulated material *D*. The pulverized material is fed automatically at the top *E* and the hydrogen is admitted at the end *F* and after circulating through the furnace passes through outlet *K*. Inside the cylinder there is provided a reciprocating worm *G* which is kept revolving slowly by means of the chain drive pulley *H*. The movement of the worm constantly exposes fresh portions of the material to the action of the hydrogen, and also determines the rate of flow at which the material falls through the furnace at *I*. The substance fed to the furnace in the form of the carbonate is calcined to the oxide. After leaving the furnace the reduced material mixed with the kieselguhr must not be permitted to come into contact with the air. It is therefore caused to fall into a tank of oil

J of the same kind and quality as that to be hardened. This black, oily mixture is ground to a suitable consistency, and is added, with the oil, in the converter.

In the early days the experimenter had considerable trouble with the hydrogenating process. He formed erroneous conclusions, particularly regarding the construction and mechanism of the converter. For this reason there is found a great diversity in its construction.

The secret of oil hardening depends primarily on the activity and uniformity of the catalyzer. Therefore with a highly refined oil and a catalyzer with the properties just stated the oil may be hardened in most any form of converter.

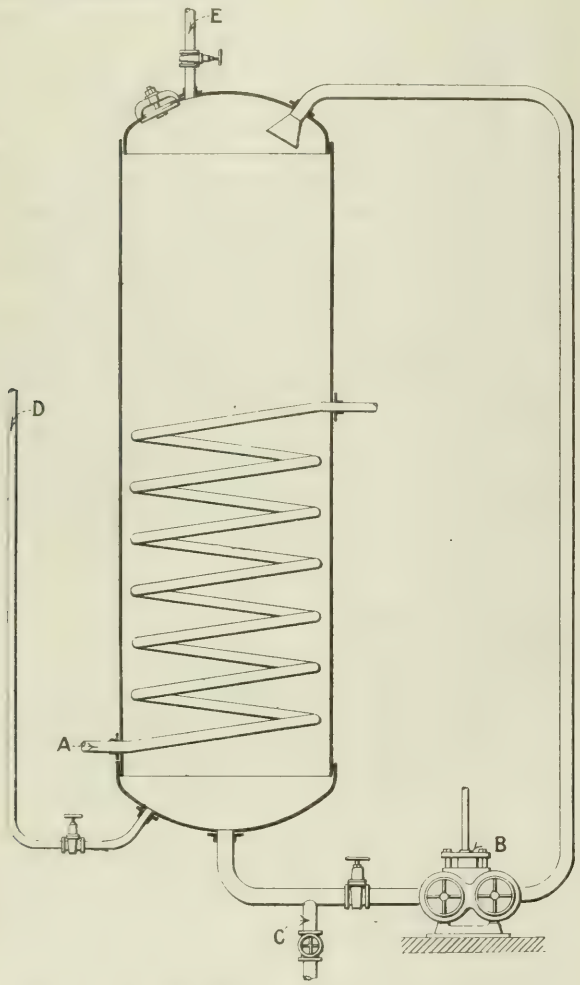


FIG. 4. DIAGRAMMATIC SKETCH OF CONVERTER

The converter as shown in Fig. 4 is a cylindrical upright tank, closed top and bottom. The lower half is occupied by steam coils; also, during operation, by the oil be be treated, mixed with the catalyzer.

A pump *B* draws the oil from the foot of the converter and discharges it continuously through a spray onto the oil in the lower half of the converter.

When conditions are properly regulated, the pressure inside the converter, as the hydrogen is pumped in, is seen to rise at first. On reaching a certain point, depending upon the temperature maintained in the oil, the pressure becomes stationary, indicating that the hydrogen is being absorbed by the oil as fast as it is pumped in. By sampling, the degree of hardness is determined, the oil is drawn from the converter through the pipe *C*, is cooled and filtered. The cooling is not sufficient to solidify the oil, but is only sufficient to prevent the oil from injuring the cloths of the filter press. Practically the whole of the metallic nickel and the kieselguhr is held back in the filters. The pressed cakes of catalyzer left on the cloth are washed and freed from oil, are broken up, and are returned to the catalyst-preparing department, where the material is ready for further use. With a well-refined oil the catalyzer may be used over and over again, for days or weeks. As there are some losses in handling the catalyzer, it is customary to make up for the loss by the addition from day to day of a small amount of fresh catalyzer.

Hydrogen Required

The amount of hydrogen required in the hardening of oils varies from 500 to 5,000 cu.ft. per ton of oil, depending upon the nature of the oil, the degree of saturation of the oil and extent of hardening required.

The amount of hydrogen consumption from actual experience on some oils is as follows:

	Cu.ft. per Lb.
Cocoanut oil	0.25 to 0.40
Soya bean, corn, peanut, cottonseed	1.75 to 2.0
Fish oils (menhaden oil)	2.0 to 2.5

The amount of hydrogen as given includes that used in making the catalyzer which would be used in the hardening of the particular oil in question.

COST OF HARDENING ONE TON OF FISH OIL (MENHADEN)

Hydrogen, 4,600 cu.ft. @ $1.15 per 1,000	$5.17½
Loss of catalyst (nickel sulphate @ $11.25 per cwt.; kieselguhr @ $4.12 per cwt.; carbonate of soda @ $13.34 per ton)	3.75
Electric current for heating @ $0.03 per kw.-hr.	.30
Power	.25
Steam, 1,375 lb. @ $0.85 per ton	.58
Water, 450 cu.ft. @ $0.20 per 1,000	.09
Filter cloths, 1 yd. @ $0.35 per yd.	.35
Labor (including preparation of catalyst):	
1 Foreman @ $0.90 per hr	
2 Laborers @ $0.40 per hr	1.70
Running repairs	.49
Total	$12.68½

The cost of hydrogen depends upon the manner obtained—for instance, hydrogen can be generated at the hardening plant, it can be purchased in cylinders and can frequently be obtained as a byproduct. In the latter event the price is very low, considerably less than in the above estimate.

It will be noted in the above estimate that this particular fish oil requires more hydrogen to harden it than vegetable oils or most any other oil excepting some certain fish, liver, and blubber oils.

The character of the generating apparatus for the production of hydrogen in relation to the hydrogenation of oils is one of utmost importance, as many factors enter into its proper selection.

The purity of hydrogen is one of importance, but there are factors that are equally as important in other ways to consider. These are:

First. Which particular type of equipment is best adapted to local operating conditions.

Second. Of the various types of the same systems of production, which types are efficient, safe, simple, most economical and conserve long life in operation.

Considerable hydrogen-generating equipment has been installed which has not proved satisfactory due to one or all of the above factors. The selection of such equipment should be left to those who are qualified by technical knowledge and long experience in the field of hydrogen-generating apparatus.

New York City.

The Lake Asphalt Industry*

Nature and Origin of Asphalt—Description of Most Important Sources of Natural Asphalt: Trinidad Lake and Bermudez Lake—Refining and Fluxing—Ultra-Microscope Shows Presence of Colloidal Clay Particles—Review of Theory of Colloidal State

By J. STROTHER MILLER, Jr.†

ASPHALT as obtained in nature and requiring very little if any refining to make it suitable for use has been of general interest for a great many years for many different purposes. In more recent years there has appeared another class of so-called asphalt produced in the oil industry when certain types of crude asphaltic oils are distilled. There being two general sources, namely, natural solid and artificial, or oil, asphalts, the question is immediately brought up, How was the natural product formed and what definition can we give of asphalt which would indicate these two general classes?

Theory as to Origin of Asphalt

Much work has been done upon that type of natural solid asphalt obtained from Trinidad Pitch Lake, in the Island of Trinidad, and I would refer you therefore to a report by Clifford Richardson upon this general subject of origin, appearing originally in the *Journal* of the Society of Chemical Industry for January, 1898. Briefly summarized, the theory there outlined is that asphalt is in the process of formation today. It does not originate as such, but is a secondary product, resulting from the transformation of suitable lighter form of bitumen, malthas, or even thinner oils, into harder bitumen by condensation and polymerization, a reaction in which sulphur and probably sulphates seem to take an important part. No high temperatures seem necessary once the change is initiated, but time is necessary.

Manufacture of Oil Asphalt

The method of manufacturing an oil asphalt is probably familiar to you all. As asphaltic oil is distilled, the gasoline naphthas, burning oils, gas oils and lubricating oils are obtained from the distillate, and the residue is controlled to give the best grade of oil asphalt obtainable from the particular crude oil under manipulation without economically sacrificing any of the more valuable distillates.

Asphalt Defined

There have been several definitions proposed for asphalt. I will cite two or three.

First. Asphalt may be simply defined as a solid or semi-solid form of mineral bitumen, either pure or containing more or less mineral or other earthy matter. Speaking in general terms, it may be said there are three grand divisions of natural mineral bitumens, viz., gaseous, liquid and solid. The asphalts consist of a mixture of various saturated and unsaturated solid hydrocarbons and their derivatives.

Second. Asphalt, solid or semi-solid native bitumens, consisting of a mixture of hydrocarbons of complex structure, largely cyclic and bridge compounds, together with a small proportion of their sulphur and nitrogen derivatives, but free from any appreciable amount of solid paraffines, melting upon the application of heat and evidently produced by nature from petroleums containing little or no solid paraffine. Solid or semi-solid residues produced from probably similar oils by artificial processes are sometimes called asphalts, but should properly be termed oil asphalts. The more common types of native asphalts are known by the name of the locality in which they occur, such as Trinidad, Bermudez, Maracaibo, Cuban, California, etc. Native asphalts with few exceptions contain water, extraneous organic or vegetable matter and inorganic matter such as clay, sand, etc.[1]

Third. Solid or semi-solid native bitumens. Solid or semi-solid bitumens obtained by refining petroleums, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleum or derivatives thereof, which melt on the application of heat, and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds.[2]

I could go on indefinitely through the literature and show that most every author has given his own definition. This chaotic condition is receiving serious attention by several different societies at present.

Sources of Natural Asphalt

With this brief and general outline let us proceed to the description of the two sources of native asphalt from which the largest amount of ashphalt has been pro-

[1]Office of Public Roads, Department of Agriculture, Circular 93.

[2]Progress report of Special Committee on Materials for Road Construction presented at the annual meeting of the American Society of Civil Engineers, Jan. 20, 1915.

FIG. 1 RELATIVE LOCATIONS OF TRINIDAD AND BERMUDEZ ASPHALT LAKES

*Presented at the Dec. 8, 1919, meeting of the New Jersey Chemical Society, Newark, N. J.

†Chief chemist, Technical Department, Barber Asphalt Paving Co., Maurer, N. J.

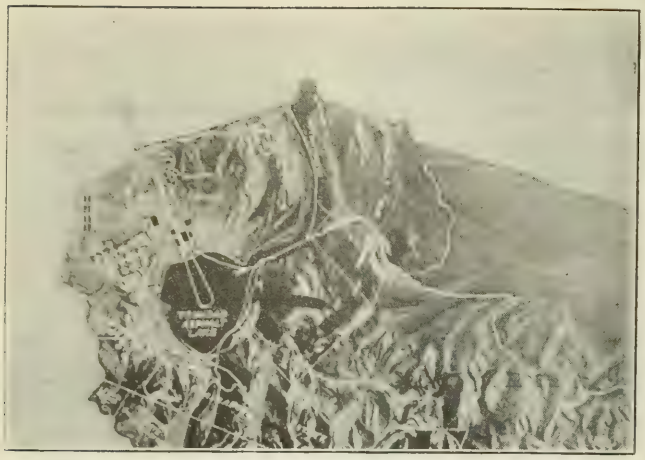


FIG. 2. RELIEF MAP SHOWING LOCATION OF TRINIDAD ASPHALT LAKE

duced, namely, Trinidad and Bermudez Lakes. The two lakes are situated in South America; the Trinidad Lake on the western coast of the Island of Trinidad in the British West Indies, and the Bermudez Lake on the eastern coast of Venezuela about thirty miles inland by air line. The relative locations of the two lakes are shown in Fig. 1. The Gulf of Paria, about eighty-five miles in width, separates the Island of Trinidad from Venezuela.

The island is about 700 miles north of the Equator and about 2,000 miles south of New York City. Its area is about 1,700 square miles, or less than the area of the State of Delaware. The climate is tropical, but is favored by the trade winds which tend to ameliorate the tropical temperature, averaging as it does about 85 deg. F. the year round, never varying more than 20 degrees. The only difference between one season of the year and another is the difference in rainfall.

Description of Trinidad Lake

The Trinidad Lake, and "lake" best describes it, is situated about one mile from the sea and about 138 ft. above sea level. Fig. 2 is a relief map showing the exact location of the lake. It is about 114 acres in extent. Its surface is undulating, the mass of asphalt seemingly lying in large folds, and where these folds meet there is a crevice formed, varying in depth from a few inches to a few feet in which rain water constantly stands, forming miniature canals. This characteristic formation is illustrated in Fig. 3. The mass is in imperceptible constant motion, which can be detected only by noting the relative position of the miniature canals at various times. This motion is also indicated by its behavior after digging, as will be described later on. Fig. 4 shows one edge of the lake.

Depth of the Lake Unknown

The greatest depth of the lake has never been found. In 1893 a series of borings were made, and the one at the center of the lake was carried to a depth of 135 ft., the entire depth being through solid asphalt of uniform character and composition, but the boring had to be abandoned, as the tube or casing had been carried so far from the vertical (one foot in six) as to render any further boring valueless. The depth found, however, indicates an almost inexhaustible supply of this wonderfully uniform material, for while mining has been carried on continuously for over thirty-eight years, the level of the lake has dropped only 6 or 8 ft. in all that time. This would seem apparent, for there is a perceptible rise in the center of the lake, but the new material is either of the same character or replenishment must be very deep, else the borings would have indicated a change in character. The borings near the edge of the lake indicated considerable slope to the sides, and it is believed the lake rests in a bowl-like depression, probably an extinct mud volcano.

Digging and Transporting Crude Trinidad Asphalt

There is a narrow-gage road and endless cableway running from the refinery out over the lake, and turning in a large semi-circle so as to traverse as much of the lake as possible, returning to the starting point. This road is not ballasted, yet there is very little sinking of the ties into the asphalt. A train consisting of several small flat cars, each car carrying a dumping bucket of about 500 lb. capacity, is pulled over this track by an endless cable running over the ties, and by means of a portable clutch a native sitting on the front of a train is able to start or stop the train at will. The natives dig the solid asphalt with broad mattocks and load the chunks into the cars by hand. The space left after a day's digging is completely filled within forty-eight hours, which is another proof of the continual motion of the mass of asphalt. After loading, the cars are pulled either to the refinery or the terminus of an endless overhead cableway which carries the loaded buckets down hill and out over the dock to the steamer, the loaded buckets going down hill, producing sufficient power to pull the empty buckets up hill. The crude Trinidad asphalt, as it is called, is shipped in bulk in the holds of steamers, to all parts of the world, but during transit amalgamates into a solid mass and has to be dug out again.

Description of Bermudez Lake

We will now journey for a moment into the wilds of Venezuela to take a hasty glance at the Bermudez Lake. The only means of approach from the Gulf of Paria is by steamers up a desolate river known as the San Juan. For five hours we see nothing but mangrove swamps on either side of this wide and placid river, the only signs of life being the customs officials' hut at its mouth, and myriads of multi-colored birds. The last five miles of the trip is up a tributary of the San Juan known as the Guanoco River. This really is a deep creek, it being so narrow that the steamers cannot turn, so they turn at the fork of the two rivers and

FIG. 3. WATER STANDING IN FOLDS ON SURFACE OF TRINIDAD LAKE

back up to the dock at Guanoco in order to have a straightaway course when loaded. We take a narrow-gage road at Guanoco for a seven-mile trip through jungleland. Indeed, you cannot step off the ties of the road without going up to your ankles in water. All through this jungle you see the beautiful tropical flowers and birds of many colors, but never a note of song from the birds or a sweet scent from the flowers.

Bermudez Lake (Fig. 5) is about 2,000 acres in extent and varies from 3 to 10 ft. deep in those parts that have been worked. It is not quite as hard as the Trinidad Lake and the ties supporting the railroad have to be shifted frequently. There is considerably more water to contend with here, as the seasons vary by one

FIG. 4. EDGE OF TRINIDAD ASPHALT LAKE

being wet and the other very wet. There is also considerably muddy silt to be mucked off the top, this mud being washed in by the heavy rains from the hills to the west. Owing to this mud you will find more vegetation on this lake than on the Trinidad Lake.

Handling Crude Bermudez Asphalt

The asphalt is loaded by hand into dump cars which are pushed by natives in trains of three or four cars to an elevated track at the edge of the lake, there to be dumped into wooden skips. These skips are hauled on flat cars seven miles to the steamer's side at Guanoco, lifted by the steamer's winches and dumped into the vessel's hold. The Bermudez crude runs together while in transit, the same as the Trinidad, and has to be dug out again upon its arrival at destination.

Refining Crude Asphalt

As the operation of refining is the same for both asphalts, we will describe more fully the Trinidad.

As obtained crude, the Trinidad contains approximately and uniformly through all cargoes, 39 per cent of bitumen, or that portion that is soluble in carbon disulphide, the accepted solvent of the asphalt industry for determining bitumen, 32 per cent of mineral and other matter, and 29 per cent of water. For comparison, Bermudez crude varies as to its water content, averaging about 25 per cent, 1 to 3 per cent of mineral matter and 68 to 72 per cent of bitumen. The refining in either case consists in driving off the water in a steam-heated still open at the top, at a temperature of about 350 deg. F. It takes about eight hours to refine a still of fifty to seventy tons. It is then either drawn off into slack barrels, such as cement is shipped in, surface cooled by water to prevent splashing while being hauled about the refinery yard and shipped direct to customers or is fluxed before drawing.

Fluxing Refined Asphalt

Fluxing of a refined asphalt consists in adding a predetermined quantity of a petroleum residuum, or flux, which flux is bought under stringent specifications assuring a uniform material suitable for paving and other purposes. Refined asphalts have a consistency or penetration of from about 2 deg. for Trinidad to 20 deg. for Bermudez. This consistency is determined by means of a sewing needle of certain size and make, under a fixed load acting for a fixed time at a standard temperature and a degree of penetration is ten times the number of millimeters the needle sinks into the asphalt. The refined is too hard for use in paving operations. The proper consistency is dependent upon climatic and traffic conditions, as well as the grading of the mineral aggregate with which it is mixed to produce a paving mixture. The fluxed asphalt must not be too hard in cold weather and yet not too soft in summer. You have all noticed and I presume heard unfavorable comments upon the softness of some sheet asphalt pavements in the summer time. Did you ever see a sheet asphalt pavement with heel marks, horses' calk marks or tire tracks in it in winter? What becomes of them? They iron out, and a pavement that does not mark a reasonable amount in summer must be viewed with suspicion. It will probably be too hard in winter. This is one feature in which technical control has been and will be of much assistance to the paving industry.

Asphalt Cement

When the refined is fluxed it is called an asphalt cement, as it is used to cement particles of mineral matter together, and after a still has been fluxed to proper penetration or consistency it is shipped in either single or double head hardwood barrels, according to

FIG. 5. VIEW OF BERMUDEZ ASPHALT LAKE

its consistency, and is ready for use when received, except that it has to be remelted. Some customers prefer to flux the refined themselves; others desire it ready fluxed, and for country road purposes it is shipped ready fluxed in the majority of cases.

Asphalts have been applied to many different uses in the past few years and the simple fluxing to varying degrees of consistencies referred to above does not ade-

FIG. 6. LOADING DOCK AND STEAMER IN GUANOCO RIVER

quately describe conditions today. Some uses require the softest, while another use requires the same melting point but a much harder consistency. Such variations are obtained by proper blending of two or more asphalts or the incorporation of materials other than asphalts. Obviously the type of material suitable for use in hard rubber compounds would not be suitable for saturating canvas to produce a waterproof and mildew-proof piece of goods. Neither of these products would be applicable for building tank linings to withstand temperatures up to 120 deg. F. and mixed acids (such as sulphuric and nitric of about 25 per cent strength) such as are met in the dye industry.

Colloidal Mineral Matter in Trinidad Asphalt

I would like to refer now to the mineral matter that occurs in Trinidad Lake asphalt. It appears to exist in a colloidal state, so we will consider that subject very briefly, for while many of you are, no doubt, familiar with this subject, yet those present who have not ventured into this realm of the "poetry of chemistry," as it has been aptly termed, will no doubt find something of interest to their own problems or difficulties, for colloidal conditions exist all around us; in fact, Dr. Fisher would have us believe the human system is more or less a colloidal one, the tissue structure being a water-in-oil emulsion, which is another way of describing a water colloidal dispersion in oil.

Graham's Investigation of Colloids

The first systematic investigation of and the name "colloids" are due to Thomas Graham, whose results were published in numerous papers between 1861 and 1864. His discoveries may be briefly summarized under two general heads. In studying dialysis of various substances, i.e., the diffusion of dissolved substances through organic membranes like parchment into the pure solvent, he found that some of them passed freely through the membrane into the surrounding solvent, while a number of others failed to do so, or diffused at an extremely slow rate. Generally speaking, the former were bodies which were known to crystallize, while the latter, like glue, gelatine, gum arabic, etc., were known only in the amorphous condition. Graham accordingly divided soluble bodies into two classes, crystalloids and colloids (from colla, meaning glue).

The second discovery was that a number of substances generally considered as insoluble could, by appropriate methods, be obtained in what at first sight appeared to be real solutions. They did not, however, diffuse through parchment, and on account of this property they were called "colloidal solutions" or simply "sols," which term has now become generally accepted. These "sols" showed a further striking peculiarity, which distinguishes them sharply from true solutions, as extremely small additions of electrolytes or reagents such as ordinarily would not react at all with the dissolved substances caused radical alterations in the condition of the solutions. Silicic acid sol sets to a transparent jelly when a trace of carbon dioxide is added thereto, and a ferric hydroxide sol is immediately broken down by a slight addition of sodium sulphate with the precipitation of the ferric hydroxide as a flocculent mass. Obviously these were phenomena quite different from known reactions of a purely chemical nature and the sols had to be considered as systems differing from ordinary true solutions.

Ultra-Microscope Aids Study of Colloids

Since Graham's time the whole subject has been studied by an ever-increasing number of investigators, both physicists and chemists, with new methods and appliances, the most important of which has been the ultra-microscope, invented in 1905 by Zsigmondy and Siedentopf, which even in that short time has enormously enlarged our knowledge of colloidal solutions. The principal step forward in theory has been the proof, now quite conclusive, that "colloids" in Graham's sense are not a definite class of substances, but that by suitable means and methods a very large number of bodies can be prepared in a colloidal condition, which indicates and is generally accepted that it is a *state* and not a *form* of matter.

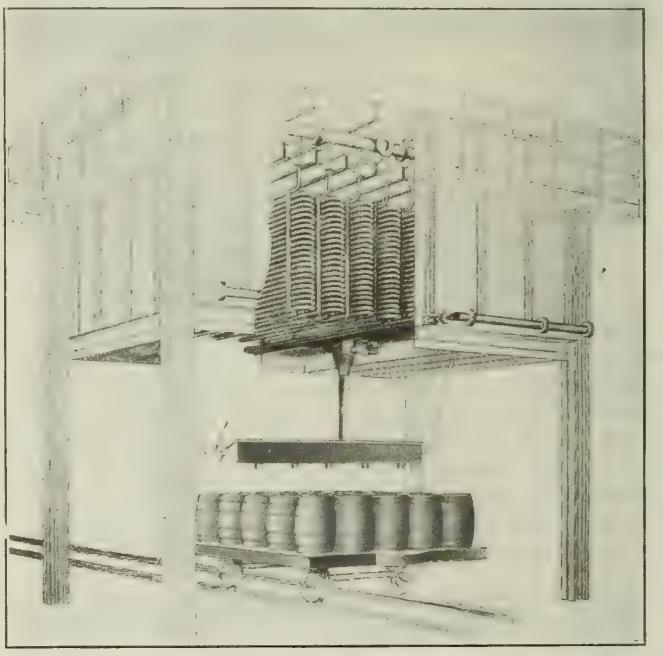


FIG. 7. STEAM STILL FOR REFINING ASPHALT

Bancroft's Views on Colloidal State

More recently, W. D. Bancroft has stated that Graham's view that a colloidal substance must be amorphous has been dropped and we now call a phase or state of matter colloidal when it is sufficiently subdivided, not committing ourselves definitely as to the degree of subdivision. Colloidal chemistry appears to Bancroft as the chemistry of bubbles, drops, grains, films and filaments.

FIG. 8. STORAGE PILE OF REFINED LAKE ASPHALT IN SLACK BARRELS

All surfaces, both of solids or liquids, have the power of adsorbing solids, liquids, or gases. A familiar instance of this is the formation of an air film or water film on the surface of glass. It is perfectly familiar to all of us that small drops of a liquid will coalesce to a single drop when brought in contact. It is not so familiar that solids also coalesce when brought in contact, because solids, as we know them, have a film of air on the surface and we do not actually bring them in contact. Cushman and Goggeshal report in their work that a powder which would pass a 200-mesh screen surged like a liquid. The film of air was so large relatively to the mass of the particles that they were really dealing with little elastic balls having a hard core. Heating drives out the air film and tends to make solids more malleable so that pressure brings more points into actual contact. We can join two pieces of glass while they are still very viscous, and we join two pieces of platinum in the laboratory at temperatures far below its melting point. Cleaning of surfaces prior to soldering is another familiar instance, although here we have the question of clean surfaces as well as absence of air film.

In the above discussion Bancroft is attempting to develop the thought that solid grains or liquid drops will agglomerate if actually brought into contact, and to keep them from doing so we must have a surface film of some sort. Dirty mercury will remain as a single liquid mass indefinitely. If we disintegrate the mass, a film will form over each drop and will prevent the drops from coalescing. The case of breaking this mass of mercury depends upon the surface tension of the mercury.

Brownian Movement of Fine Particles

If we drop a stone into water, it sinks rapidly; if we grind the stone into coarse particles, these sink less rapidly; if we continue to grind finer and finer, we finally reach a point or state that we would expect the particles to sink the slowest, the rate, of course, being a function of their diameter. This is not the case, however. When the particles are subdivided below a certain size, they actually fail to settle out. They then take on a constant unceasing motion known as the "Brownian movement." This movement was first noted in 1827 by Dr. Brown, a botanist, after whom it is named. The movement is composed of an oscillating motion of particles around a central position and an erratic translatory motion.

This motion decreases as particles grow larger and ceases entirely if the diameter exceeds a certain size. Various suggested causes, such as vibration, convection currents due to changes of temperature or of concentration were gradually eliminated by experiment, and it became evident that the movement could hardly be due to any transient cause.

The study of the phenomena received an enormous impetus by the invention of the ultra-microscope, as the very small particles disclosed by it for the first time showed it so vividly that Zsigmondy was inclined to look on it as something differing not only in degree but also in kind from the Brownian movement. Methods were devised which facilitated the measurement of the amplitude of oscillation—that is, the time between two similar positions.

Theory as to Cause of Brownian Movement

Since then various mathematical relations between these quantities have been developed, but the theory as to the actual cause of this Brownian movement is still in dispute, although the most generally accepted theory seems to be that the whole phenomenon conforms to conclusions drawn from the kinetic theory and that there is no essential difference between this motion and molecular motion. The stability seems also to be intimately connected with the electric charge, as it has been shown generally that colloidal particles are so charged.

Ultra-Microscopic Study of Mineral Matter in Asphalt

For many years the insistent presence of a small percentage of mineral matter in all extracted bitumen from Trinidad Lake asphalt baffled the operators, and while we all felt it was a very finely divided clay, yet it was not until 1914 that Clifford Richardson initiated the work that finally showed us these particles in the ultra-microscope.

Richardson's Theory of Asphalt Formation

How this clay occurred in this manner is explained by Mr. Richardson briefly as follows:

"The crude asphalt in the lake consists of a complex system of several phases, gaseous, liquid and solid, organic and inorganic, more or less in equilibrium, displaying colloidal properties of industrial as well as scientific interest. The asphalt owes its origin to certain geological conditions existing side by side in that locality. Oil sands occur at different depths, which contain vast quantities of petroleum, as has been demonstrated by the many wells which have been successfully sunk, a petroleum of unique character, differing from any previously known, and of a highly asphaltic nature. Rising toward the surface along some line of least resistance, the petroleum meets the paste of fine silica and clay which forms the mud of the spring. With this the oil becomes emulsified, probably by the action of the natural gas which accompanies it at very high pressure. In the lapse of time the entire crater of the spring has been filled with the resulting material and it has overflowed the rim, running down the slopes to the sea.

"Fresh material is in process of formation today and issues at several points on the surface of the deposit of a consistency so soft that it can be readily molded into balls with the hands, without adhering to them owing to the free water with which it is associated. This

so-called "soft pitch" is also accompanied with natural gas of unusual composition, containing, in addition to the hydrocarbons usually found in such gas, carbon dioxide and hydrogen sulphide, in some localities in the neighborhood of the deposit as much as 33 per cent of the former and 3.5 per cent of the latter. At the same time the soft pitch itself is evolving gas, either the result of the release of pressure or of a reaction going on between the bitumen and the mineral matter it contains, this gas consisting largely of hydrogen sulphide and carbon dioxide, probably the latter cause, as it continues for years after the material has been exposed to the air, while if the soft asphalt is sealed up in a tin can the latter will explode in the course of time from the gas pressure developed.

"The main mass or older form of the asphalt in the crater is sufficiently hard to make it possible to flake it out in large pieces of from 50 to 100 lb. in weight. In this form it resembles an exaggerated Swiss cheese owing to the gas cavities it contains. While brittle enough for this, an excavation of some depth at any point is filled up and obliterated in twenty-four hours by the flow of asphalt from the adjoining material. Large masses of the asphalt taken from the deposit and kept in storage, without lateral support, present all the features of the glacial flow of ice.

"The asphalt, therefore, originating in a soft condition as demonstrated by the fresh material, which is constantly being formed and which emerges near the center of the deposit, becomes hard in the course of a year or two. The cause of this and of the evolution of the gas which is observed may be attributed to the presence of a catalyzer. As will be shown, the asphalt contains clay in highly dispersed condition, carrying adsorbed ferrous sulphate, which may play such a role."

Colloidal Suspensions of Clay in Pure Bitumen

In the endeavor to reproduce these conditions, clays from many different sources, including clays from oil springs found on the Island of Trinidad, have been experimented with in many ways and that method showing the most promise is to make a clay slurry with water, adding this to a pure bitumen at a temperature below that of boiling water and slowly cooking out the water. This method results in some colloidal particles in the bitumen, but not nearly approaching the number per unit of volume as found in the lake asphalt.

Examination of Bitumens by Ultra-Microscope

In preparing a bitumen for examination by the ultramicroscope, it is best to have about a 10 per cent solution of bitumen in benzol. After swinging for one-half hour or more in a centrifugal machine it can be examined immediately, or if it is desired the solution can be allowed to stand for several months or filtered through a Chamberland filter. Whether one or all of these methods are followed, we still find the particles persisting in the solution.

Effect of Colloidal Clay on Physical Properties

These minute particles of clay no doubt adsorb the bitumen, creating a surface energy far in excess of any type of mineral filler added to a bitumen in the usual dry way such as in making a sheet asphalt mixture. If we add to one portion of a bitumen a percentage of dry clay and to another portion of the same bitumen add the same quantity of the same clay, but in the form of a slurry, and the resulting mixtures are rolled out in the form of a long cylinder and coiled spirally in a tube, it will be noticed in a short time that the spiral made of dry clay and bitumen is flowing together and deforming generally, whereas the one made with the wet clay holds its shape indefinitely. In other words, the colloidal clay has had a greater physical effect in the mechanical modification of the bitumen than the dry clay. It has made a more stable bitumen as regards its susceptibility to temperature changes without any chemical modification of the hydrocarbons composing the bitumen.

This experiment conclusively shows the effect of increased adsorption due to the colloidal state of the mineral matter in Trinidad Lake asphalt. This adsorption increases the surface tension or energy of the film, thus increasing the stability.

Awakened Industrial China

In speaking before the Chicago Foreign Trade Club recently, Julian Arnold, commercial attaché of the U. S. Department of Commerce, reviewed the developments which have been made in the Orient in the past twenty years, with especial reference to China. There has been during that time a modern educational system installed, the growing of opium has been wiped out, a modern press is being developed, with over 300 newspapers published regularly, and a national spirit has been awakened.

In the line of foreign trade possibilities there is a population of 400,000,000 people as compared with 70,000,000 in South America. There is as much coal in China as in the United States. They also have iron ore, antimony, zinc, lead and tin, and these resources are now being opened up. Eighty-five per cent of the population is engaged in agriculture, with the farms averaging five acres each. The great outstanding problem is the lack of transportation. Give China 100,000 miles of railroads and these markets will be opened to the entire world, developing this section of the earth to ideas of modern industrialism.

The Shanghai Chamber of Commerce is doing much to help the American manufacturer in finding markets in the Orient. American goods are popular because of the quality marketed. The language must be taught in our universities. The cable service should be improved. As conditions are today this country offers the greatest trade opportunities in the world.

Extension of Laboratory Facilities for Analysis of Imports in Brazil

A law of Jan. 13, 1920, provides for the immediate establishment of laboratories for the analysis of imported products in the custom houses of Santos, Porto Alegre, Corumba, Recife, Bahia, Parahyba, Fortaleza, Maranhao, Belem, and Manaos, with the gradual extension of such facilities to all the custom houses of the republic for the purpose of preventing the introduction of articles injurious to the public health. A fee of 2 per cent of the total import duties, payable in paper currency, is to be charged for the analysis of the following articles: All kinds of fabrics; chemical products, drugs, and pharmaceutical preparations; canned meats and fish, excepting codfish; vegetables; starches; cheese; butter; all other alimentary products; and articles used in the preparation of foods and drinks.

General Sibert and the Chemical Warfare Service

By Paul Wooton

NO SURPRISE was occasioned among his close friends when Major General William L. Sibert requested that he be relieved of the command of the Fifth Division at Camp Gordon, Ga., and be placed on the retired list of the Army. While no complaint or comment is coming from General Sibert, it is well known in Washington that his heart was in the Chemical Warfare Service and despite determined efforts to take up army post life again, he found it impossible to do full justice to his assignment. General Sibert expects to embark in the near future in active private work.

While General Sibert is not a chemist, he is recognized as having been the most important single factor in the development of the Chemical Warfare Service. He regarded the upbuilding of this branch of the Army as the crowning achievement of his military career. He is understood to be very grateful for having been permitted to continue his work to the point where he persuaded the Congressional committees in charge of military legislation that the development of chemical warfare should be pursued actively and entirely independently of the other subdivisions of the War Department.

GENERAL WILLIAM L. SIBERT
Former Director of the Chemical Warfare Service, Who Has Applied for Retirement from the Army

In view of the personal feeling that it was necessary to arouse in thus opposing the wishes of the General Staff, it is believed that General Sibert realizes that the work now can be carried on best by another, and is more than satisfied with the assurance that chemical warfare is not to be a subdivision of an existing War Department agency and that active development of this branch of the military service is to be continued. The wisdom of such conclusion is evidenced by the growing interest within the War Department in the Chemical Warfare Service, and it is believed now that all concerned will co-operate to secure the maximum benefits from the work which will be carried on by that arm.

In the view of his associates, General Sibert's greatest achievement came during the war in bringing the agencies engaged in chemical warfare activities into a cohesive whole. When he was assigned to the gas warfare section, as it was known then, General Sibert found the manufacture of masks being conducted under one agency, the manufacture of gas and the filling of shells under another, while the training of gas troops was under still other direction and a fourth agency was in charge of gas research.

Good work was being done in each particular line, but the greatest difficulty was being found to secure the desired co-ordination of all the activities entering into gas warfare. This unification of the chemical warfare activities was made just in the nick of time. Operations at the front were being hampered by the lack of certain materials not properly supplied by some of the former subdivisions. The situation became so bad that a cable was actually sent from headquarters in France to General Sibert, advising him that it would be necessary to stop the offensive use of gas troops unless these materials could be made available in the very near future. With his then unified service, General Sibert found no difficulty in bringing about the quantity of production required.

General Sibert's experience in the field was particularly valuable to him in making up the work in this country to meet practical conditions existing on the front. Through the lack of intimate touch with field conditions, the manufacture of vincennite continued on a considerable scale in this country some time after its worthlessness under battle conditions had been demonstrated to the satisfaction of the chemical officers with the expeditionary forces. Vincennite, which promised so much under laboratory and experimental conditions, failed to give results in actual battle because anything less than killing quantities of the gas in no way impaired the effectiveness of the enemy. It was in such matters as these that General Sibert proved of such help to the situation just at the time when it was most critical.

The fact that General Sibert knew only the chemistry of the West Point graduate and of the engineer led him to lean heavily on the prominent chemists with whom he surrounded himself. He had no preconceived theories of his own, which might have been the case had a chemist been thrust into a work concerning which there were so many uncertainties. His lack of technical chemical knowledge led him to concentrate on the practical phases of the service, an aspect now held to have been equally responsible with the remarkable technical achievements for the success of the American Chemical Warfare Service in the World War.

Current Events
in the Chemical and Metallurgical Industries

New Jersey Chemical Society Holds Annual Meeting

The New Jersey Chemical Society is one of the progressive organizations of that state. The steady, remarkable growth which it is enjoying was evidenced in more ways than one at the annual meeting, held at Achtel-Stetter's, Broad St., Newark, on Monday evening, April 12, for despite the handicaps brought about by the railroad strike, there was a good attendance and an excellent program, with good-fellowship prevailing in overflowing measure. The reports presented showed conclusively that the association has become an important factor in this industry in the state, and its work is receiving more and more attention.

The organization is in a way still in its infancy. It was organized in 1918 with primary purpose to bring into closer contact those in the trade, profession and business, and at the same time permit those interested in chemical work to participate in its proceedings. Many monthly meetings have been held and a real, concrete interest has been secured for the benefit of all concerned. To Carleton Ellis, of Montclair, N. J., a large measure of credit is due, for as president of the association since its inception, and greatly instrumental in its formation, he has piloted affairs in an able, masterful way, giving considerable time and attention to the work, with no little effort devoted to increasing the membership.

Election of Officers

Mr. Ellis was re-elected president at the annual election, thus filling the chair for the third consecutive time. R. P. Calvert, who has been acting secretary of the association, was elected vice-president, succeeding Frederic Dannerth, who has recently taken up residence in Brooklyn. D. K. Howard was re-elected treasurer, while J. A. Wilson was appointed secretary. Those comprising the board of governors for the ensuing year will include H. G. Cawley and G. A. Armstrong. Others acting on this board during the year past are H. B. Baldwin, R. P. Calvert, W. A. Lucas, C. P. Titus, F. D. Crane and E. G. Little.

The first year book of the association has been published, and is a comprehensive and valuable volume. It reviews the association's activities up to a recent date and sets forth a list of the chemical and affiliated industries now operating in New Jersey. Incidentally, this list makes a fine showing, for the broadening of the industry in this section during late years is generally well known.

The program for the evening was preceded by the usual fine dinner, which was thoroughly enjoyed by those assembled. The principal addresses were made by Linn Bradley, of East Orange, and J. V. Meigs; the first dealt with the development of the potash industry in the United States, while the latter covered the subject of alcohol and other motor fuels as substitutes for gasoline.

Mr. Bradley, as chief engineer for the Research Corporation, of New York, has had a broad experience in the potash branch of the industry and speaks with authoritative and definite knowledge of this subject. He has given particular attention to the matter of potash recovery and devoted a large part of his paper to this phase of work.

He spoke of the installation of potash recovery plants at various cement mills, the first successful plant of this nature being that of the Riverside Portland Cement Co., at Crestmore, Cal., a development which came about after the installation of the Cottrell processes at this works for dust elimination.

Reference was made to the recovery of potash as a byproduct of blast-furnace operation, showing extensive accomplishments in this direction. The initial work of this character developed as a result of investigations at the plant of the Bethlehem Steel Co., at South Bethlehem, Pa. With the potash balances made, iron ores have been found in various parts of the country that give as much as from 1 to 3 per cent of potash, notably in the Alabama district, and yet carry sufficient iron for profitable blast-furnace operation.

A particularly interesting mention covered the forthcoming activities of a large potash corporation now building a plant in New Jersey for the production of potash from what is termed "New Jersey green sands." This plant, located in the Raritan River section, will be one of the largest works of its kind in this part of the country; it will be devoted to a varied, yet affiliated line of manufacture, including lime, potash salts, potash brick, green sand residue and other products. The company has acquired extensive green sand properties, containing a percentage of potash, near Eatontown, Monmouth County, and will use this as the source of supply. The process covers the heating of this so-called green sand mineral with lime for the extraction of potash.

Gasoline Substitutes

Mr. Meigs in an interesting talk outlined the necessity for the development of practical substitutes for gasoline, particularly in the line of fuel for automobile motors. He said that figures made public by oil experts indicated that native supplies of crude oil would be exhausted at a not very remote date. At the present time alcohol, he pointed out, gave evidence of being the most promising substitute, with shale oil closely allied in this connection. Various methods of obtaining alcohol were also considered by Mr. Meigs, dealing with standard practice of today.

Imports of Scientific Apparatus

Imports of scientific apparatus during February of 1920 were valued at $2,555. This compares with imports during the corresponding month of 1919 of $2,092. Imports of scientific apparatus during the eight months ended with February were valued at $48,191, which shows a decrease from the imports during the corresponding period of the year previous, when they totaled $69,113.

Further Nitrate Hearings

The hearings before the Senate Committee on Agriculture regarding the proposed fixed nitrogen corporation were continued daily from Thursday, April 8, until the following Tuesday. Supplementing the general criticisms (reported last week in CHEMICAL & METALLURGICAL ENGINEERING), Mr. Washburn, president of the American Cyanamid Co., again emphasized that there is no place in the present market for the material which the administration expects to make at Muscle Shoals.

E. Kilburn Scott called the attention of the committee, in Mr. Washburn's presence, to certain contradictions which he alleges will be found in Mr. Washburn's present statements and those which he made in 1916, when he urged the erection of the Muscle Shoals plant. Mr. Scott says that Mr. Washburn is now condemning his own plan.

LANDIS SUMMARIZES OBJECTIONS

W. S. Landis, chief technologist of the company, also was on the stand, taking up particularly other testimony which was presented to the committee and criticising various alternate proposals to the production of certain chemical products at these plants, particularly the possibility of making calcium nitrate, ammonium nitrate and ammonium nitrite.

In résumé of the objections of the company to continuance of Muscle Shoals operations, he stated three reasons, as follows: (1) The corporations cannot easily compete with the Government, which charges no amounts to operation for taxes, etc. (2) Operation by the Government will unreasonably take away from existing companies their patronage in fields which they have developed at considerable expense to themselves. (3) Continuance of the plant operation on the basis proposed will amount to an appropriation by the Government of processes and patents which belong to private interests and are beyond the contract rights of the Government.

Special emphasis was laid upon the point that completion of the dam operation at the present high prices of materials was considered commercially wrong. Costs of materials used in the Government estimates for the plant operation were also criticised; particularly the charge for coke at $6 per ton, was characterized as too low and the charge of 5c. a lb. for electrodes was criticised. However, explaining these charges, Colonel Burns of the War Department stated that the best estimates as to stable future conditions were taken in these points and the correspondingly low income from the sale of the products had been assumed. Therefore it was his belief that these low prices for materials were amply offset by the fact that $65 per ton was the amount estimated as the Government income from the sale of the ammonium sulphate, whereas present market conditions are very much above this figure.

SCOTT SUGGESTS USE OF ARC PROCESS

E. Kilburn Scott of New York City also appeared before the committee favoring the bill for the continuance of the plant operation by urging that the arc process should be used in part in the course of development. An extensive presentation of the claimed merits of this process and the advantages believed to accompany its use at Muscle Shoals under present conditions were set forth.

The War Department requested opportunity to reply to the criticisms and the hearings were adjourned to be resumed on Tuesday morning, April 20, at which time the nitrate division was to resume its arguments.

GRAHAM COMMITTEE TO REPORT SOON

Within two weeks Representative Graham of Illinois, chairman of the committee investigating expenditures in the War Department, expects to address the House giving the conclusions of the majority of the committee as to the activities of the Government looking to the manufacture of nitrogen.

War Department Releases Sodium Nitrate

During the discussion in the House of Representatives of the resolution authorizing the Secretary of War to turn over a portion of the reserve of nitrate of soda it was revealed that the Government's reserve was purchased at a cost ranging from $56 to $84 a ton. It was declared on the floor of the House that there would be no loss to the Government in the transaction, as the price which would be received would be in excess of the original cost of the nitrate.

The resolution as drafted and approved by the Secretary of War called for the use of 50,000 tons of the War Department's reserve. The House approved the amendment, however, increasing the amount to 100,000 tons. It also amended the resolution previously passed by the Senate so as to allow the outright sale of the nitrate rather than require replacement with a similar quantity of nitrate.

In an effort to make profiteering in this material more difficult two additional amendments were adopted. One provided that "not less than one ton or more than 100 tons may by sold to any purchaser." The other amendment requires the Secretary of War to report to Congress not later than Dec. 6 the names of all the purchasers together with the prices realized from each sale.

Zinc Tariff Bill Reported Favorably

After a long delay the Senate Committee on Finance has reported favorably, without amendment, the zinc tariff bill which was approved by the House on Sept. 2. Zinc-bearing ore containing 25 per cent or more of zinc is to be dutiable at 1c. per lb. on its zinc contents. A strenuous effort was made to induce the committee to authorize a duty of 2c., but after careful consideration this request was denied.

In addition the bill provides duties as follows: On zinc oxide and white pigment containing zinc, but not containing lead, dry, 1c. per lb.; ground in oil, 1¼c. per lb.; white sulphide of zinc, 1½c. per lb.; chloride of zinc and sulphate of zinc, 1c. per lb.

In reporting the bill to the Senate, Senator Watson pointed out that the American zinc-producing industry is in a serious condition. Out of eighty-seven mills, which were operating in the Webb City district of Missouri, only two now are working. In Webb City, he asserted, one-third of the inhabitants have left. In addition, he said, 400,000 tons of zinc ore are piled on Australian docks ready for shipment. Since this ore is a byproduct of lead-silver operation, the producers are willing to take any price they can get for it. He also pointed to the menace of Mexican production, which may increase rapidly if conditions in that country should permit.

Personal

A. W. AMBROSE of the U. S. Bureau of Mines has been appointed superintendent of the petroleum experiment station of the Bureau at Bartlesville, Okla. He succeeds W. P. DYKEMA, who has resigned in order to be able to devote more time to the natural gas investigations of the Bureau.

R. L. COMSTOCK, formerly of the Brown Co., Berlin, N. H., is now with the Warner Chemical Co., Cartaret, N. J., as plant chemist.

HARRIS D. HINELINE resigned as research engineer with the Westinghouse Electric & Manufacturing Co. to become a member of the faculty of the Science School of the Carnegie Institute of Technology, department of chemistry, Pittsburgh, Pa.

GEORGE P. HORN, formerly of the Service Bureau of the Portland Cement Co.'s Pittsburgh office, is now chief chemist of the Security Cement & Lime Co. He will have charge of the laboratories at the cement plant at Security, Md., and the lime plant at Berkeley, W. Va.

Dean DAVID MCKINLEY will remain in office as president of the University of Illinois, as recently confirmed by the board of trustees.

EDWARD MALLINCKRODT, president of the Mallinckrodt Chemical Co. of St. Louis, has been elected to the board of directors of the Laclede Gas Light Co. of St. Louis.

C. G. RICE of Boston has been elected president of the U. S. Smelting, Refining & Mining Co. to fill the vacancy caused by the death of William G. Sharp last July.

E. KILBURN SCOTT, consulting engineer, of New York, has recently been in Chicago and Western points on professional business. Mr. Scott has been called to Washington to testify before the Senate Committee on Agriculture relative to the arc process of nitrogen fixation.

FERDINAND L. SNYDER, formerly assistant engineer of the Baltimore Copper Smelting & Rolling Co., has resigned to accept the position of efficiency and assistant plant engineer, Portsmouth Cotton Oil Refining Co., Portsmouth, Va.

Dr. E. C. SULLIVAN has been elected vice-president of the Corning Glass Works, Corning, N. Y.

CYRIL S. TAYLOR has resigned from the Bureau of Standards, Washington, to go in the research department of the Aluminum Company of America at its laboratories at New Kensignton, Pa. Mr. Taylor expects to begin his work in the new position some time during June.

F. G. TRYON, who just has been appointed head of the mineral fuels division of the U. S. Geological Survey, is widely known among chemists from the fact that he was in charge of chemical and explosives statistics for the Council of National Defense during the early portion of the war, and later was in charge of statistics of chemicals, fuels and explosives for the General Staff.

Obituary

ROBERT TREAT SPICE, professor emeritus of chemistry at Cooper Union, who died April 8 in his seventy-fourth year at his home in Bloomfield, N. J., had been a teacher in various private and public institutions of New York and Brooklyn for more than forty years.

Chemistry and physics were his specialties. These subjects were taught by him at the Girls' Evening High School, in Court St., Brooklyn, in the late '70s; next at the Brooklyn Polytechnic Institute, and from 1888 to 1900 at the Girls' High School in Brooklyn. While occupying this last position he taught classes in chemistry and astromony in the evenings at Cooper Union. In 1900 he gave up all other work to devote himself day and evening to Cooper Union as professor of chemistry, retaining this post until obliged by failing health to retire in 1914.

THEODORE N. VAIL, head of the American Telephone & Telegraph Co., died April 16, in his seventy-fifth year. Bell invented the telephone, Vail made it a business success. Bell set out to prove and did prove that men could talk over wires, and still the obstinate world continued to poke fun at "Bell's toy." Vail caught and held a vision of this "toy" put to worldwide commercial use. He was the man of vast business capacity in the story of the telephone. He strung the first long-distance line, and the same world that had sneered at Bell called it "Vail's folly." He lived to direct the second largest corporation in the world, with 19,000,000 miles of wire.

Funeral services were held on Sunday, April 18, and at 11 o'clock, Eastern standard time, on that day the service on every Bell telephone throughout the country was suspended for one minute in tribute to the man who was for so many years the master of the organization.

Current Market Reports

The Non-Ferrous Metal Market

New York, April 19, 1920.—Prices of copper, tin, lead and antimony are unchanged. The decline of silver continues, the present quotation being $1.19½ per oz., against $1.26 last week. There has been a general stiffening in the price of scrap metals.

	Cents per Lb
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	11.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	62.25
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	8.70
Zinc, spot, New York	8.80
Zinc, spot, E. St. Louis	8.30

OTHER METALS

Silver	oz.	$1.19½
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f. o. b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	103.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless high brass tubing	30.50

SCRAP METALS

	Cents per Lb. Buying Price
Aluminum, cast scrap	22.50 @24.50
Aluminum, sheet scrap	23.50 @24.50
Copper, heavy machinery comp	15.50 @16.00
Copper, heavy and wire	15.75 @16.00
Copper, light and bottoms	14.25 @14.75
Copper, heavy cut and crucible	16.25 @17.25
Brass, heavy	10.00 @10.25
Brass, light	8.50 @ 9.00
No. 1 clean brass turnings	10.00 @10.25
No. 1 comp. turnings	13.75 @14.25
Lead, tea	5.25 @ 5.40
Lead, heavy	7.00 @ 7.50
Zinc, scrap	4.25 @ 4.50

The Iron and Steel Market

Pittsburgh, Pa., April 16, 1920.

The iron and steel market became stagnant, except for the booking of some contracts for finished products, when the rail strike occurred and rendered a large part of the industry idle. Last Monday most of the blast furnaces tributary to the Connellsville coke region were banked, as is was certain no coke would get through, and day by day more capacity went down, as the byproduct ovens had no stocks of coal to speak of. The territory most affected was the Youngstown district, the Calumet (Chicago and Gary) and the Pittsburgh districts coming next. The East was less affected and the South very little. At this writing the strike seems to be waning rapidly, but it will be several days before there is anything like a free movement of coal and coke. It may be estimated roughly that nearly half the industry loses somewhat more than a week's output.

Such loss is a very serious one from the viewpoint of the moment, but the more natural viewpoint is the one at long range, for the whole problem of the iron and steel trade since the first of the year has been the question of recovery from the acute shortage of material that existed at the end of the old year. When could the industry "catch up"? Up to the time of the rail strike, as indicated in previous reports, production had been proving much larger than had been predicted in many quarters. The market, the one that still exists, was made on the basis of the shortage and the expectations of its being difficult if not impossible to produce enough to relieve the shortage. If production had been proving 10 per cent greater than expected, then the loss of output caused by the rail strike, say 2 per cent of a half year's production, may be compared with that 10 per cent, appearing insignificant by comparison. It may be said, of course, that the rail strike is only one trouble, and that there may be others, but the rail strike was more or less expected. During the steel strike in the late months of last year it was commonly remarked in the trade that just about the time the iron and steel industry got through with its own strike it would probably be crippled by a rail strike, this conforming to the familiar dictum that life is just one thing after another. Iron and steel production really has quite a bright prospect now.

The lethargy that manifested itself in the iron and steel markets upon the appearance of the rail strike was rather greater than would be expected in normal conditions, seeing that no one expected the strike to last any length of time, and the episode rather suggests that the market has a natural tendency to take things easy at this time. If consumers of pig iron and steel products have any particularly sanguine views as to the future, they have no opportunity to profit by making purchases, since it is obvious that prices are already as high as they are likely to go, and there is no incentive to buy except to insure the receipts of supplies. In the case of purchases from independent steel producers a premium over the real market basis has to be paid, for the independents are all asking more than the Steel Corporation or Industrial Board prices, and it has become moderately well established that the market is essentially taking those prices as a basis and other prices as containing delivery premiums above that basis. As to Steel Corporation sales, they continue to be made in greater volume than the shipments, the corporation customers showing no hesitancy.

Steel Corporation Tonnages

The March increase in the Steel Corporation's unfilled obligations was indeed greater than the February increase, the increases having been 389,994 tons in March, 216,640 tons in February and 1,020,075 tons in January. The increase in bookings from February to March was greater than appears in these figures, seeing that shipments in February were about 90 per cent of capacity and shipments in March about 96 per cent, so that there was a greater drain in the latter month on the order books. The March bookings become the more impressive when it is noted that the corporation's sheet and tin plate subsidiary was not selling to any extent, being booked up for the present half year and not having opened its books for regular second half business.

Last Tuesday, as expected, the American Sheet & Tin Plate Co. opened its order books for second half contracts with manufacturing consumers and third quarter contracts with jobbers, prices being those formerly adhered to, as contained in the Industrial Board iron and steel price schedule which became effective March 21, 1919. The pig-iron producers departed upward from that schedule as soon as they got the chance, late last year. Many of the independent producers departed downward from the schedule in April and May of last year, while afterward all independents got above the schedule. The Steel Corporation alone adhered strictly to the schedule right along, making no departures in either direction.

The prices set for sheets and tin plates are: Blue annealed sheets, 10 gage, \$3.55; black sheets, 28 gage, \$4.35; galvanized sheets, 28 gage, \$5.70; tin plates, 100-lb. weight, \$7 per base box. A base box is 31,360 sq.in., tin plate being sold by area, not by weight.

The independent tin plate manufacturers will, in general, adhere to the \$7 price in transacting business with regular customers, but probably more tonnage will be saved to sell on the prompt market, at the premiums expected to rule, than was the case when contracts were made for the present half year.

The independent sheet manufacturers, on the other hand, appear to be paying absolutely no attention to the action of the leading interest. They have all been quoting and receiving prices above the Industrial Board schedule, the prices varying according to time of delivery, and ranging from half a cent to several cents a pound above the Steel Corporation basis. An independent mill could hardly expect to sell its product for the entire second half of the year at a premium, while if all or a large number dropped to the Steel Corporation level the buyers might become suspicious. The present situation exists, and with it the independents can hardly do otherwise than adhere to their prices and sell what they can for such deliveries as the trade will take. Apart from this, there is the awkward fact with many of the independents that they must buy sheet bars and cannot get them except at much above the Industrial Board price of \$42. As high as \$90 has been paid recently, and regular tonnages could hardly be bought for third quarter except at \$60 to \$75. The sheet mill could not absorb such a difference.

Pig Iron

The pig iron market continues stagnant and no appearance is presented of prices tending to depart from the level previously quoted as the market: Bessemer, \$42; basic, \$41.50; foundry, \$42, f.o.b. valley furnaces, freight to Pittsburgh being \$1.40.

Ferro-Alloys

While complete information is lacking, it is a fair guess that production and consumption of ferro-alloys is about equally affected by the rail strike. The market is stagnant and is quotable about as follows: Prompt domestic ferromanganese, \$200@250 delivered; second half, \$180@200; electrolytic ferrosilicon, delivered, \$80 for 50 per cent and \$140 for 75 per cent; bessemer ferrosilicon, f.o.b. furnaces at New Straitsville and Jackson, Ohio, \$59.50 for 10 per cent, \$62.80 for 11 per cent and \$66.10 for 12 per cent.

Chemical and Allied Industrial Markets

New York, April 19, 1920.

The condition of these markets is probably as bad as it has ever been in the history of the trade. Demand on the part of users continues brisk, with no material at hand to dispose of these orders. Spot offerings are all nominal, as nearly all lines are bare and producers are unable to ship any goods in to relieve this condition. The combination of freight embargo and the truckmen's strike has effectually paralyzed any activity during the past week. It is reported that in some cases producers have large quantities of material waiting shipment but owing to the car or steel drum shortage they are unable to move it from their plants. A real shortage of raw materials in some markets is responsible for the present high prices, as demonstrated by listings of the coal-tar intermediates in general, which are practically nominal throughout.

PRINCIPAL PRICE CHANGES

	Today	Last Week	Last Month	Last Year
Formaldehyde	$0.60-$0.80	$0.60-$0.80	$0.90-$1.00	$0.22-$0.22¾
Dimenthylaniline	nominal	0.95-1.50	0.95-1.50	0.55-0.60
Epsom salts	3.60-4.25	3.60-4.25	3.60-3.75	2.25-2.35
Sodium bichromate	0.35-0.40	0.35-0.40	0.35-0.36	0.09-0.10
Turpentine	$2.50	$2.30	$2.20	0.77-0.78

Prices of chemicals in general remain unchanged, as there is very little trading being done at prices that would be a fair indication of the real market quotation. The spot market on some of the more active items is practically bare and whatever offerings are made are at extreme prices. *Alum,* potash lump, came up slightly under heavier demand and at the close of the week was listed at 8@8¾c. per lb. *Aqua ammonia,* 26 degree, drums, is listed at 8½@10¾c. per lb., against 7½@10½c. of last week. This rise has been caused by increased inquiry and a tightening of supplies. *Bleaching powder* remains in the same position, with very little material available. Nominal quotations of $4@$4.25 per cwt. still hold, while prices as high as $5 have been heard for spot material. *Cream of tartar* is firmer at 56@58c. for contract and 59@61c. per lb. for less than car lots. *Sodium bicarbonate* came up to $2.45@$2.60 per cwt., with foreign inquiry heavier than during the previous week. *Sodium nitrite* is back to normal, supplies on hand being fairly heavy; 22@26c. per lb. is now the average selling price on this item. *Glauber's salt* is in very poor condition and there is very little material being offered at $1.50@$1.70 per cwt. and as high as $2 is being asked for spot material.

Coal-Tar Products

The coal-tar products market presents the same general aspect as was previously reported. There have been very few material changes on the list, high water prices being generally sustained by the steady demand and shortage of supplies. *Napthaline crushed* is firmer at 8@9½c. per lb., *flake* holds at 9@10c., while *ball* grade, under considerable pressure, is listed at 10½@11c. per lb. *Phthalic anhydride* remained firm at 65@75c. per lb., with one concern making the price and holding it down to undersell the smaller competitors.

Naval Stores

The naval stores market is practically at a standstill, as there is scarcely any grade of rosin available and no turpentine at all to be had. Nominal quotation of $2.49 per gal. for turpentine has been received, but there is no material changing hands at this or any other price. This is principally due to the fact that no shipments from Savannah can be made because of the shipping strike along the coast.

Vegetable Oils

Activity in vegetable oils has fallen off slightly during the past week. Prices have not been materially affected, the listings in general holding firm at former levels. *Cocoanut oil,* Ceylon grade, is listed at 18½@19c. per lb. and *cottonseed,* crude, is firm at 17½@18c. per lb. while *linseed* is slightly easier than it was last week at $1.84, raw, car lots, $1.77 for raw, tank cars, and $1.87 per gal. for boiled, car lots.

Chicago, April 14, 1920.

A complete absence of spectacular features marks the chemical trade in Chicago for the past several weeks. Firmness characterizes prices in all lines, except in vegetable oils, and their weakness, which has previously been noted, has become accentuated. A decrease in the availability of acids is also noticed which apparently indicates higher prices to come. Alkali products are still at a premium and advances continue to be registered.

One element that contributes largely to shortage of local stocks is that of transportation. There is great scarcity of metal drums in which to pack materials, and tank cars also are in very poor supply. This renders the transfer of chemicals from the plant to the user difficult. Added to that, the current railroad men's strike has complicated matters. Plants whose products are sold up months ahead find themselves with an accumulation of manufactured product which they are unable to ship, and jobbers and consumers, even though fully covered by supply contracts, are unable to get goods. At present the rail strike seems to have spent the greater portion of its strength so far as the Chicago district is concerned.

Heavy Chemicals

With the exception of alkali products this market shows no changes of moment. *Formaldehyde,* while about as scarce as was the case when $1 a pound was being asked, is now going for 61@65c., with the latter figure probably most accurately reflecting the market. All *alcohols* remain in heavy demand at top prices. *Wood alcohol* is now higher than ever before, transactions being noted at $2.80@$3 for 97 per cent. *Ethyl alcohol,* 190 proof, is quoted nominally at $5.35@$5.50, practically none being available, and *denatured* can be purchased at a prevailing price of $1.

Caustic soda is very hard to get. A peculiar feature is that while the price in cars, f.o.b. works, is now 6¼c. on solid and 6½c. on granulated, what spot stocks are available may be purchased at from ⅛c. to ⅜c. lower. The reason is that dealers' stocks have been acquired on contract at considerably lower figures. Needless to say, only small quantities are available. *Soda ash* is daily becoming harder to get, as the plants are all far behind on orders. Current quotation of 3¼@3¾c. should be considered nominal. *Bleach,* suffering from a shortage of containers, is up on market to 4c. per lb. in carloads. Actual transactions in spots have gone as high as 4½c. *Sal soda,* though still scarce, has receded somewhat in price. Current quotations are $1.35 per cwt. from factory, $1.50 per cwt. from Chicago stocks.

Sodium nitrite shows a further return to normal, 25c. per lb. being the ruling quotation. Much interest is being shown in glycerine and a slight increase, to 25c. per lb., for c.p. grade is noted. *Blue vitriol* is also in good demand and has recently advanced ¼c., to 8¼@8½c. Acid stocks are getting low; however, no price changes of importance have occurred. Owing to increased costs, *acetic* is up slightly, 28 per cent commercial being quoted at $4.37½ per cwt. *Nitric* has also advanced a half cent, today's price on 38 deg. being 9½c.

Coal-Tar Products

Shortages of containers and transportation facilities tend to keep supply limited and prices strong. *Benzol,* with demand insistent, is up to 30c. in cars, while *toluol* still holds at the old price of 28c. *Aniline oil* remains at a premium, recently advancing to 36c. per lb. The *salts* are also advanced to 34c. and both oil and salts are very hard to obtain for immediate delivery. *Naphtha* is also scarce, and it is difficult to name definite quotations. Holders of stock are asking 26c. and even higher.

Vegetable Oils

An almost total lack of buying strength has caused further slump in vegetable oils. Supply is plentiful in all lines. *Cocoanut oil* is today being quoted at 16¼c. on the Coast in either tanks or barrels, and in barrels the local price is 17⅜c. *Corn oil,* with no buyers, is offered from stock at 15¼c. and in cars, f.o.b. works, at 14⅝@14⅝c. *Cottonseed oil* shares the general depression, the crude being worth 15⅜c. while prime summer yellow in sellers' tanks is offered at 16½c. No quotation is available on refined, deodorized, in barrels. *Soya bean oil* shows the greatest weakness of the entire list, with Coast quotation in tanks 13½c. and local stocks in barrels finding no takers at 15c.

Flotation Oils—Naval Stores

Entry of the new crop has so far influenced *turpentine* but slightly, ruling price now being $2.40 in bbl., $2.22@$2.25 in cars. It is freely admitted that this price is too high, and a break may be anticipated at any time. This market will probably see two-dollar turps in a short time. Flotation oils do not seem to know where to stop in the price climb; .933 pure steam distilled pine oil is up to $1.85 today and the destructively distilled grade is only 10c. cheaper, at $1.75. *Pine tar oil* and *rosin,* remaining in good demand, show no fluctuation.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	3.50 – 4.00	4.25 – 4.50
Acetic, 56 per cent	cwt.	8.00 – 8.25	8.25 – 8.50
Acetic, glacial, 99½ per cent. (above)	cwt.	12.00 – 14.00	16.50 – 17.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 – .85	1.17 – 1.18
Hydrochloric	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech.	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.04½ – .05	.05½ – .07
Molybdic, C. P.	lb.	–	4.25 – 5.00
Nitric, 40 deg.	lb.	.07 – .07¼	.07½ – .08½
Nitric, 42 deg.	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.44 – .45	.46 – .48
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	–
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	16.00 – 18.00	–
Sulphuric, 60 deg., drums	ton	–	–
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	–
Sulphuric, 66 deg., drums	ton	32.00 – 3.00	–
Sulphuric, 66 deg., carboys	ton	34.00 – 35.00	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P.	lb.	–	1.35 – 1.45
Tannic (tech.)	lb.	–	.60 – .80
Tartaric, crystals	lb.	–	.69 – .74
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.35 – 3.50	–
Alcohol, denatured, 188 proof (nominal)	gal.	–	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	–	.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08½	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01¾ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03¼ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ – .10¼	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15½ – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.10 – .12	–
Ammonium sulphate	lb.	.07 – .08	.08½ –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.10½ – .11
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	–
Barium chloride (nominal)	ton	125.00 – 135.00	170.00 – 180.00
Barium dioxide (peroxide)	lb.	.23 – .27	28 – .30
Barium nitrate	lb.	.17 – .19	20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.85 – .90	–
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	.05 – .06	.05½ – .07
Calcium chloride, fused, lump	ton	22.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01½	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.35 – 5.00
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.		.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.80 – 1.05
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.06 – .07	.08 – .09
Chloroform	lb.	.29 – .30	.31 – .32
Cobalt oxide	lb.	–	2.00 2.05
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.10 – 4.30
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	.14 – .14½	.15 – .18
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	–	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.		1.50
Magnesium carbonate, technical	lb.		.13 – .14½
Magnesium sulphate, U. S. P.	100 lb.	3.40 – 3.55	3.60 – 4.25
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.16 – .17	.17½ –
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	–	.60 – .65
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.36 – .37	.38 – .42
Potassium bitartrate (cream of Tartar)	lb.	.56 – .58	.59 – .61
Potassium bromide, granular	lb.	–	.50 – .65
Potassium carbonate, U. S. P.	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.21 – .25	.28 – .30
Potassium chlorate, crystals	lb.	.15 – .16	.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	$0.65 – $0.95
Potassium prussiate, red	lb.	1.00 – 1.05	1.10 – 1.2
Potassium prussiate, yellow	lb.	.34 – .36	.38 – .41
Potassium sulphate	ton	225.00 – 240.00	–
Rochelle salts (see sodium potas. tartrate)		–	–
Salammoniac (see ammonium chloride)		–	–
Salsoda (see sodium carbonate)		–	–
Salt cake	ton	22.00 – 26.00	–
Silver cyanide (nominal)	oz.		1.25 –
Silver nitrate (nominal)	oz.		.77 – .82½
Soda ash, light	100 lb.	2.75 –	3.50 – 3.60
Soda ash, dense	100 lb.	2.80 – 3.25	3.55 – 3.65
Sodium acetate	lb.	.06 – .07	.07 – .08
Sodium bicarbonate	100 lb.	2.55 – 2.60	2.75 – 3.00
Sodium bichromate	lb.	.33 – .34	.35 – .40
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06½ – .06½	.07 – .17½
Sodium borate (borax)	lb.	.08 – .08½	.09 – .09½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 –	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.14 –	.15 – .16
Sodium hydroxide (caustic soda)	100 lb.	4.50 – 5.50	6.00 – 6.50
Sodium hyposulphite	lb.	–	.03 – .04
Sodium metabisulphite	lb.	.2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.26 – .27	.33 – .35
Sodium peroxide, powdered	lb.	–	.30 – .32
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .27	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.50 – 1.70	1.75 – 2.00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.07 – .07½	.08 – .08½
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 –
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.50 – .60	.65 –
Zinc carbonate, precipitate	lb.	–	.19 – .20
Zinc chloride, gran.	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.11½ – .12½	.13 – .15
Zinc oxide, U. S. P.	lb.	–	.19 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.42 — .48
Anthracine, 80% in drums (100 lb.)	lb.	.90 — 1.00
Benzaldehyde (free)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.25 — 1.35
Benzidine, sulphate	lb.	1.20 — 1.25
Benzoic acid, U. S. P.	lb.	.90 — 1.10
Benzoate of soda, U. S. P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .31
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech.	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .65
Beta naphthol, sublimed	lb.	.70 — .90
Beta naphthol, tech.	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 — .18
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 — 1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 — 1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 — .70
Dichlorbenzol	lb.	.08 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline (nominal)	lb.	—
Dinitrobenzol	lb.	.30 — .37
Dinitrochlorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.34 — .36
Dinitrotoluol	lb.	.40 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine (nominal)	lb.	.55 — .65
H-acid (100 lb.)	lb.	1.90 — 2.00
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.10 — .12
Monoethylaniline	lb.	1.70 — 1.85
Naphthalene, crushed, in bbls. (250 lb.)	lb.	.08 — .09
Naphthalene, flake	lb.	.09 — .10
Naphthalene, balls	lb.	.10 — .11
Naphthionic acid, crude	lb.	.70 — .85
Nitrobenzol	lb.	.14 — .19
Nitronaphthaline	lb.	.41 — .50
Nitrotoluol	lb.	.30 — .36
Orthoamidophenol	lb.	3.75 — 4.25
Orthodichlorbenzol	lb.	.15 — .20
Orthonitrochlorbenzol	lb.	.81 — 1.25
Orthonitrotoluol	lb.	.35 — .40
Orthotoluidine	lb.	.35 — .45
Paraamidophenol, base	lb.	2.50 — 3.50
Paraamidophenol, HCl	lb.	2.50 — 3.25
Parachlorbenzol	lb.	.08 — .12
Paranitraniline	lb.	1.00 — 1.35
Paranitrotoluol	lb.	.45 — .50
Paraphenylenediamine	lb.	3.00 — 3.50
Paratoluidine	lb.	2.00 — 2.50
Phthalic anhydrid	lb.	.65 — .75
Phenol, U. S. P., drums extra (240 lb.)	lb.	.23 — .25
Pyridin	gal.	2.25 — 2.50
Resorcin, technical	lb.	4.25 — 4.50
Resorcin, pure	lb.	6.25 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.50 — .52
Salicylic acid, U. S. P.	lb.	.55 — .60
Toluol	lb.	.90 — 1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal	$0.5 —	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.38 —	$0.39
Beeswax, refined, light	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal) †	lb.	.43 —	.45
Japan	lb.	.19 —	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.11
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11½
Paraffine waxes, refined, 133-135 m.p.	lb.	.12 —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.13½ —	.14
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	.....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.95	—$19.50
Rosin E-I	280 lb.	19.75	— 20.00
Rosin K-N	280 lb.	20.25	— 21.95
Rosin W. G.-W. W.	280 lb.	22.00	— 24.00
Wood rosin, bbl.	280 lb.	15.50	— 18.50
Spirits of turpentine	gal.	.....	— 2.49
Wood turpentine, steam dist.	gal.	2.35	— 2.40
Wood turpentine, dest. dist.	gal.	.....	— 2.00
Pine tar pitch, bbl.	200 lb.	8.40	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 15.00
Retort tar, bbl.	500 lb.	15.00	— 15.50
Rosin oil, first run	gal.	.92	— .95
Rosin oil, second run	gal.	.94	— .97
Rosin oil, third run	gal.	1.10	— 1.15
Rosin oil, fourth run	gal.	1.17	— 1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.32½ —	.33
Plantation—First latex crepe	lb.	.47½ —	.48½
Ribbed smoked sheets	lb.	.47 —	.48
Brown crepe, thin, clean	lb.	.45 —	....
Amber crepe No. 1	lb.	.46 —	.47

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.24¾ —	.25¼
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½ —	.19
Cocoanut oil, Cochin grade, in bbls. (nominal)	lb.	.19½ —	.20
Corn oil, crude, in bbls.	lb.	.17¾ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.18
Cottonseed oil, summer yellow	lb.	.18½ —	.19
Cottonseed oil, winter yellow	lb	.21 —	.23
Linseed oil, raw, car lots	gal	1.84 —	.....
Linseed oil, raw, tank cars	gal.	1.77 —	.....
Linseed oil, boiled, car lots	gal.	1.87 —	.....
Olive oil, commercial	gal.	2.50 —	3.00
Palm, Lagos	lb.	.16 —	.16½
Palm, bright red	lb.	.15¾ —	.17½
Palm, Niger	lb	.15 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½ —	.22
Peanut oil, refined, in bbls.	lb	.27 —	.28
Rapeseed oil, refined in bbls.	gal	1.64 —	1.70
Rapeseed oil, blown, in bbls	gal.	1.64 —	1.68
Soya bean oil (Manchurian), in bbls. N. Y.	lb	.19 —	.23
Soya bean oil, tank cars, f.o.b., Pacific coast	lb	.15½ —	.16

FISH

Winter pressed Menhaden	gal	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal	1.30 —	1.35

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$38.00	—$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	..... —	.....
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal)	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. mines	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. mines	net ton	55.00 —	65.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.08½
Graphite, crucible, 88% carbon content	lb.	..... —	.09
Graphite, crucible, 89% carbon content	lb.	..... —	.09½
Graphite, crucible, 90% carbon content	lb.	..... —	.10
Graphite, crucible, 91% carbon content	lb.	..... —	.10½
Graphite, crucible, 92% carbon content	lb.	..... —	.11
Graphite, crucible, plus 92%	lb.	..... —	.12½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine	nominal lb.	1.45 —	....
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	180.00 —	240.00
Spiegeleisen, 16-20% Mn.	gross ton	60.00 —	65.00
Ferro-molybdenum, per lb of Mo.	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.50

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
*Coke, foundry, f.o.b. ovens	net ton	7.00 —	.....
*Coke, furnace, f.o.b. ovens	net ton	6.00 —	.....
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Government prices.

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets add 30c. per 100 lb. for 25 to 28 gage; 25c for 19 to 24 gage for galvanized corrugated sheets add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM — The Dixie Brass & Fdry. Co., 6th Ave. North, between 12th and 13th Sts., plans to build an addition to its present plant. Estimated cost, $50,000.

California

GLENDALE—The city plans to construct a complete sewer system, including a sewage disposal plant, etc. Bonds for this project will be voted upon. Estimated cost, $500,000. J. C. Sherer, city clk. Olmsted & Gillilen, 1112 Hollingsworth St., engrs.

Colorado

GREELEY—The Industrial Sugar Co. plans to build a beet sugar factory on a site half way between Johnstown and Milliken, southwest of here. Estimated cost, $1,000,000.

Connecticut

BRIDGEPORT—The Bryant Electric Co., 1421 State St., plans to build a 4-story, 50 x 140-ft. manufacturing plant addition on State St. Estimated cost, $125,000.

BRIDGEPORT—The Eastern Malleable Iron Co., Naugatuck, has awarded the contract for the construction of a 1-story, 80 x 180-ft. foundry on South Ave., to the T. J. Pardy Constr. Co., 1484 Seaview Ave. Estimated cost, $45,000.

NEW BRITAIN — Landers, Frary & Clark, Commercial St., have awarded the contract for the construction of a 6-story factory for the manufacture of cutlery and electric specialties, to the Torrington Bldg. Co., 197 Water St., Torrington.

Florida

DELAND—The DeLand Gas Improvement Co. has received bids for the construction of a gas plant, here. A. J. Parkhurt, gen. mgr.

FERNANDINA—The Florida Phosphate Terminal Co. is constructing a building, here. The plant will be able to load several 6,000-ton ships in two days. Drying equipment, etc., will be installed in same. Estimated cost, $500,000. Charles E. Waddell, Asheville, N. C., engr.

Illinois

CHESTERFIELD—The Bd. Educ. will soon award the contract for the construction of a 2-story, 44 x 86-ft. high school. Chemical equipment will be installed in same. Estimated cost, $40,000. Deal & Ginzel, Lincoln, archts.

CHICAGO—The Arabol Mfg. Co., 200 North Jefferson St., has awarded the contract for the construction of a liquid glue plant on 64th Ave. and 16th St., to R. C. Wieboldt. The company is building the first unit of the plant. Estimated cost, $750,000.

CHICAGO—The Englewood Ice & Storage Co. plans to build an artificial ice plant at Wallace and West 69th Sts. Plant will have a daily capacity of 200 tons. Estimated cost, $200,000.

CHICAGO—The Essenkay Products Co., 222 West Superior St., has purchased a site on Wentworth Ave. and 83rd St. and plans to construct a tire filler plant on same. Estimated cost, $200,000.

CHICAGO—The Kosmos Ice Co. plans to construct an artificial ice plant at Halsted and 58th Sts. Plant will nave a daily capacity of 100 tons. Estimated cost, $170,000.

CHICAGO—Paul F. Olsen, archt., will soon award the contract for the construction of a foundry for the Home Stove Wks., 2606 West 18th St.

CHICAGO—The Western Electric Co., Inc., 500 South Clinton St., is building a group of factory buildings at the Hawthorne Wks. Estimated cost, $3,500,000.

Indiana

FORT WAYNE—John H. and Wilson C. Ely, archts., Firemans Trust Bldg., Newark, N. J., will receive bids until April 24 for the construction of a 2-story bulb factory here, for the General Electric Co.

Iowa

ALBIA—The city will soon award the contract for the construction of a sewage disposal plant, etc. C. C. Atchison, city clk.

CEDAR FALLS—The Bd. Educ. will receive bids until May 15 for the furnishing of mechanical equipment for four school buildings. Chemical laboratories will be installed in same. Estimated cost, $1,400,000. Rugh & Zalesky, 601 Security Bldg., engrs.

HAWARDEN—The Independent School Dist. will soon award the contract for the construction of a high school, here. A chemical and physical laboratory will be installed in same. G. L. Lockhart, 391 Endicott Bldg., St. Paul, Minn., archt.

MAYNARD—The Maynard Consolidated School Dist. will receive bids until April 27 for the construction of a 2-story, 96 x 144-ft. consolidated school, here. A chemical laboratory will be installed in same. Estimated cost, $150,000. Netcott & Netcott, 517-519 Black Bldg., Waterloo, archts.

REINBECK—The Bd. Educ. plans to build a 2-story, 110 x 146-ft. high school, here. A chemical laboratory will be installed in same. Estimated cost, $225,000. Netcott & Netcott, 517-519 Black Bldg., Waterloo, archts.

SIOUX CITY—The Purity Biological Laboratories, manufacturers of vaccines and anti-hog cholera serums, 311 Nebraska St., plan to construct laboratories here. The first wing of the proposed plant will cost $150,000. Estimated cost of entire plant, $500,000. W. J. Kennedy, pres.

Louisiana

SHREVEPORT—The city is having plans prepared for altering the filter plant, etc. Chester & Fleming, 1111 Union Bank Bldg., Pittsburgh, Pa., engrs.

Maryland

BALTIMORE — The Natl. Steel Rolling Co., Keyser Bldg., plans to build a plant. Estimated cost, $100,000.

Massachusetts

PITTSFIELD—The General Electric Co., Morningside, plans to build a 1-story, 100 x 400-ft. manufacturing building. Estimated cost, $250,000.

SOUTH ATTLEBORO — The Home Bleach & Dye Wks., Branch St., Pawtucket, has awarded the contract for the construction of a 3-story, 75 x 90-ft. dye house, to J. J. Prindiville Co., 59 Concord St., Framingham. Estimated cost, $60,000.

WOLLASTON (Boston P. O.)—The Howard Chemical Co., c/o E. R. Simpson, archt., 176 Federal St., Boston, will soon award the contract for the construction of a 3-story, 55 x 120-ft. chemical manufacturing plant on Old Colony Ave. Estimated cost, $50,000.

Michigan

MARSHALL—The Flint Fdry. Co. plans to build a 1-story, 70 x 200-ft. and 80 x 118-ft. foundry buildings. Foundry equipment will be installed in same. Estimated cost, $75,000. C. E. Boyd, mgr.

PONTIAC—C. W. Ham, city clk., City Hall, will receive bids until May 17 for the construction of a 10,000,000-gal. filtration plant and a filtered water reservoir, including a wash water tank, coagulating basin, etc.

Minnesota

ELLSWORTH—E. A. Meester, village recdr., will soon award the contract for the construction of sanitary sewers, disposal works, including a disposal tank sludge bed, etc. Estimated cost, $40,000. Druar & Smith, Globe Bldg., St. Paul, engrs. Noted March 17.

HANCOCK—The Bd. Educ. will receive bids until April 28 for the construction of a 2-story, 60 x 110-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $100,000. A. A. Roberts, clk. S. Jacobson, 403 Endicott Bldg., St. Paul, archt.

HIBBING—T. J. Godfrey, clk., will receive bids until April 27 for the construction of a 2-story, 62 x 106-ft. high school on Mesaba St., for the Bd. Educ. A chemical laboratory will be installed in same. Estimated cost, $500,000. W. T. Bray, Torrey Bldg., Duluth, archt. and engr.

KEEWATIN—School Dist. 9, Itasca Co., has awarded the contract for the construction of a 2-story, 160 x 174-ft. high school to J. M. and W. A. Elliott, Exch. Bldg., Minneapolis at $354,715. A complete chemical laboratory will be installed in same.

LAKE BENTON—E. W. Kimball, village recdr., will receive bids until April 26 for the installation of 1 sludge bed, 2 ejectors, and 1 treatment bed, etc. Estimated cost $30,000. Bradley Eng. Serve., St. Cloud, engr.

MOORHEAD—Independent School Dist. 2 received bid for installing laboratory fittings in the proposed school, here, from the Kewaunee Mfg. Co., $9,222.

NASHWAUK—School Dist. 9, Itasca Co., has awarded the contract for the construction of a 2-story, 160 x 174-ft. high school to A. C. Thomas Guthrie Constr. Co., Guardian Life Bldg., St. Paul, at $365,360. Complete laboratory equipment will be installed in same.

New Hampshire

MANCHESTER—The city is having plans prepared for the construction of a practical art high school. A chemical and physical laboratory will be installed in same. Estimated cost, $300,000.

New Jersey

EAST ORANGE—The Simms Magneto Co., 279 Halsey St., has awarded the contract for the construction of a 2-story, 154 x 167-ft. factory on North Arlington Ave., to the Amer. Concrete Steel Co., Essex Bldg., Newark. Estimated cost, $385,000.

EGG HARBOR CITY—The city is having plans prepared for the construction of a sewage disposal plant, etc. Estimated cost, from $40,000 to $50,000. Remington & Vosbury, 6th and Market Sts., Camden, engrs.

HADDONFIELD—The city Borough Hall, will receive bids until May 10 for the construction of a sewage disposal plant with clarification tank and sprinkler filters. Estimated cost, from $45,000 to $50,000. Remington & Vosbury, 6th and Market Sts., Camden, engrs.

WOODBURY HEIGHTS—The city is having plans prepared for the construction of a sewage disposal plant, etc. Estimated cost, from $40,000 to $50,000. Remington & Vosbury, 6th and Market Sts., engrs.

New York

BUFFALO—The Bering Steel Fdry. Co., Morris St., plans to build a 1 and 2-story steel foundry addition to present plant. Estimated cost, $20,000.

BUFFALO—The Standard Oil Co., Atlas Wks., 1103 Elk St., plans to construct a 1-story chilling and pressing building. Estimated cost, $30,000.

NEWARK—The H. A. Inman Co. plans to build a 1-story, 60 x 60-ft. foundry bldg. adjacent to present plant. Estimated cost, from $12,000 to $15,000.

OGDENSBURG — The Cooper's Brass Wks., Inc., plans to purchase the distillery plant of J. P. Wiser & Sons Co., Ltd., Prescott, Ont., and by means of alterations and additions convert same into a brass manufacturing plant. Estimated cost, from $30,000 to $40,000. Address R. J. Donohue.

ROCHESTER—The Eastman Kodak Co., 343 State St., plans to build a 32 x 36 x 14 ft. dry kiln; cost, $5,200, and a 32 x 162 x 31-ft. fabricating plant at Kodak Park; cost, $10,000.

ROCHESTER—The Langslow Fowler Co., 216 Jay St., plans to build a 1-story, 45 x 122-ft. drying kiln on Smith St. Estimated cost, $15,000.

North Carolina

CHERRYVILLE—The city has awarded the contract for the construction of a sewage disposal plant, to Tucker & Laxton, Inc., Charlotte, at $12,662. Noted Feb. 11.

North Dakota

BISMARCK—The city is having plans prepared for the construction of a new water treatment, filter, water softening and chlorine treatment plants. Estimated cost, $225,000. T. R. Atkinson, city engr.

McVILLE—The Town Council will soon award the contract for furnishing a concrete septic tank, etc. Estimated cost $28,000. Atkinson & Hall, Devils Lake, engrs.

Ohio

CLEVELAND—The Bd. Educ., East 6th St. and Rockwell Ave., plans to build a 1-story high school addition on West 93rd St. and Willard Ave. Chemical laboratories will be installed in same. Estimated cost, $350,000. F. G. Hogan, Dir. W. R. McCormack, East 6th St. and Rockwell Ave., archt.

CLEVELAND—The Cuyahoga Fdry. Co., c/o Frank Hronek, archt., 3608 East 131st St., has awarded the contract for the construction of a 1-story, 100 x 210-ft. foundry on East 71st St. and the Belt Line, to Frank Vejsicki, 3492 Washington Park Blvd. Estimated cost, $100,000.

COLUMBUS—The Climax Rubber Co., 21 West Gay St., is having plans prepared for the construction of a 3-story, 200 x 200-ft. tire and tube factory on West Goodale St. Estimated cost, $200,000. W. F. Blair, archt.

EAST LIVERPOOL — The Davidson Porcelain Co. plans to build a porcelain plant.

ELYRIA—The Lakeshore Rubber Co., 734 Natl. City Bldg., Cleveland, is having plans prepared for the construction of a 3-story, 80 x 240-ft. rubber factory along the New York Central R. R. tracks, here. Estimated cost, $125,000. Akron Eng. Co., Akron, archt. and engr.

FREMONT—The Fremont Fdry. Co. has awarded the contract for the construction of a 1-story, 60 x 220-ft. foundry, to the Fort Pitt Bridge Wks., House Bldg., Pittsburg, Pa. Estimated cost, $100,000.

YOUNGSTOWN—The city is having plans prepared for the construction of a 2-story, 60 x 150-ft. municipal hospital. A chemical laboratory will be installed in same. Estimated cost, $250,000. C. F. Owsley, Mahoning Bank Bldg., archt.

YOUNGSTOWN—C. L. Cliff, clk., R. F. D. 3, will receive bids until May 14 for the construction of a 2-story township school on Churchill St., for the Liberty Township School Bd. A chemical laboratory will be installed in same. Miller & Son, 408 Dollar Bank Bldg., archts.

Oklahoma

MANGUM—The Bd. Educ. will soon award the contract for the construction of a 3-story high school. A chemical and physical laboratory will be installed in same. Estimated cost, $130,000. Hawk & Parr, 501 Security Bldg., Oklahoma City, archts.

Pennsylvania

ELKINS PARK — The School Dir. of Cheltenham Township will receive bids until May 3 for the construction of a 4-story, 75 x 225-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $400,000. H. C. Wise, 925 Chestnut St., Philadelphia, archt.

LANCASTER—The City Council plans an election in May to vote upon $825,000 bond issue for various city improvements, including a sewage disposal plant, etc.

PHILADELPHIA — The Luithlen Dye Wks., J. and Estaugh Sts., plan to build a manufacturing plant addition, etc. Chemical equipment for making dyes will be installed in same. W. Steele & Sons Co., 16th and Arch Sts., archts. and engrs.

PHILADELPHIA—The H. A. May Fdry. Co., Eastwick and 61st Sts., will have plans prepared for the construction of foundry buildings on Walnut and 30th Sts. Foundry equipment will be installed in same. Estimated cost, $100,000. Peuckert & Wunder, 310 Chestnut St., archts. and engrs.

PHILADELPHIA—The Orlando Dyeing Co. has awarded the contract for the construction of a 2-story, 95 x 104-ft. factory on Rorer and Schiller Sts., to A. Crompton & Bros., 4614 Oakland St. Chemical equipment for making dyes will be installed in same. Estimated cost, $62,000.

Rhode Island

PAWTUCKET—The Phillips Insulated Wire Co., Freeman St., has awarded the contract for the construction of a 1-story, 45 x 85-ft. manufacturing plant addition on Winthrop Ave., to Willmorth Mackillop Co., Inc., Freeman St. Estimated cost, $15,000.

Texas

McKINNEY—The Sunlite Co. plans to build a 1-story factory for the manufacture of auto lenses, near here. Estimated cost, $150,000. E. R. Brackett, engr.

PORT NECHES—The Magnolia Petroleum Co., 723 23rd St., Galveston, is having plans prepared for the construction of the first unit of an oil refinery, to have a capacity of 50,000 bbl. per day. Estimated cost, $200,000. John Sealy, pres. G. D. Anderson, Beaumont, engr.

Utah

BINGHAM (Bingham Canyon P. O.)—The Utah Consolidated Mining Co. plans to build a mill to concentrate copper ores by flotation with a capacity of 1,000 tons. The company is in the market for flotation machinery. Estimated cost, $75,000.

Vermont

ST. JOHNSBURY — The Cary Maple Sugar Co. has awarded the contract for the construction of a 2- and 4-story, 54 x 200-ft. factory, to the H. P. Cummings Constr. Co., Fidelity Bldg., Portland, Me. Estimated cost, $125,000. Noted Jan. 21.

Virginia

CULPEPER—The town has awarded the contract for the construction of a waterworks system, to Diehl & Vance, archts. and consult. engrs., Virginia Carolina Bldg., Norfolk. Contract for the construction of small filter plant including coagulating basin, etc., will be sublet.

Wisconsin

BURLINGTON—The Burlington Brass Wks. will build a 1-story, 100 x 140-ft. foundry. Work will be done by day labor. Noted March 23.

MILWAUKEE—The Natl. Brake & Electric Co., Belleview Place, is having plans prepared for the construction of a 1-story, 160 x 180-ft. addition to its foundry. Estimated cost, $150,000. H. J. Esser, Camp Bldg., archt. and engr.

ROBERTS—The Bd. Educ. is having plans prepared for the construction of an addition to the high school, here. A small chemical laboratory will probably be installed in same. Estimated cost, $50,000. Alfred H. Wheeler, 410 Globe Bldg., St. Paul, Minn., archt.

SHEBOYGAN FALLS—C. S. Weisse Co., c/o L. A. Weisse, had plans prepared for the construction of a 4-and 6-story, 60 x 250-ft. tannery on Buffalo St. Estimated cost, from $100,000 to $150,000.

VIROQUA—Edward J. Older, city clk., will receive bids until April 29 for the construction of 2 sewage disposal plants consisting of tanks, sprinkling filters, etc.

Ontario

KITCHENER—The Long Tanning Co., Francis St., has awarded the general contract for the construction of a 3-story tannery to Casper Braum, King and Water Sts. Estimated cost, $150,000.

TORONTO—The Canadian Natl. Carbon Co., 265 Adelaide St., W., and the Prest-o-Lite Co., of Canada, Ltd., 120 Elm St., are having plans prepared for the construction of a 2- and 3-story, 80 x 400-ft. and a 2-story, 80 x 400-ft. factory buildings at Hillcrest Park. Equipment for making dry cells, batteries, acetylene, etc., will be installed in same. Estimated cost, $450,000.

TORONTO—The Y.M.C.A., 21 McGill St., and the Dominion Council, 604 Jarvis St., plan to construct a 4-story Y.M.C.A. building. Chlorinating and violet ray equipment for the swimming tank will be installed in same. Estimated cost, $650,000.

Quebec

CHELSEA—The Royal Securities Corp., Ltd., 164 St. James St., Montreal, plans to build a pulp and paper mill on the banks of the Gatineau River, near here. Estimated cost, $1,000,000.

Saskatchewan

SASKATOON—The North Star Oil Refining Co. will soon receive bids for the construction of a refinery. A warehouse and tanks will be constructed in connection with same.

MOOSE JAW—The Western Oil Co., Ltd., will soon receive bids for the construction of a large oil refining plant.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its sixth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN WELDING SOCIETY will hold its annual meeting at the Engineering Societies Building, 33 West 39th St., New York, on Thursday, April 22.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHAMBER OF COMMERCE OF THE U. S. announces that its eighth annual meeting will be held at Atlantic City, April 27 to 29, the subject of which will be "Increased Production."

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK is pleased to announce the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Water Supply and Drainage in Water Cantonments," Wednesday, April 21, at 4 p.m., Prof. D. D. Jackson, administrative head, department of chemical engineering, Columbia University (*Lantern*); "Modern Coke and Gas Manufacture" (Koppers process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E., will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13, 14 and 15.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5 which will be held in Glace Bay.

THE NATIONAL ACADEMY OF SCIENCES will hold a meeting at the Smithsonian Institution and the new museum, Washington, D. C., April 26 to 28, at which there will be discussions and reports on timely subjects of general interest. All scientific sessions will be open to the public.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NATIONAL SAFETY COUNCIL, Engineering Section, will hold its spring conference in the Engineering Societies Building, New York City, on April 27.

THE NEW JERSEY CHEMICAL SOCIETY plans the following: Saturday, April 24, 2:30 p.m., visit to the plant of the Raritan Copper Co., Perth Amboy, N. J.; Monday evening, May 10, regular meeting; Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J., regular meeting and ladies' day.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. KLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, April 28, 1920 *Number* 17

Lessons from the Last A. C. S. Meeting

THE American Chemical Society is big; it has now over 15,000 members. Its meetings are so well attended that the problem of hotel accommodation becomes difficult even in the greatest cities. The same holds true in regard to convenient railway accommodations. The number and variety of papers read are no less than bewildering. At the St. Louis meeting last week there were 266 papers on the program, and if we were to include the additional addresses brought out in the discussions which followed these presentations the number would be materially increased.

Immensity of this sort brings certain inconveniences in its train. The allotment of papers to the various sections is sometimes a difficult matter and the lack of publication of the papers or even of abstracts of them before the meeting makes it hard for a member or visitor to determine which he will hear. Titles are occasionally misleading.

And yet proposals for changes in procedure meet with objections which are at once sincere and worthy of consideration. The thing most needed, in our opinion, is that a short abstract of each paper be printed under its title in the program. Secretary PARSONS says this would be possible provided a hard and fast rule were made to the effect that no paper be admitted unless a digest of not over a certain number of words were forwarded to him by the author before a given date. The provision of exceptions to the rule would make it of no effect because authors, as a general rule, will not abstract their own papers if they can avoid it; and again, authors are seldom good abstractors of their own works. We understand that such a rule exists in the American Institute of Chemical Engineers, but we also understand that even in this comparatively small organization it is the secretary who really does the work. To abstract 266 papers on such a variety of subjects would require a whole congregation rather than one or more Parsons!

The question is raised whether the number of papers is not too great. Many would be better printed than read and in such a form they would be more useful. But at least 75 per cent of those presented will never see the light of print and this is the only chance that anyone but the author will ever get to see them. The mere record of such contributions on the programs is of great value, for it tells by whom research is in progress. We think it would add to the value of the record if the academic or technical occupation of each author were also given as well as his address. If we had our way about it, we should insist on the requirement that every author furnish an abstract of his work presented. In the end it would be of marked value to the contributors.

The unanswerable argument in favor of the large number of papers is also made that it is wholesome to invite chemists to tell of what they are doing. Every effort should be made to encourage this. We have been especially impressed at this meeting with the frank contributions from the laboratories of industrial establishments which are engaged in lively competition. We have not reached full measure in this respect as yet—or anything like it—but the tendency is growing among their scientific men. As mentioned elsewhere, it has been proposed that the general meetings of the Society be restricted to one instead of two each year. Along with this it is suggested that sections in neighboring states have joint meetings one or more times in the interim. The convenience of this is offset by the possibility that such a procedure might make for sectionalism, which is to be avoided at all hazards, and again, especially in regard to industrial chemistry, it is important that those engaged in it get a chance to exchange views with their colleagues from all over the country.

We wish it were possible for a larger number of professors of chemistry to attend these meetings. During a short visit to the dye section on Wednesday morning there were discussed and elucidated the following subjects: The application of certain dyes for photographic sensitizing. This comparatively new subject is pregnant with possibilities. Its great use, of course, has been in army air work, but owing to the much clearer delineation which certain dyes provide, it promises much in the field of astronomy as well. New tests for the purity of intermediates were proposed, the merits of formic acid in the dyeing industry were presented and the reasons why, and an illuminating presentation of the action of synthetic dyes in chemicotherapy was given. We believe that young men should be taught chemistry as a thing of today and alive rather than as a thing to be groaned out of text books and boned over. These meetings emphasize the vitality of the subject.

The sections continue to multiply. The dye section is growing strong, the rubber division is finding itself, the leather chemistry section is started and it deserves to succeed. Leather manufacturers have been singularly backward in furthering the science of tanning—with notable exceptions—and we understand there are still a number of influential old leatherbacks who feel that it is a great mistake to wander away from the regular leather association. Of course there is the danger that they may get some new notions and come back talking about colloid chemistry! In fact, one of the leading leather chemists read a paper at the Colloid Symposium on "Vegetable Tanning as a Colloid Chemical Process." To the good old practical tanner who thanks GOD that he is not a theorist such a title must sound like the hissing of a snake. The division of industrial and engineering chemistry is almost overburdened with variety. The few isolated papers on

metallurgy seem almost lost in the shuffle and it seems fair to question whether the subject of metallurgy is properly within the domain of the Society or not. The successful Symposium on Cellulose Chemistry has led to the proposal that a cellulose section be organized, and we expect to see the plan mature.

The St. Louis meeting was successful.

Extrusion Or Diffusion?

SINCE Messrs. RAWDON and SCOTT have given considerable attention, in their paper on the Microstructure of Iron and Mild Steel at High Temperatures, reprinted on page 787 of this issue, to Dr. HOWE'S ideas regarding the expulsion of excess insoluble constituent to the boundaries of austenite grains, a brief consideration of this theory may be interesting. In his recent book on "The Metallography of Steel and Cast Iron," he cites the various following facts to support his proposed mechanicalized transport of exotics, which might be described as an "elbowing" effect:

First, those constituents appearing as needles in Widmanstättian bands are in that arrangement due to an expulsion to the octahedral cleavages of austenite rather than to an inherent crystallinity of the cementite or ferrite itself. The former is described as being orthorhombic, assuming the form of a rhombohedron, while OSMOND and CARTAUD find sublimed crystals of both α and β iron to be cubic.

Second, excess constituent will be found at the former location of slip bands after annealing overstrained metal.

Third, slag particles are at boundaries because crystals of austenite growing from a mother liquor *push* them away.

Fourth, since slag is posited by "elbowing," its later frequent accompaniment of ferrite (or cementite) borders is caused by a like action.

Fifth, ferrite (or cementite) is *extruded* to the borders of austenite crystals upon cooling through the critical range, thus forming the well-known network shown in microphotographs.

Sixth, excess constituent is by the same action extruded to all exposed surfaces, whether outer skin or inner cavities.

Presumably Dr. HOWE would be quite willing to admit that there is another way to explain the migration of excess constituent, rather than by an elbowing effect; all of these reasons of his, with the exception possibly of the last, might be well explained otherwise. In other words, one alternative hypothesis is that excess constituent migrates to preformed nuclei of the same substance, much as a crystal grows in aqueous solution. The movement of substances through solution (solid or liquid) is matter of diffusion to maintain equilibrium; that is, continual dissolution at one place of low concentration and redeposition in another place at higher concentration rather than a mechanical transportation of the substance *en masse*.

His statement that internal cavities are lined by ferrite in hypo-eutectoid and cementite hyper-eutectoid steels is rather a poser to one who does not accept his idea of elbowing effect. RAWDON and SCOTT'S experiments showing a pronounced decarbonization when heating either grade of steel *in vacuo*, leave one somewhat bewildered by the imposing evidence cited by Dr. HOWE showing migration of cementite to superfices during heating. On the other hand, the proponent of diffusion might ask him to cite some instance where austenite has been able to transport, bodily, a slag inclusion, or some *insoluble* constituent. Certainly the grain boundaries in Figs. 1, 2, 3, 6 and 8 appear to be entirely independent of the black spots, presuming them to represent non-metallic inclusions. If austenite will elbow out cementite or ferrite, as the case may be, it certainly ought to elbow out a particle of sulphide or any other foreign matter that might be there. On the other hand, diffusion is powerless to move an insoluble substance. So that the real test of the problem would be to discover some sample wherein an insoluble constituent has been moved.

Instances of this sort are possibly totally lacking in published literature. Dr. GIOLOTTI remarked that unpublished researches prove to his own satisfaction that slag is not moved after heat treatment. Dr. STEAD has written, in describing some of his experiments on the diffusion of phosphorus, that after long-time annealing he was able to break up all dendritic structure and to equalize phosphorus throughout the metal, but he states explicitly that even then non-metallic inclusions were not changed in location.

The Greater Circulation of Chemists

EVERY spring and fall a thousand or so American chemists, representing the widest range of interests and thought, have shown their professional spirit by setting aside their normal activities for a week and attending the semi-annual meetings of the American Chemical Society. About one-fourth of this thousand have manuscripts, giving the findings of their laboratories, which they are scheduled to talk over hurriedly in a time allowance varying usually but little from ten minutes. It would be superficial to conclude that the motive of the remaining three-fourths in making the journey to the convention city was primarily a desire to listen to the other fourth, especially when it is considered that those of the papers presented that are considered important will soon be published.

It might be thought that papers of insufficient consequence to deserve space in the journals should be barred from taking up the precious minutes of the meeting. This would be consented to without argument, were it not for the fact that many points are brought out in the discussions which prove to have great value and would never have been brought to wide attention if it had not been for the suggestion found in some minor-grade paper. However, it is in this very important aspect that the treatment of papers presented before the American Chemical Society is lamentably weak. Discussions are not fostered by giving counter-opinion time to formulate and be presented. Practically no provision is made for light on the other side in the papers published and it is left to each individual reader to furnish his own salt by way of condiment with what he feeds his brain.

It may be said that to a limited extent, after the sessions close, the congregations in the lobby, halls, dining rooms, take up in their conversation an interchange of opinion on papers just delivered along with all sorts of other topics of interest to chemists. It is this phase of the meeting that has the greatest value

and more than repays for all expenditure of time and money for personal attendance. The acquaintance, the critical opinions, the ideas that everyone gains or should gain from such a congregation of the highest chemical talent is of the greatest value. It is not the attendance of the meeting as a programmed performance that counts, but the greater circulation of chemists in their own channels.

The precedent set by the Harvard Graduate Chemists Association in scheduling a luncheon on the Tuesday of each meeting week was immediately followed by the alumni of Chicago, M.I.T., and Pennsylvania. This will be very beneficial as well as enjoyable. It will give the alumni chemists an opportunity to get acquainted with those who preceeded or followed them in the old labs at their alma mater.

Byproduct Coke Passes Beehive

AMONG the things for which the year 1919, now happily passed into memory if not into happy memory, will be remembered is that in that year the output of byproduct coke in the United States first exceeded the output of beehive coke, the preliminary figures of the United States Geological Survey, just issued, showing production of 25,171,000 net tons of byproduct coke and 19,650,000 tons of beehive coke, making a total of 44,821,000 net tons, the proportions being 56 per cent byproduct and 44 per cent beehive.

In one sense the passing of beehive coke by byproduct coke in 1919 was a lame performance, in that the byproduct output, while exceeding the beehive product of 1919, fell far short of equaling the beehive output in numerous preceding years. The beehive record is 35,364,224 tons produced in 1916. From another viewpoint the performance was particularly creditable, for 1919 was a year of light demand for coke, and byproduct coke showed its stamina by declining only 3 per cent in tonnage from 1918, when beehive production slumped off by 36 per cent.

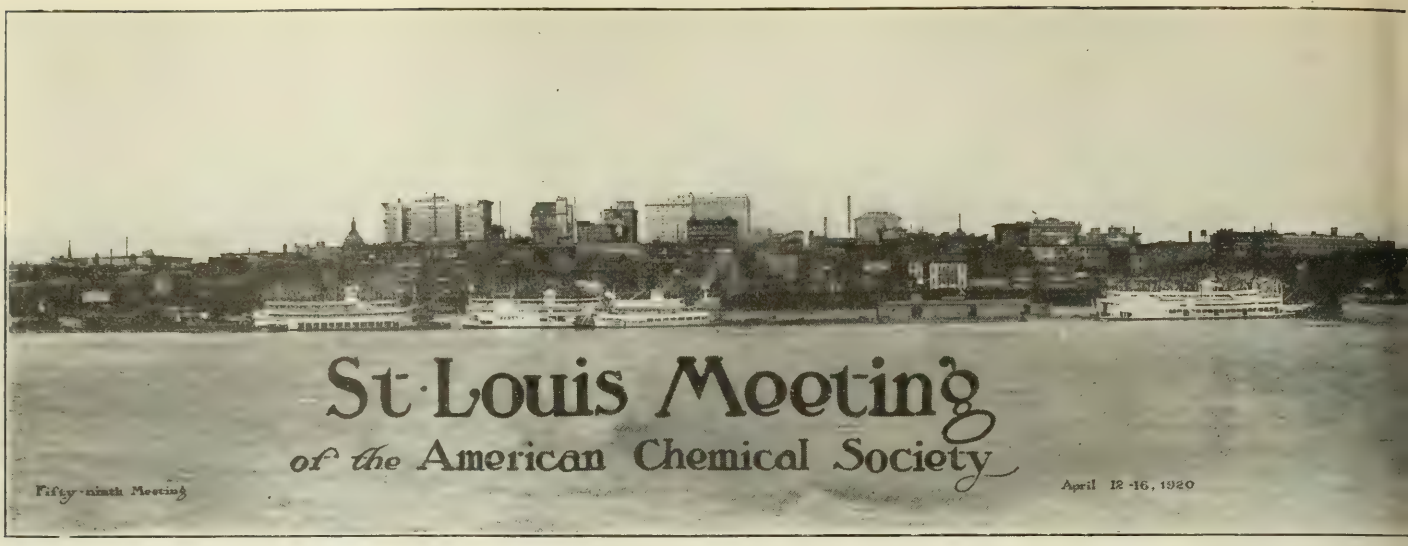
Whether the rise in byproduct coke manufacture in the United States should be considered slow or fast depends on the viewpoint. It has been fast considering that the present capacity is double the capacity of five years ago and more than quadruple the capacity of ten years ago. On the other hand, the merits of the byproduct process were being preached in vain more than a quarter century ago, although the arguments were backed up by some substantial figures drawn from experience abroad.

It is safe to say, at any rate, that byproduct oven building was backward for a time and then was quite in the forefront. This is what would naturally be expected, for the burden of doing the thing rested very largely upon the iron and steel industry, seeing that in smelting its ores that industry consumes 80 per cent or more of the coke produced in the country. Now, the iron and steel industry is one that has grown rapidly in tonnage, requiring constant reinvestment of its profits, and it has also had occasion to make many improvements in methods and appliances, this also requiring much capital. Accordingly the industry has always had occasion to invest more money than it had, and something had to wait. The industry is highly competitive, in that while all may sell at much the same price—the present exception is a good test of the general rule—the concern that lags behind others in making improvements is likely to get lost. Hence when byproduct coke oven building eventually became "the thing" the work was prosecuted rapidly. It was not until 1900 that byproduct coke production crossed the million ton mark, while in 1907 it crossed the five million ton mark. In 1912 more than 10,000,000 tons was produced, while in 1917 more than 20,000,000 tons was made—22,439,280 tons, to be precise. Last year's production, as noted above, was about 25,171,000 tons, and the Geological Survey estimates the capacity, at full rating for each plant, at 39,500,000 tons at the beginning of the present year. Assuming that 85 per cent of rating is a fair expectation of actual output, this makes the real capacity rating at the beginning of this year about 33,600,000 tons. Plants being built should raise this to 36,800,000 tons.

Nearly all the byproduct coke made is used in the iron blast furnace, only limited tonnages going to the foundry and for miscellaneous uses. The blast-furnace requirements may be estimated approximately. The coke furnaces may be taken at about 45,000,000 gross tons of pig iron a year. The coke consumption per ton of pig iron has been reported for a number of years, decreasing to 2,252 pounds per ton in 1915 and then increasing thereafter, chiefly, it appeared, on account of coke turning to poor quality during the war. On account of its regularity, byproduct coke shows somewhat better performance than beehive coke, and 2,200 pounds is a conservative estimate for future performance. This would mean 49,500,000 tons of coke to operate all the coke blast furnaces, and of this the byproduct ovens could furnish, according to the estimate, 36,800,000 tons, or 74 per cent. Considering simply the total coke, and taking blast-furnace consumption as 81 per cent of the total consumption, the entire coke requirements would be 61,000,000 tons, with, say, 37,000,000 tons byproduct and 24,000,000 tons beehive, the proportion being 60 per cent and 40 per cent. This leaves quite a field still for the beehive coke oven, even though there would be a 32 per cent decrease from the 35,464,224-ton record made in 1916.

Cogitations on Colloidal Theories

THE colloid symposium held at the meeting of the American Chemical Society in St. Louis brought forth several statements which give food for contemplation to even those who are uninitiated in the mysteries of the general nature of colloids. It seems that the ideal of the soap chemist is to obtain a bar of water that would stand alone. MARTIN H. FISCHER says that he likes ions, but there are not an awful lot of them around. A discovery by JOHN ARTHUR WILSON that the standard methods of tannin analyses approved by the American and European leather chemists' associations were found to give results which in scientific practice were from 50 to 250 per cent out of the way was as startling as it is true. We expect to hear from makers of various extracts that Mr. WILSON'S conclusions are soused and tanned with error; but against this is the fact that he has put them into practice and they work. With a start like that made by Mr. WILSON it will be a grand thing all around if American tanners in general take a hitch in their belts and go in quest of greater scientific control. Truly the research and application of colloid chemistry is to bear an even greater economic influence on the chemically controlled industries.



Report of the Events of the Convention—Review of a Selection of Addresses, of the General Meetings and Divisions of Industrial Chemists and Chemical Engineers, Sugar, Leather, Dyes, Physical and Inorganic Chemistry

THE fifty-ninth meeting of the American Chemical Society was held in St. Louis, April 12 to 16, inclusive. About 1,000 members attended in spite of the interference brought to transportation by the railway operators' strike. The program contained 266 papers, of which notes from some of the more important are presented in this report. The description of the industrial excursions and the report on the rubber section could not be included in this issue, but will be published later.

The General Meeting

The general meeting of the Society was held at Hotel Statler at 10 o'clock on April 11. The Hon. HENRY W. KIEL, Mayor of St. Louis, made the address of welcome, to which response was made by President NOYES. Dr. ERNEST SOLVAY of Brussels was then elected to honorary membership in the Society and memorial resolutions on the death of Prof. ALFRED WERNER of Zurich, also an honorary member, were presented and adopted. The Hon. E. P. COSTIGAN of the U. S. Tariff Commission was scheduled to speak on "The Chemical Industry and Legislation," but duties at Washington prevented him from attending. In his place PAUL BROWN, editor of *America at Work* of St. Louis, spoke on "The Physical Basis for the Economic Development of the Mississippi Valley."

Mr. Brown proved an able speaker and the only possible conclusion to draw from his remarks is that St. Louis is the navel of the world. He said that the Mississippi River was now under control and that the tendency of future traffic will be from north to south instead of from west to east, on the ground that there is a greater variety of products by longitude than by latitude. The use of the great river is only beginning. He observed that the North has a great lesson to learn from the South in the community spirit in farming which has developed there, while Northern farming has tended to encourage individualism. He noted also that the center of population of the United States, which is but 125 miles from St. Louis, is also the center of the production of raw commodities.

The second general address was by Dr. CHARLES H. HERTY, editor of the Society's *Journal of Industrial and Engineering Chemistry*, on "Victory and Its Responsibilities." Dr. Herty was in great form. He said that five years ago we chemists lamented the fact that we could not get a hearing. Newspapers paid no heed to our warnings or recommendations. Today the chemist has come into his own. Then he told what the Society had done to bring this about, of the development and work of its publicity bureau, commended certain books on popular chemistry that made one of the editors of CHEMICAL & METALLURGICAL ENGINEERING blush, and declared that clippings from newspapers today in regard to chemical news are generally correct and readable.

He referred to five public measures that affect the chemist in his work, some of which are still pending. These were respectively the Longworth, Bacharach, Nolan and Army reorganization bills and prohibition. At the mention of the last measure it seemed as though sympathy with the speaker was beginning to wane, but the only point that he brought out was the improvement of present over former regulations in regard to the choice of denaturants for alcohol. In regard to the Longworth bill, he said he never saw greater consternation than that depicted on the countenances of two leaders in the dye industry in Germany when they read in the Frankfurter *Zeitung* that it had passed the Senate.

The Nolan bill for increasing the facilities and appropriations for the Patent Office passed the Congress with but one dissenting vote. That would have been impossible a few years ago.

The Bacharach bill, which does away with duty-free apparatus for institutions of learning, is another feature of leading importance. If we train our young chemists to use foreign-made apparatus, glassware, porcelain, balances or the like, what chance will American-made apparatus have with them when they start out to work?

Everybody except the highest authorities in the War Department seemed to recognize the value of chemistry in warfare and fortunately, despite opposition, the Congress has seen fit to insist upon its continuation as a separate branch of the service. It is the obligation of

the chemists of America to give this department of the army our loyal and earnest support.

The National Exposition of Chemical Industries has been a great help in putting chemistry upon the map. And the authorized capital of chemical corporations within the past five years is nearly five hundred million dollars, while during the first three months of the current year new companies with capital of over sixty million dollars have been authorized.

Grave Responsibilities of Chemists

In view of these developments, chemists have grave responsibilities. They must be fearless and original. And they must provide for education. This is not a rosy side today. It is too much to ask men to remain as professors unless they can live on their salaries while industry offers so much richer rewards.

And again, if two such institutions as Cornell University and the Massachusetts Institute of Technology offer all the facilities of their staffs and laboratories to the War Department, and the Department, with a war before it, declares it has no need of chemical enlightenment or aid—which happened three years ago—there is something wrong. The error was corrected after expensive delay, but the question arises whether we are not to blame if such misconceptions of chemistry exist in high places. Since the armistice it has been proposed by the War Department itself that we build a $20,000,000 institution and provide for the complete chemistry of warfare by sending West Point graduates there who have had fourteen weeks in chemistry and giving them another year at it! Something wrong there, too. The fact is, Dr. Herty said, we haven't yet taught our people what chemistry means and we must do it. He quoted Prof. Duisberg of the Bayer Co., who said: "They will make a hard treaty for us, and we must accept. You beat us in production in this war, but we will beat you in production in the next war." And he brought out a record of German military plans to send over a dirigible airship 775 ft. long to drop five tons of poison gas on New York on Thanksgiving in 1918.

It was, in fact, a very lively speech.

Council Meeting

The meeting of the Council began at 4 p.m. at the University Club, but in response to the request of about thirty members who were delayed by the railway strike, all transactions were made subject to revision after their arrival at the evening session, which convened at 9:15. Members of the Council who were present were guests of the St. Louis Section at dinner during recess, at which about 100 councilors in all were present. It was resolved to hold the 1921 spring meeting at Rochester and the 1920 fall meeting during the second week in September at Chicago. There exists a tentative understanding between the American Chemical Society and the American Association for the Advancement of Science to hold the fall or winter meeting if possible jointly during convocation week once in four years if this should be possible, but the Chicago Section advised against it on the ground that it would be very difficult to secure proper hotel accommodations for members of both of these great bodies at the same time. It was recommended that the local sections in the neighborhood of Chicago join in a special meeting with Section C of the Association during convocation week (between Christmas and New Years) if such arrangement can be made. The request of the Pittsburgh Section to hold the fall meeting of 1921 in that city was held for consideration.

New sections were established at Denver, Col.; College Point, N. J.; Omaha, Neb., and Savannah, Ga. Mr. A. V. H. Mory of Cincinnati was elected councilor at large to fill the vacancy caused by the election of Dr. W. A. Noyes to the presidency.

It was also voted that nomination blanks sent by the secretary to local sections for nominations for the presidency shall include also blanks for nominations of councilors at large. Also that the Society unite with other associations in the formation of a standard metric system council. Drs. Alsberg, Bancroft and Derrick were re-elected representatives of the Society as members of the National Research Council. A committee of three was appointed to look into the question of preventing platinum thefts. Co-operation with the American Ceramic Society was determined upon. The heads of the divisions of abstracts were requested to co-operate with the British committee in preparing annual reports of the progress of chemistry in their respective branches.

A committee was appointed to look into and propose measures to remedy the present bad condition in institutions of higher learning in regard to the scarcity of instructors of chemistry and the inadequate salaries offered to them.

The question as to whether abstracts of all papers

presented shall be required to be sent to the secretary within a reasonable time before each meeting as a requirement to their inclusion in the program was tabled and a motion to hold meetings annually instead of semi-annually was made a leading subject for discussion and decision at the next meeting of the Council in September.

PASSAGE OF LONGWORTH BILL URGED

The following motion presented by Dr. HERTY was unanimously carried:

> The American Chemical Society, through its representative Council, urges upon our Senators the necessity of prompt passage of the Longworth bill in the form reported by the Senate Finance Committee. Under the absolute protection afforded by the blockade of German ports and encouraged by the favorable legislation of the preceding Congress, the coal-tar chemical industry has grown by leaps and bounds. But to meet the unusual competition threatened from the present unified German industry, far greater safeguards must be established than were formerly considered necessary. The delay in enacting such legislation has caused the withholding of large amounts of capital and the creation of an atmosphere demoralizing to research and to the technical development of the industry. We feel that the fate of this industry lies now with the United States Senate, and we urge the enactment of the bill as originally reported to the Senate by its Finance Committee, convinced that this legislative support will speed the industry's complete development, thereby assuring American consuming interests freedom from outside domination and providing a powerful factor in national defense.

The Smoker

The smoker was held in the great hall of the Liederkranz Club on Tuesday evening. There were about a thousand persons present and the St. Louis Section provided an elaborate musical and dramatic entertainment, an excellent collation and a frothy, sparkling beverage from the great brewery at St. Louis that looked and tasted like beer, but wasn't. As some one said: "It was beer all the way down to the necktie; after that it wasn't." Some good topical songs were provided of which we might quote some verses, but won't!

The Banquet

The banquet was held at Hotel Statler and was largely attended by prominent citizens of St. Louis as well as by members of the Society. A. C. BOYLSTON, plant manager of the Mallinckrodt Works, presided as toastmaster. FRANK CARTER, of the St. Louis bar and president of the Chamber of Commerce, spoke of the growth of chemical industry and emphasized the importance of its position in relation to the development of agriculture as well as other activities in national well-being. Dr. FREDERIC A. HALL, chancellor of Washington University, urged a closer union between neighboring chemical establishments and the research facilities offered by the university over which he presides. He concluded with an appeal to chemists to bear in mind the great responsibilities which are theirs and cautioned them lest they neglect the spiritual aspect of life, which is the business of every man.

Dr. WILLIAM A. NOYES, president of the Society, followed with an outline of the growth of chemistry in America and emphasized the obligations of chemists to the general welfare. Dr. L. V. REDMAN, of Chicago, spoke for his section and offered felicitations to that of St. Louis. Dr. CHARLES L. REESE, chief of the department of research of the du Pont company, made a strong plea for the humanities as a preliminary requirement for the study of chemistry. He also urged better support of the teachers of chemistry on the ground that if we do not see to it that their opportunities and living conditions are improved, chemistry will cease to perform its function in this country. He declared that industry can neither prosper nor even hold its own unless teaching is made attractive to the best type of men.

AMERICAN CHEMICAL SOCIETY IN GENERAL SESSION IN ST. LOUIS

Dr. RALPH H. MCKEE, professor of chemistry at Columbia University, announced that he was born in Missouri and related some illuminating experiences. ELLWOOD HENDRICK, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, after a humorous introduction, replied to the appeal of Chancellor Hall with the suggestion that a broader and more general understanding of chemistry might aid in the development of spiritual life. He pointed out that the popular concept of astronomic magnitudes and of geologic ages had magnified the idea of deity until it ceased to be within the range of human understanding, and that this has destroyed the feeling of nearness and familiarity. It crippled the sense of things unseen by brushing their presence away from the earth. Chemistry, on the other hand, has to do with particles, powers and forces, amazingly minute. The study of it teaches us that the road to infinity leads in both directions; and with this in mind we might better attune our ears to the Still Small Voice amid the Silences. Dr. CHARLES C. CASPARI, chairman of the St. Louis Section, told of his experiences in planning for the meeting and made his acknowledgments to his associates in the work.

A subject that was not mentioned at the banquet but which may as well be recorded here is the debt of the New York members of the Society to HERBERT G. SIDEBOTTOM, of The Barrett Co., secretary of the local section, who provided railway accommodations and generally looked after their comfort and convenience with rare kindness, diligence and efficiency.

Physical and Inorganic Chemistry

PREDICTION OF SOLUBILITY

J. H. HILDEBRAND gave the present status of his work on solubility with corrections on his solute-solvent tables. The great importance of the problem of solubility has been recognized ever since the days when the first alchemists sought a universal solvent. It is true that we have become somewhat less ambitious, or perhaps somewhat wiser, because we realize not only the unlikelihood of success in such a quest, but also the difficulty, which seems not to have occurred to the alchemists, of finding a container in which one could keep a universal solvent. But the chemist still works largely with solutions. His methods of analysis depend almost wholly upon precipitation and resolution and his education consists, to a very large extent, in learning solubilities of substances.

Although this is true, it is also unfortunately true that there are few properties more difficult to predict than solubility. How many chemists are there who would dare to predict which of two newly discovered salts would be more soluble in water or whether the "mustard gas," used during the war, would be miscible in all proportions with gasoline or whether phosphorus would be more soluble in benzine or in chloroform?

Dr. Hildebrand felt many years ago that the scant progress made in the theory of solutions has been due largely to the fact that aqueous solutions, because of their great practical interest, have occupied the attention of chemists to the exclusion of nearly all others, and aqueous solutions are probably the most complicated of all because of the prevalance of dissociation and hydration and because water itself contains several species of molecules. Since it is always important in the development of a theory to proceed from the simplest cases, attention has been focused by the writer principally upon non-aqueous solutions. It is possible to report an amount of progress in this direction sufficient to justify a feeling of confidence that the foundation has been laid for a satisfactory treatment of the theory of solubility.

Most of the investigators of physical chemistry seem to think that osmotic pressure offers the only valid foundation for deriving the various laws having to do with solutions. The writer has chosen rather to proceed from a purely statistical law discovered by Raoult. This law states that, in a liquid mixture of two kinds of molecules, each molecule will have the same tendency to escape into the solid or vapor state that it would have if the liquid were composed entirely of molecules of its own kind. In mixtures obeying this law it is possible to calculate the solubility of either substance in the mixture, whether it be in the gaseous or solid form. We may say qualitatively that the higher the boiling point or critical temperature of a gas the less soluble it will be in any solvent; also that the higher the melting or subliming point of a solid the less soluble it will be in any solvent. Both of these statements follow from the idea that the process of solution consists in liquefaction and the farther the substance is removed from the liquid state the more difficult it is to liquefy it.

Now although physical chemists have been familiar with these principles for a long time, it has not been possible to state in advance what molecules would be sufficiently alike to behave in the ideal manner postulated by Raoult's law. We find that molecules may be very different in chemical composition and still be sufficiently alike to obey Raoult's law. It has, therefore, been necessary to search for properties which would furnish a true measure of the degree of similarity of different kinds of molecules so far as concerns attractive forces between them. This search has been successful and we are able to announce that by the aid of readily accessible data such as densities, boiling points, heats of vaporization, surface tensions, it has been possible to arrange substances according to their "internal pressures" in a table in which the near neighbors are sufficiently alike to obey Raoult's law very closely and hence to show solubilities agreeing with the calculations of solubility made on the basis of Raoult's law. On the other hand, the farther apart in the table the substances considered, the more unlike are their molecules in the sense of the attractive forces existing between them, and the less soluble they are in each other. Thus a substance at the bottom of the table would be less and less soluble as we proceed to solvents higher up. Almost without exception, the solubility data available agree with this generalization, and a number of predictions were made that have since been abundantly verified.

CHEMICALLY ACTIVE NITROGEN AND HYDROGEN

GERALD L. WENDT and A. C. GRUBB reported their success in obtaining chemically active nitrogen in the research laboratory of the University of Chicago. This form is produced by the corona discharge at 20,000 volts from a fine wire through pure nitrogen at atmospheric pressure. Under most favorable circumstances as much as 4 per cent of the nitrogen is transformed into an active form which reacts readily with hydrogen to form ammonia; with oxygen to form oxides; and with lithium, sodium, potassium, magnesium, aluminum, iron and zinc to form nitrides; and

with sulphur to form a sulphide. It is probably different from Strutt's nitrogen, which has been produced at low pressures, in that the latter gave neither ammonia nor oxides of nitrogen. Whether it is atomic or an ozone form has not been determined, but on account of its extreme stability the latter is more probable. It forms very slowly in the discharge and persists for hours afterwards, unlike the ozone forms of oxygen and hydrogen. It has a distinct odor resembling formaldehyde.

From a similar investigation on hydrogen, the authors report that the "ozone form of hydrogen" has now been prepared by the three methods—the action of alpha rays, in the vacuum electrical discharge, and in the corona at atmospheric pressure. Attempts to produce activation by means of Schumann light failed. The ozone hydrogen, or hyzone, is extremely unstable, reverting to the usual inactive form in less than a minute. Figures are given in a detailed study of the formation of ammonia from the hyzone and nitrogen, activated nitrogen and ordinary hydrogen, active nitrogen and hyzone, and mixtures of the two plain gases activated together and reacting in the corona.

Radiation and Chemical Reactivity

Eric K. Rideal described the application of the quantum theory. He stated that the kinetic energy of the molecule must not be neglected nor the relationships evolved by Plank misapplied as by some investigators in the past.

It is now generally recognized that the forces holding the atoms together are electrical in nature and that the angular momentum (Bohr) or the electromagnetic atomic flux (Bernouilli) of the valence electrons are universal constants. By the application of Plank's radiation hypothesis, it is evident that the energy changes associated with changes of state as in the latent heats of transformation or the electrolytic potentials of the elements as well as the heats of combination of elements and compounds, which all necessitate the movement of one or more valence electrons from their original to new orbits, should all be capable of calculations in terms of the various vibration frequencies of the electrons involved and the constant h of Plank's quantum formula.

The latent heat of evaporation of the elements can be calculated from the relationship $L = Nh$. Honda has calculated the latent heat of fusion and Langmuir the approximate values of the electrode potentials from the natural vibration frequencies of the atoms and the electrons, while the heats of formation of a great number of compounds have been calculated in like manner by Haber, McLewis, Bernouilli, Perrin and others.

The problem of reactivity is, however, somewhat different from the relationships discussed above and may be advanced in the form of a question. Will an atom or molecule become reactive when and only when we impart to its valence electron a quantum of energy, the critical energy increment?

Few experiments have been made to test this point. The vaporization of metal electrons (the photo-electric effect), the resonance of the vapors of sodium, iodine, mercury under suitable monochromatic radiation, the photochemical reactions, all indicate, however, the plausibility of the hypothesis.

On the other hand with the assumption of a purely kinetic critical energy increment, the Maxwellian distribution law offers a satisfactory solution to the problems of the rate of physical and chemical action, e.g., the rate of vaporization, the rate of thermionic emission or the rate of chemical reaction. According to Rice both factors are normally operative, but the kinetic contribution is small.

Attempts to accelerate the hydrolysis rate of an ester by infra-red radiation have so far yielded negative results, but calculation indicates that but a small effect is to be anticipated. Attempts have likewise been made to test the radiation hypothesis of reactivity by a study of catalytic action both homogeneous and heterogeneous. It may be assumed either that the catalyst increases the activating absorbable radiation density, suggested by the close relationship between reaction velocity and the specific inductive capacity of the medium, or, as is more probable, that it functions through the formation of an intermediate compound. This presupposes that a molecular species can exist in several possible stages of activation and differs from Baly's force field and C. N. Lewis's polar theory in that these possible stages of activation are associated with energy contents which vary *per saltum* and not continuously, corresponding to spectral lines in a Bohr atom. Thus it appears that oxygen requires activation to different extents for it to combine with activated hydrogen to form water, silicon to form silica, and ozone can possibly be formed in two distinct ways. A catalyst on this view would be easily activated itself and would react with the reactant after it has been activated by radiation which is plentiful in the medium.

It allows the reaction to proceed in the spectral region, which is more intense than that in which the reaction normally takes place; it does not alter the radiation density to suit the reaction but the reaction to suit the radiation density.

In heterogeneous catalysis we may likewise assume either an increase in the absorbable radiation density in the film in contact with the catalyst or, as is more likely, we may postulate the formation of intermediate adsorption compounds of the types suggested by Langmuir, the reactants and catalyst being activated in the usual way. In heterogeneous catalysts we have therefore two factors operative: first, those influencing surface adsorption, such as superficial area, poisons, product adsorption, excess adsorption of one reactant, slow diffusion, and, secondly, activation governed by the rates of supply of radiation of particular frequency. Thus palladium may be regarded as a better hydrogenating catalyst than iron, not because its hypothetical hydride is more labile, or because the density of the radiation which activates hydrogen is denser at the surface of the palladium than iron, but because palladium will react with hydrogen which has been slightly activated, while iron will react only after the hydrogen has received a much larger critical increment.

Hydrated Hydrogen Ions

James Kendall, of Columbia, indicated the trend of his investigation on the ionization of strong electrolytes, especially acids having both free hydrogen and hydrated hydrogen ions. His work is expected to clear up certain points on the irregularity of ion velocity under electric potential as well as give data of value in the study of solubilities and solutions.

Radium-Uranium Ratio

S. C. Lind and L. D. Roberts gave the results of their investigation on the radium-uranium ratio, which

they found to be 3.398×10^{-7}. This is in close agreement with the 1908 value.

Nitrogen Chloride

W. A. Noyes and George H. Coleman reported progress in their work on the formation of nitrogen trichloride. They have obtained a yield of a few milligrams by the use of the traveling arc in a mixture of the two gases.

Ozone and Nitrogen Oxides

F. O. Anderegg spoke on the present progress of his investigations at Purdue University on the formation of ozone and nitrogen oxides from air in the high frequency corona. He pointed out that the lack of important accomplishments in the past was due to the fact that the underlying principles were not worked out and designs were being made from too limited an amount of empirical work. He predicted that much higher yields of ozone will be obtained with low concentrations of the undesirable nitrogen oxides in the near future.

Selenium Oxychloride

Victor Lenher presented a paper on selenium oxychloride, a neglected inorganic solvent. He called attention to the fact that selenium is not a rare element, but is commonly secured from the anode mud in copper refining, by fusing with sodium nitrate and sand. This forms a selenite and tellurite which is further treated with sulphuric acid.

Selenium oxychloride is a liquid whose properties have hitherto been almost wholly neglected. The raw material, selenium, is at present a waste byproduct from the electrolytic refining of copper. From the crude material selenium oxychloride can be produced at a very low figure and by the most simple chemical procedure, the actual procedure being to bring in contact selenium dioxide and selenium tetrachloride in carbon tetrachloride solution.

Its chemical properties are such that it will likely prove a valuable reagent to the chemist. It is an excellent solvent for many of the inorganic oxides which are commonly considered to be very refractory in character. Molybdenum trioxide, for example, can readily be separated from the oxide of tungsten. The solution of molybdenum trioxide in selenium oxychloride shows a deep indigo blue color when exposed to bright light, the solution again becoming colorless when placed in the dark.

The reagent is an excellent solvent for unsaturated organic substances. The unsaturated hydrocarbons and aromatic hydrocarbons dissolve readily in the solvent, while the paraffine hydrocarbons do not. Bakelite, redmanol, the waterproof insoluble casein glue used in airplane construction, pure rubber, vulcanized rubber, asphalt and bitumen dissolve with ease. The bituminous material can be dissolved from soft coal, leaving a carbonaceous residue.

The vegetable oils mix readily with the reagent, while with raw linseed oil a rubber-like mass is formed, quite similar to that produced by the action of chloride of sulphur on certain oils.

The chemical behavior of the reagent is quite selective. Many inorganic oxides are completely insoluble in it, while others dissolve with ease, making possible many separations. Metallic sodium is not acted on by the reagent, even at 175 deg. C., while with metallic potassium a violent explosion takes place.

Study of Plant Distribution and Plant Life

D. P. Wherry, in a study of plant distribution with hydrogen ion indicators, has found that it is a matter of common observation that certain geological formations or certain types of soil are prolific with certain types of plant life. Whether the limitation is due to chemical or physical factors is in dispute, although most writers favor the physical theory, considering the texture of soil, amount of water available for the plants, climate, etc., as all-important. It is noteworthy, however, that few chemical studies have been made by these writers.

The only sound method of treating the subject is on the basis of the ionization theory, and this will be accepted eventually. Thousands of tests with many of the native soils show that plants require a definite hydrogen ion concentration. Plants belonging to the orchid family are particularly sensitive in this respect.

The speaker urged that modern physical-chemical methods be applied in the study; that instead of the p_H method, one be substituted with calculations beginning at the neutral point, and that in addition to the study of native plants, attention be paid to the soil acidity capable of giving the best yield with all of our ordinary crop plants.

Chemical Resources of the St. Louis District

O. H. Pierce, in speaking of the chemical resources of the St. Louis district, defined the position of the chemist as one who changes the raw materials into articles for the use of the people. He pointed out the importance of the two classes of raw materials, namely, the mineral and agricultural products of a district. Of these, by far the more important to the chemist are the mineral resources. J. E. Spurr, editor of *Engineering and Mining Journal*, was quoted as saying that literally and figuratively the people who control the mineral resources own the earth.

The district which was covered included all of Missouri, southern Illinois, western Kentucky and Tennessee, northern Arkansas, eastern Oklahoma and eastern Kansas. A comparison of the resources of the district with those which are considered of high importance to the chemical industries showed that the St. Louis district was very nearly self-supporting. In coal, petroleum, lead and zinc it takes a very leading part; in aluminum ore it is practically the sole contributor. This is also true of various other products of minor importance.

The agricultural products of the district are of three general types: The live stock, which contributes to the leather industry, to edible oils and fats and to glue—the live stock being of chief value; the corn-belt area, which lies to the north, contributing largely to the corn products industries; the district overlapping the cotton-producing areas, to the south, which contributes largely to the prominence of St. Louis in the cottonseed oil and cottonseed cake industries.

Chemical Warfare

Colonel Amos A. Fries, the new director of the Chemical Warfare Service and recently Brigadier General in command of the Chemical Warfare Service in France, delivered an illustrated public lecture on Wed-

nesday evening, April 14. He revealed a condition not even suspected by the general public, and that is that large quantities of poison gas made in the United States are still in storage and show no signs of deterioration. The Government did not know that this gas would be of much value, and had begun to sell quantities of it for industrial purposes. The demand of various manufacturers for these death-dealing gases has been so great that several of them will not be sold for the present for fear of cutting down these reserves.

Phosgene, one of the deadly gases in use early in the war, is now extensively used in the making of several shades of green dyes. It is also employed as a deodorizer, and on account of its effect on oxide of iron it is very valuable for bleaching sand in the making of optical glass. Out of the war gas phosgene has been evolved a means of breaking the German optical glass monopoly. The special value of phosgene as a bleaching agent was first appreciated at the Edgewood Arsenal, where it was seen that the gas had bleached the brickwork almost white.

Considerable quantities of chlorine, made originally to be compounded with other gases for military use, have been disposed of by the Government for industrial purposes, much of it being used in chlorinating the water supplies of cities. Although as yet no industrial use has been found for mustard gas, it is thought that the research along the lines of determining its uses is justified. Considerable quantities are still available.

If the deadly vapors which slay in war can also be made to serve many industrial uses, the Chemical Warfare Service would be made all the more effective.

The Government cannot afford to attempt an organization even one-tenth the size of that which brought the assistance of 1,200 technical men and 700 service assistants, and the co-operation of universities and industries during the war, now that the Chemical Warfare Service is operating on a peace basis. The Chemical Warfare Service must maintain a small research organization. There will be certain lines of investigation that can best be carried out, which no other institution desires to touch. It must have enough trained men to tell at least tentatively whether a new idea, a new substance or a new method can be successfully adapted to chemical warfare. This will involve in large measure a thorough understanding of military problems, military organization and military methods.

The thousand research men who are working throughout the United States to every one that the Chemical Warfare Service can maintain will certainly bring forth 75 to 90 per cent of all new ideas, materials and methods for use in chemical warfare. It is hoped that such knowledge and such touch with the various chemical industries may be kept and that we can count on this one and that one to produce within a given number of days, on the outbreak of war, a given quantity of gases. The Edgewood plant should be capable for at least five years, with moderate upkeep, of being put into large-scale production on short notice.

Industrial Chemistry Division

Effect of Impurities on the Metallurgy of Tungsten

Clarence W. Balke, in speaking of the effect of impurities on the metallurgy of tungsten, divided the impurities into two groups, the first being those metals which were reduced in tungsten powder in the hydrogen furnace. These included gold, platinum, iron, calcium, nickel, etc. The second group consisted of the oxides which are not reduced, such as arsenic, sodium, caesium, magnesium, lanthanum and thorium. He found that iron cobalt and nickel produced exaggerated growths when carried over into the sintering furnace, causing the bars to crack when placed in the swaging machine. Sodium and other metals cause a shrinkage of 0.04 per cent and retard the formation of the proper grain structure in the first group. Conclusions from his investigation have shown that any impurity in the process is detrimental to the proper working of tungsten metal.

Carbonization of Missouri Cannel Coals

An investigation on the carbonization of Missouri cannel coals by H. L. Dunlap and K. K. Kershner was described in detail. Five different cannel coals were subjected to destructive distillation in a gas-fired horizontal retort and the results compared with a bituminous coal coked under the same conditions. Both the oils and gases collected at different stages of the carbonization were examined.

The oils from cannel coals have a low specific gravity and consist chiefly of paraffine hydrocarbons. These oils resemble the oils obtained by low-temperature carbonization of bituminous coals. Cannel coals yield a larger quantity of gas than bituminous and this gas has a high calorific and illuminating value. Only two of the coals examined gave a coke of any commercial value. Cannel coal might be of value to mix with bituminous coals for gas production because of the high illuminating value.

Specifications for Chemical Reagents

W. D. Collins opened up an interesting discussion on problems and specifications for reagent chemicals. The chemist does not specify definite properties for the chemicals he purchases on the market. Some progress has been made on getting up a set of specifications for the chemist similar to that issued in the U. S. Pharmacopœia. The following suggestions were offered for discussion:

The American Chemical Society should establish and publish specifications consistent with good manufacturing practice. Methods of determining strength should be fully prescribed. Only impurities likely to be present should be considered. A blank test should be prescribed and the specifications should obtain no provisions for penalties, but should be left to individual dealings.

Extracting Furfural From Corncobs

H. L. Dunlap and K. K. Fischlowitz presented the results of experiments on extracting furfural from corncobs. Although furfural has hitherto been known as a comparatively rare organic chemical, a number of uses for it are already known, and the field for future developments seems very promising. The series of dyes may be produced by inter-action with various coal-tar derivatives; hard resins similar to the well-known bakelite; and also soluble resins which may find application in the varnish and lacquer trade. Furfural, although not as efficient as formaldehyde, has antiseptic and deodorizing qualities and has also found use as an insecticide. It is a yellow aromatic oil of high boiling point, 162 deg. C., and has an odor closely resembling

benzaldehyde. It may be extracted by treating sulphuric solution of corncob pulp with live steam in an Elyria enameled kettle and subsequent extraction with benzine. Theoretically about 10 to 11 per cent by weight of furfural may be extracted from the corncob pulp, but results so far obtained give a commercial extraction of 4½ per cent.

Standardization of Laboratory Apparatus and Instruments

Thomas B. Freas, in speaking on the standardization of laboratory apparatus and instruments in respect to quality, shape, size and packing, showed the need of the manufacturer for having standard sizes of laboratory apparatus so that he might produce on a quantity basis. He showed how in Columbia University 50 per cent increase in laboratory efficiency was accomplished by standardizing the apparatus used. He further proposed that a standard office be organized and supported by the American Chemical Society.

Crystal Growth in Bearing Metals

Edward J. Mahin, of Purdue University, spoke on the crystal growth in bearing metals and inclusions and ferrite crystallization in steel, together with the solubility of inclusions. Bearing metals are essentially a conglomerate of hard crystals in a soft matrix. Heat treatment does not change the structure where inclusions are encountered. Numerous metallographic slides were presented showing the migration of phosphides when metal plugs of the non-ferrous metals as well as the ferrous metals are inserted in holes drilled in a steel plate and subjected to heat treatment. The introduction of a third element has some effect on the solubility of ferrite in austenite.

Apparatus for Recovering Iodine From Kelp

Merle Randall described an installation of apparatus which is being put into operation at the Government kelp plant on the Pacific Coast for the recovery of iodine from kelp leach liquors. Iodine and decolorizing carbon will be produced.

Selenium and Tellurium

Victor Lenher, in a paper on "Selenium and Tellurium," showed that the supply of these elements was not so rare, as over 300,000 lb. of selenium and 125,000 lb. of tellurium are produced annually. The complete results of his experiments with these two metals will be produced in a later issue of Chemical & Metallurgical Engineering.

Incentive to Research

William J. Hale of the Dow Chemical Co. described a plan by which industrial concerns could offer more incentive for research in pure and applied chemistry among the graduate school men in the American universities at large and especially among the younger members of the faculties. He stated that he was convinced that large donations are available for the asking, which could be used in rewarding those men financially whose published papers were judged to be worthy of national recognition. Titles such as assistant director of research should be given by the universities to those men who have received such rewards repeatedly and thus proved their ability. Dr. Hale thought that from $500 to $1,000 should constitute the ordinary reward, which, added to the salary of an instructor, would tend to make it more sufficient, as well as make him more efficient.

Economic Status of the Chemist

A. M. Comey of the du Pont company reported the findings of the investigation on the salaries paid to chemists based on the number of years since they completed their college training. He showed that, on a total average, salaries were rapidly advanced and were not as low as has been currently believed. A motion was made to recommend to the Council that a canvass be made by sending a questionnaire to all the members of the society to determine both salaries and grades of chemical work being done.

Specific Heat of Petroleum at Different Temperatures

F. W. Bushong presented a lecture with curves showing the "Specific Heat of Petroleum at Different Temperatures," and concluded that specific heat is proportional to or a function of the absolute temperature, including the paraffines. Curves compared the work of Nernst, the Bureau of Mines, Schiff and Mayberry with the work done in the research laboratory at Kansas University.

Filter Presses

D. R. Sperry presented an instructive and interesting paper on the application of the filter press to problems in chemical industry. The filter press is a press only in that plates are held together by the action of a hand screw and is not used to squeeze the solution from the slurry. It is used to separate solids from liquids and to lixiviate the residue by a washing process. Simple washing occurs subsequent to the filtering operation, in which case the recesses containing the cakes are not completely filled before the washing. Thorough washing is in operation where the wash water is introduced behind the filter cloth.

Chemical Corrosion

D. P. Shaw gave a new method for determining chemical corrosion. The loss of weight is not taken into consideration, but rather the equivalent depth of penetration of the corroding agents in the metal over unit periods of a month's time. Corrosion depends upon the shape of the piece, the volume of the solution, the temperature, the time of exposure and the methods of cleaning test pieces. Of these the concentration and temperature are the most important features and time also has an appreciable effect in the fact that an exposure under twenty-four hours does not give reliable results. Tests should be carried on for at least forty-eight to ninety-six hours. He concluded that this was a very important subject on which little work had been done and that the three most important factors are fusion coefficient, velocity of corroding solution and the ionization coefficient.

A New Type of Catalyzer

W. D. Richardson presented a paper on a new type of catalyzer for the hydrogenation of oils and other purposes. This paper is published in full on page 793 of this issue.

Specific Heat of Heavy Mineral Oils

Herbert Bailey and C. B. Edwards presented the results of investigation on the determination of the specific heat of heavy mineral oils and described the practical application of oil for transmitting heat in chemical plants. The apparatus used was a thermos bottle equipped with a stirring arrangement and into which a nichrome coil was introduced with leads attached to a pyrometer on the outside. The results were plotted with specific heat against temperature ranges.

Potash and Reconstruction

J. W. Turrentine spoke on "Potash and Reconstruction." Upon the signing of the armistice most of the potash plants in America put out their fires, because it was thought that immediately Germany would flood the American market with all that potash which she had not exported during the period of the embargo and which in the imagination of the American producer was being piled up in Germany. Unfortunately for the American producer, this was a false alarm. Germany during the war period was not engaged in the production of anything that she didn't have immediate need for.

Now in Europe the potash monopoly, formerly entirely in the hands of Germany, is divided between the Germans and the French, the French having acquired very important and valuable potash mines which were situated in Alsace. The world hoped from this division to obtain potash under competitive conditions and at reduced cost, but one hears more of mutual understanding between these two interests to establish prices than prices being reduced through competition.

However, there is one very important difference between the present situation and that which existed before the war, and that is that where before the war the Germans sold potash to the American farmer at 60c. per unit weight delivered in New York, he is now charging his own farmer $2 a unit weight, delivered at German points. It is hard to see what chance, therefore, the American farmer has of getting potash cheaper than the German farmer. Therefore, the American finds himself between two difficulties, an exorbitant price for foreign potash and an American potash industry largely shot to pieces through lack of informed and concerted opinion.

The Summerland, Cal., Kelp Experimental Plant

He further described in a subsequent paper the experimental plant at Summerland, Cal.. which was founded for the purpose of ascertaining if any American potash industry could be based on the giant seaweed as the raw material. To date about thirty products, byproducts and derivatives have been established as obtainable from kelp when processed in the manner in vogue there. Some of these have commercial value and some have little or none. Among the products are such materials as potash and various salts of potash, table salt, crystalline iodine and various salts of iodine, ammonia in various forms, bleaching carbons of various grades, oils of different characteristics and degrees of usefulness, creosote and disinfectants and other derivatives prepared from it, pitch, prussian blue, and combustible gas; and of these potash salts, iodine, bleaching carbons, ammonia, oils and combustible gas are obtainable profitably. However, to date only potash, iodine and bleaching carbons have been put on a commercial basis and soon are to be produced on a large scale as a part of the daily operation of the plant.

Thus, three products, potash, iodine and bleaching carbon, for which America has been dependent on foreign countries, are now being produced from kelp. This dependence will be entirely wiped out with respect to iodine and bleaching carbon, and certainly at least impaired with respect to potash.

A considerable number of papers were read by title only and will appear later in the publications of the American Chemical Society.

Sugar Division

S. J. Osborn of the Great Western Sugar Co. opened the first meeting of the sugar section by showing how vital chemical control was to the beet sugar industry. He claimed that, as a matter of fact, the sugar industry leads all others in chemical control. All the operations, from those of the beet grower on down through the extraction plant and refinery, are watched for even the smallest fractions in variations of sugar percentages.

Testing and Using Saccharimeters

C. A. Browne spoke at length on testing and using saccharimeters. He announced that the first instrument to be made in America had recently been turned out at Rochester and it was hoped that during the coming year one hundred instruments would be manufactured.

Refining Sugar Juices Mechanically

F. W. Zerban gave an excellent account of some recent work in refining sugar juices by mechanical means. As is well known, such active chemicals as sulphur dioxide, lime, and acid phosphates contribute certain disadvantages as well as benefits in their use in sugar refining. Mr. Zerban used quite large amounts of Filter-Cel mixed with an imported Dutch bleaching carbon called noirit, which mechanically removed the juice impurities. The molasses obtained resembled a cane sirup and should sell at a high premium. The process was too new to derive figures as to its exact economic status, but there can be no doubt as to its feasibility.

Dye Section

Charles L. Reese, chairman of the Dye Section, in opening the proceedings of that section, said that the American dye industry gave great promise of success and its progress would be largely dependent upon favorable legislation.

The commercial aspect of the dye business is obviously of first importance; unless the industry is managed well, as a commercial enterprise, it cannot succeed even with the best technical staff and equipment. The past twelve months have not been characterized by the same rapid flow of capital to new ventures in chemical commerce, but that is a healthy rather than an unhealthy symptom, because there was a tendency to rashness evident in much of the promotion entered into just before and after the close of hostilities. The significant feature is that much has been done to put the industry on a sound basis and to safeguard the investment already made. There has been, however, considerable reluctance on the part of those in charge of the finances of the industry to make additional investments when the money was needed for the proper development of projects already under way, on account of the lack of accomplished legislation to protect this young key industry.

Encouraging Results Obtained in the Dye Industry

The dye industry is yet too young to have proved itself worthy of the confidence of those who have shown their belief in it by giving it financial support, but the recent developments have tended to show that the confidence was warranted. The technical development has been very apparent to those in close touch with the details of the industry. Yields have been pushed up with a resultant saving of material. The quality of intermediates and finished products has been very markedly improved and in addition it has been possible to increase the diversity of colors manufactured.

This is all very gratifying, but to me the most significant thing about it is not material, but rather mental—it is a measure of the rapid growth of knowledge among our technically trained men and shows, I take it, that they are entirely capable of developing that profound specialized knowledge of applied organic chemistry which is an essential of a successful dye industry.

Improvements in the Equipment of the Dye Industry

There is another pleasing feature of recent progress; designers of chemical equipment have shown that there is still much that can be done to improve the mechanics of the dye industry. They have not been content to reproduce foreign designs, they have struck out for themselves, and have already made some revolutionary improvements. This I consider very important because it shows that this industry is a fertile field for American ingenuity, and that we can expect to make very important economies in characteristically American ways.

Need of Educating the Laborers for the Kind of Work They Have to Perform

Besides the technical man there is another worker in the plant upon whom a great deal depends; he is the wage earner. Even the simplest operations about a dye plant are important and may make or mar a product. The use of a metal instead of a wooden shovel, or similar careless handling in any little particular may mean ruin to valuable material. Until the laborer learns the meaning of this there will be unnecessary trouble. I think that some effort should be made to educate the right kind of men by giving them elementary courses in chemistry, or at least by seeking to give them some understanding of their duties, so that they may learn to do them in something more than a mechanical way.

The German employers gave great attention to provision of everything possible to make their labor permanent and content; free hospitals, reading rooms, swimming pools, special classes in cooking for the girls, kindergartens for the children, all these and many other advantages were provided. I think that this is a feature of the German industry which we shall find it necessary to adopt, though in a modified form, which will suit our special conditions.

Progress of Industry Dependent on Legislation

Legislation of the utmost importance to the industry is under consideration. It is quite clear that the young industry must have protection—that is agreed to by nearly everyone—but the means of attaining the end has been the subject of much debate. It seems certain that adequate protection will be forthcoming and that a law will be enacted which will insure a far more satisfactory tariff than has ever before been in effect, one which has been formulated with the constant advice of experts.

In addition we may hope for an embargo for the next three years. It is a pity that action has been delayed so long. Even though the delay may have been justified, yet it has acted as a powerful deterrent to the erection of plants necessary for the proper expansion of the industry.

German Dye Patents

Samuel A. Tucker dealt with the classification of the 671 German dye patents owned by the Chemical Foundation which forms the largest division of any class of enemy-owned United States patents taken over by it, and covers practically all classes of dyes. The method of classification followed enables one to locate any patent either by the chemical constitution of the dye or its application. Many of the 134 patents actually licensed either by the Chemical Foundation or the Federal Trade Commission were discussed at considerable length.

A list of patents of which the Schultz number was known but which had not yet been licensed was given. The advantages in the form of license as issued by the Chemical Foundation were pointed out and the influence which the company may have on the American chemical industry was discussed.

Leather Chemistry Section

The first meeting of the Leather Section of the American Chemical Society was opened by the chairman, Dr. Louis E. Levi, with a graphic description of chemical work in the tannery. He described the difficulty with which the chemist entered the tannery twenty-five years ago as compared to the ease with which he now works in the chemical control of this industry at the present time. In these days of mineral tannage the chemist must control the tanning liquors as well as all chemicals which are bought by the purchasing agent. As the tanning of today is yet in its infancy, the research chemist has a load of precious tanning methods to uncover and operate for the great material benefit of his employer and himself.

The True Tanning Value of Vegetable Tanning Material

John Arthur Wilson and Erwin J. Kern read a paper on "The True Tanning Value of Vegetable Tanning Material," and described a new method of analysis for determining the tannin content of these materials in contrast to the present methods of the American Leather Chemists Association, which was revolutionary in the extreme. The American Leather Chemists Association method varies from 43 per cent to 198 per cent in error as compared with the new method.

The new method requires more time, but gives greater accuracy and uniform results. The hide powder used in this method is not chromed. The moisture content of the hide powder has no effect, and the analysis may be easily and effectively accomplished.

The discussion on this paper brought out the fact that the actual yield of tannin in leather when analyzed closely checks the result of the analyses.

The chemical action of tanning was defined as the formation of chemical combinations by the reaction of the proteids in the hide with acid, salt, and even bases.

The Currying of Leather for Belting

Edward E. Marbaker delivered a paper on "The Currying of Leather for Belting." The tanning of steer hides produces the heavy leather from which belting is made. The leather, as it leaves the tannery, is not suitable for belting, because it is hard, harsh and more or less cracky. It must be thoroughly scoured to free it from dirt and excess tanning extracts and loading materials when such are present. The next step is to "set out" the butt, a process which flattens out the irregularities of the surface, such as wrinkles. Subsequently greases and oils are introduced into the leather, and the final product is pliable, smooth to the touch so far as the grain is concerned, and very much stronger than the original "rough" leather. It is in this form that it is used for belting, and the process of cleansing or greasing or "stuffing" is known as "currying."

Leather for belting is tanned in the form of butts, which are hides with the heads, bellies and flanks removed. The finished butt is from 70 to 80 in. long, from 48 to 54 in. wide, and weighs from 20 to 30 lb. This may be handled whole, but usually it is cut into a center and two side pieces, these varying in width according to the kind of belting for which the leather is to be used. The scouring process is then carried out on these three pieces separately. It is purely mechanical and is carried out on machines which give a very efficient scrubbing.

The scoured leather may or may not be dried out before "stuffing," according to the process which is used. There are three general methods of stuffing: (1) the cold hand process; (2) the hot hand process; (3) dipping.

Other Papers

Other papers presented in this section were as follows:

John Arthur Wilson and Edwin A. Gallun, "The Neutral Salt Effect and Its Bearing Upon Leather Manufacture."

Erwin J. Kern, "The Determination of Sulphate in Sulphonated Oils."

Arthur W. Thomas, "A New Method for the Determination of Sulphuric Acid in Leather."

Arthur W. Thomas and M. J. Kelly, "Time Factor in the Absorption of the Constituents of Chromic Sulphate Solutions by Hide Substance."

Arthur W. Thomas and S. B. Foster, "The Conductivity Titration of Chrome Liquors."

I. Newton Kugelmass, "Physico-Colloidal Interpretations of the Tanning and Tawing Procedures."

Colloid Symposium

Under the joint chairmanship of Profs. W. D. Harkins of Chicago University and Harry N. Holmes of Oberlin College, the most important technical event of the meeting was held in the great ballroom of the Hotel Statler on Thursday morning. The various divisions of the Society suspended their activities in order that all the members might attend this symposium. There was standing room only, and most of that was occupied.

The paper by Jerome Alexander on some practical aspects of colloid chemistry was read by the chairman.

What promises to be one of the most far-reaching advances made under the stress of the recent war, when necessity literally was the mother of invention, is the discovery that by means of a suitable fixation or peptizing agent and suitable treatment very large percentages of sheet tars and finely powdered coal may be dispersed in fuel oil with a sufficient degree of permanence to enable the mixture to be stored, piped, atomized and burned practically like fuel oil itself.

Since it will at one stroke relieve the drain on the earth's rapidly diminishing stores of petroleum, as well as lead to the efficient utilization of all kinds of coal waste, such as culm, screenings, and dust, inferior fuels, such as peat and lignite, and even cellulose waste, such as slabs and sawdust, this new composite fuel may be hailed as a powerful factor in the conservation of our natural resources and as a lasting benefit to mankind.

Realizing the vital importance of the Allied oil supply in the conduct of naval, military and manufacturing operations, the German submarine bent every effort to destroy tankers. Marshal Foch is said to have cabled America, "If you don't keep up your petroleum service we shall lose the war." While the Allied navies were dealing with this peril in a most decisive fashion Lindon W. Bates, of New York, head of the Engineering Committee of the Submarine Defense Association, with the assistance of Dr. F. E. Shepperd and other chemists of the Eastman Kodak Co., courteously opened to him, developed a colloidal fuel which, by practically doubling the usefulness of every oil cargo would, of itself, have materially assisted the defeat of the Hun's efforts.

Coal or other combustible solid is prepared for dispersion by being pulverized so that about 95 per cent passes through a sieve which has one hundred meshes to the inch. This means, of course, that by far the greatest weight is in particles hundreds and thousands of times larger than colloidal dimension.

Wilder D. Bancroft followed with an appeal for more light on the nature of gelatinous precipitates. He asked why ferric-hydroxide plus a certain amount of water gave a gelatinous precipitate. Is it ferric-oxide and water? This is probably the true condition of precipitate, because when water vapor comes off continuously from the compound it finally goes over to ferric-oxide upon standing. A distinction should be made between gelatinous and colloidal precipitates.

Colloid Chemistry of Soaps and Proteins

Martin H. Fischer presented an exhaustive paper on the "Colloid Chemistry of Soaps and Proteins," illustrated by charts and many samples of colloidal soap mixtures.

On the assumption that the polymerized amino-acids which we call proteins react with bases of various sorts to form salts in the same fashion in which fatty acids unite with bases of various sorts to form soaps, the colloid behavior of the former is accounted for.

The hydration capacity of the soaps varies with the basic radical, and, in general, in the order: NH_4, K, Na, Li, Mg, Ca, Fe, Cu, Hg. It varies also with the type of fatty acid, that standing lowest in any homologous series being least hydratable. When different series are compared, the less saturated possess the lower hydration capacity.

Colloid soap jellies may be prepared from the various soaps and anhydrous solvents, like monatomic, diatomic, and triatomic alcohols, aldehydes, benzene, toluene, etc. This finding speaks against the too heavy emphasis now being placed upon purely electrical notions of stabilization in colloid systems.

Hydrophilic or lyophilic colloids are defined as dispersions coarser than molecular, of one material in a second, with the dispersed substance a solvent for the dispersion medium.

Liquid soaps may be "coagulated" by alkalis and neutral salts of various kinds even when chemical reaction between soap and added substances is impossible. The consecutive changes of setting, secondary liquefaction with progressive dehydration of the soap, and its separation in "coagulated" form are explained on the basis of union between added salt and water with production of an emulsion of salt water in soap succeeded by one of soap in salt water and ending in anhydrous soap floating upon salt water.

Chemically neutral soaps do not affect an indicator like phenolphthalein in concentrated solution. On diluting with water they turn it bright red. This means either (1) that water-in-colloid system (analogous to normal cells and body fluids) cannot be properly analyzed by indicator methods but only colloid-in-water systems (analogous to the secretions from the body), or (2) that the former contain no ions.

From qualitative and quantitative analogy in colloid behavior between soaps and protoplasm the latter is held, in essence, to be a salt compound of various polymerized amino-acids with potassium, sodium, magnesium, calcium, etc., which materials have "dissolved" a certain amount of water. Introduction of acid, ammonia, or potassium into this compound represents poisoning by these materials at one end of such a soap-like series (as evidenced by increased hydration capacity and increased solubility in water); introduction of the heavy metals poisoning at the other end (as evidenced by a decreased hydration capacity and the production of difficultly soluble compounds). Just as a soap anywhere in the series can, by appropriate means, be converted into any other, just so can a normal protein or living cell be "poisoned" through the addition of materials found at either extreme in the base series; or after such poisoning be changed to nearer the normal by addition of the bases in the middle series.

Considerable discussion followed this paper in which G. H. A. CLOWES delivered a very instructive little homily on the "Chemistry of Living Substances," followed with a description by H. N. HOLMES and an exhibition of a 10 per cent dispersion of calcium stearate with machine oil and water to form a gel. If the mixture is allowed to set and cool it forms a gel, but if stirred while cooling a smooth grease is obtained. The stirring of the gel after it is cooled gives a mixture of curd and thin liquid which never attains the consistency of the grease as mentioned in the first instance. This is an example of a very intimate mixture in the case of forming grease, and in the second case, one of minor emulsion.

VEGETABLE TANNING AS A COLLOID-CHEMICAL PROCESS

A remarkable paper in more ways than one was that presented by JOHN ARTHUR WILSON on "Vegetable Tanning as a Colloid-Chemical Process." It is rare, indeed, that as valuable a contribution is made to an industry as this one in which the results of four years of intensive research were revealed. The paper is also a leading contribution to pure science.

Preliminary to vegetable tanning, a hide is freed from hair, epidermis, and adipose tissue, leaving only the corium, which consists chiefly of bundles of collagen fibers. The prepared hide is then hung in a very weak solution of the tanning material and moved to a stronger liquor each day or two until completely tanned. Vegetable tanning, then, is simply the reaction taking place between the substance collagen and the soluble matter extracted from certain vegetable materials and known as tannin. It is with the mechanism of this reaction that the paper deals.

Any continuous piece of collagen, such as a hide fiber, is believed to be made up, not of individual molecules, but of chains of atoms forming a three-dimension network with interstices, while too small to be detected with the microscope, yet very much larger than the simpler molecules and ions. A hide fiber may thus be looked upon as a single large molecule. This structure gives collagen an enormous surface per unit mass and is probably responsible for its colloidal properties.

In practice, all tan liquors are slightly acid and, when the hide is immersed, water and some of the soluble matter, including acid, diffuse into the interstices of the collagen network. But the collagen readily combines with the hydrogen ions of this acid, leaving the corresponding negative ions in the solution immediately in contact with the network. Now the presence in the absorbed solution of these negative ions balanced only by the electrical charge on the network causes an unequal distribution of all ions between the absorbed and unabsorbed solutions, and this in turn causes an electrical difference of potential to be set up between the two solutions, which can be varied at will, within limits, by the proper addition of acids or salts.

On the other hand, the tannin particles are negatively charged and balanced by an equivalent number of positive ions confined to the thin film of solution immediately in contact with the surface of the tannin particles. But the presence of these positive ions results in an unequal distribution of all ions, and therefore in an electrical difference of potential, between the surface film of solution and the main body of solution. However, this potential difference will be of sign opposite to that in the case of the collagen. Hence the surface film surrounding the tannin particles will tend to merge with the solution in contact with the collagen network; and when this occurs, the positively charged collagen and negatively charged tannin will neutralize each other by combination, forming leather.

The essential practical point to be brought out is that it is not the absolute values of the electrical charges alone that determine the rate and nature of the tannage, but the differences of potential referred to, which can be varied without altering the absolute values of the charges. The application of this theory is being pushed in the hope of improving the tanning process and placing it upon a more scientific basis.

CERAMIC PROCESSES ASSOCIATED WITH COLLOID PHENOMENA

A paper by A. V. BLEININGER on the "Ceramic Processes Associated With Colloid Phenomena" was read in his absence. Clays are mixtures of finely divided aluminum silicate, of the $Al_2O_3 2SiO_2 2H_2O$ with granular matter, such as quartz, feldspar, mica, etc., and other colloids like ferric oxide and hydroxide. The particles are of the magnitude of 5μ, or smaller. Clay suspended in water is affected in a pronounced manner by alkalis, salts and acids. The former tend to deflocculate it, the latter two cause coagulation. Both phenomena occur in

phases. Absorption of the basic ion of salts is characteristic, the acid ion remaining in the dispersing medium. Deflocculation is employed in the purification of clays and in the casting process. Measurements of the fluidity of clay suspensions offer the most convenient means of detecting the changes caused by the presence of reagents, though the distinction made by Bingham between viscous and plastic flow must be kept in mind.

The migration of the negatively charged clay particles to the positive electrode within the field of a direct current is the basis of the invention of Schwerin for the purification of clays. The addition of small amounts of NaCl increases apparently the charge of the clay particles and facilitates their deposition. The removal of the impurities from clay is, however, not accomplished through the electrical separation but independent of the latter by previous treatment with NaCl.

The plasticity of clays is associated with flow under pressure and a finite yield point as distinguished from viscous flow showing zero yield point, as proposed by Bingham. The water content, contraction on drying and the capillary flow of water to the surface of the clay are affected by the presence of electrolytes, especially those whose bases show higher valences.

Upon drying and retempering, clay shows more or less of a "set," associated with decreased plasticity, the more pronounced the higher the temperature. Completely dried and dehydrated clay is exceedingly hygroscopic and absorbs vapors with avidity. Dehydrated clay also possesses the properties of a catalyst in certain reactions and combines with bases like calcium hydrate at atmospheric temperature. Dehydration is associated with increase in volume and, of course, is endothermic.

In the firing of clay, contraction of the external volume takes place due to the effect of surface tension and the lowered viscosity upon heating. With maximum contraction and closing of the pore space the state of vitrification is reached. The mass of the clay itself undergoes expansion upon heating irrespective of the external contraction. The relation between temperature, time and contraction is a most valuable one for expressing the heat work done upon clays and other silicates and oxides. Vapor pressure likewise is a probable factor in the condensation of substances like magnesia, coal, carbon, etc., or in mixtures of inert oxides with those of higher vapor tension. The end result of the heating process tends toward the partial elimination of the colloid and the substitution of the anisotropic phase.

Prof. W. D. HARKINS followed with a brilliant address on surface energy, and the symposium was concluded by an appeal from ARTHUR W. THOMAS of Columbia University for reforms in colloid nomenclature.

Electron Society

The Electron Society was organized in December, 1919, to foster researches that may lead to the discovery of an electron formula of the physical or mechanical universe. Meetings are held once a month (excepting July and August) at the Engineering Societies Building, New York City, and are followed by informal round-table discussions of Einstein's theory, Newton's law, behavior of electrons, planetary motion, absolute motion, conservation of energy, etc. For information as to membership, dues, etc., address E. M. V. Leewah, secretary, Engineering Societies Building, New York.

Secretary Alexander Recommends Saving of All Waste Paper

In referring to his recent appeal for the conservation of waste, Secretary of Commerce Alexander made the following statement, urging the saving of all waste paper:

> Following my appeal of last week to save waste and turn it back into the channels of trade, I wish to call attention to the importance of saving all waste paper. Attention has been called quite a number of times lately to the vital shortage in paper, and if the general public could realize how a shortage of paper affects its daily life I feel sure that a saving and utilization of all waste paper would be made.
>
> Many of the better grades of waste paper are used as pure substitutes for ground wood pulp and are used in making all kinds of book, bond, ledger and writing papers. If this kind of waste was not used to some extent, there would exist an even greater shortage of wood pulp from which most of our printing papers and newsprint paper is made. The waste paper used in the above list consists of old magazines, periodicals, books, and all kinds of printed matter in general. Every pound of this waste that is saved and marketed prevents the use of original wood pulp made direct from our trees.
>
> The largest tonnage of waste paper is called "common mixed," and consists of any and every sort and scrap of paper, such as newspapers, waste from the offices, stores, public buildings, and the homes. The chief use of this kind of waste is for paper boxes, roofing and building boards, paper shipping containers (which carry up to 100 pounds of freight or express), and wrapping paper. More than 2,000,000 tons of ordinary waste paper is used for boxes and shipping containers alone. The public is so accustomed to having its goods in paper boxes that it would be dumfounded to find their use seriously curtailed, and this is what will happen if we do not look more toward the utilization of waste. The use of waste papers for this purpose prevents the consumption of over 1,000,000,000 ft. of lumber annually and is increasing daily. The utilization of waste must keep pace with this to prevent a direct use of our trees for the wood pulp. At the present time there is very little original wood pulp used for paper-board boxes.
>
> In addition to the saving of trees in the making of paper board, there is another very great saving of lumber through the use of paper "shipping cases," which are used instead of wood boxes. Reports show that it would require more than half a billion feet of lumber annually to replace the "paper" shipping cases now used by almost every manufacturer in the United States.
>
> In most towns and cities there are dealers in waste paper and other salvageable material such as rags, rubber, metals, etc., who will pay a fair price for what otherwise would be thrown away or burned.
>
> The Department of Commerce still has on hand a limited number of two publications on waste reclamation which it will be glad to send to interested persons. These publications will show what one large city has done to develop a city-wide system of waste reclamation for the home, store, and factory, and the other will give some pointers on how to organize and operate the service.

German Export and Domestic Prices for Iron

The Cologne *Gazette* announces that numerous orders for iron bars are being placed in Germany by many countries. Orders from Belgium, France, Italy and Holland are especially numerous and price seems to be a minor consideration. The *Gazette* sees in this dependence on the German iron industry a means of improving mark exchange, and gives the following list of prevailing export prices: For exports to Belgium, 1,225 francs per ton; to Holland, 230 florins; to Switzerland, Italy and Greece, 500 Swiss francs; to Spain, 500 pesetas; to Sweden, 415 crowns; to Norway, 450 crowns; and to Denmark, 500 crowns. These prices are much higher than those fixed for domestic deliveries, which range from 2,620 to 2,900 marks per ton.

Abstracts of Papers Read at the Fifth Annual Meeting of T.A.P.P.I.

Pulp From Cottonseed Linters—Fuel From Waste Sulphite Liquor—Soda Salts From Black Ash—Limestone for Bisulphite Liquor Manufacture—A Revolution in Paper Machine Drive—Liquid Sulphur Dioxide in Sulphite Pulp Manufacture

A GENERAL account of the social activities of the recent T.A.P.P.I. meeting was given in the last issue of CHEMICAL & METALLURGICAL ENGINEERING. Their technical sessions were no less valuable and interesting, as may be surmised from the abstracts of some of the papers given below.

PULP FROM COTTON LINTERS

Otto Kress and Sidney D. Wells read a paper on "Pulp From Cotton Linters," in which they point out that extensive mill trials on the pulping of cotton linters have demonstrated conclusively that they are far superior in paper-making qualities to hull fiber. The latter material has received considerable investigation during the past year, but the low yields and the comparatively poor quality of the bleached pulp obtained have led investigators to believe that second cut linters offer greater possibilities. This grade of linters can be pulped by the ordinary soda pulp equipment with a chemical consumption not to exceed 10 lb. of caustic soda per 100 lb. of dry fiber, and can furthermore be economically bleached with 2 lb. of 35 per cent bleaching powder. Cotton linter pulp will produce a stronger sheet of paper than hull fiber on account of its greater fiber length and the cost of conversion into paper stock is much lower in proportion to the value of the product obtained.

FUEL FROM WASTE SULPHITE LIQUOR

"Fuel From Waste Sulphite Liquor" was discussed by George Barsky and Ralph H. McKee. Great developments during the last few years in boiler design and boiler practice, the burning of powdered coal, and of oil, have made possible the profitable use of concentrated waste sulphite liquor as a fuel. The solid material of the waste liquor has sufficient fuel value to evaporate the liquor and enough in addition to supply power or steam for other purposes. Owing to the colloidal nature of sulphite liquors, the boiling point does not change appreciably during the course of evaporation and hence it lends itself admirably for use in a thermo-compressor evaporator. In this form of apparatus there is only a small difference of temperature between the heated and the heating side and if operating with 150 lb. steam and connected to a double-effect evaporator (i.e., comprising a triple-effect evaporator, the first effect of which is a thermo-compressor), it is possible to evaporate 5.4 lb. of water per lb. of 150-lb. steam used. This amounts to 0.185 lb. of high-pressure steam as compared to 0.276 lb. of low-pressure steam for quadruple effect. Experiments have been conducted using both raw liquor and air-fermented liquor and the following figures are representative of the results obtained per ton of pulp:

	Raw Liquor	Air-fermented Liquor
Pounds of 150-lb. steam that can be made..	7,450	5,830
Pounds of water that must be evaporated...	12,480	10,000

The steam generated can be used for the development of power in non-condensing steam engines and the exhaust could in turn be used to evaporate the liquor in multiple-effect evaporators. In terms of fuel values the net combustible material in the raw liquor is equivalent to 780 lb. of 14,000-B.t.u. coal and in the fermented liquor, 610 lb. per ton of pulp produced.

EXTRACTION OF SODA SALTS FROM BLACK ASH

Instead of the usual method of extracting soda salts from black ash in leaching cells, George M. Vrostel suggested a more efficient method presenting many decided advantages. His plan is to leach uniformly ground ash on a rotary vacuum filter. The process would be continuous and would make it possible to reduce the volume of the resulting liquor considerably. He also claimed that a more complete extraction is effected and that the process can be controlled to a much greater extent than the ordinary leaching process.

LIMESTONE ANALYSIS AND EVOLUTION FOR BISULPHITE LIQUOR MANUFACTURE

"Limestone Analysis and Evolution for Bisulphite Liquor Manufacture" was discussed by W. E. Byron Baker. In the preparation of bisulphite liquors for the manufacture of sulphite pulp the character of the limestone used is an important factor. The relative degree of success in the operation of the limestone towers is dependent upon certain characteristics in the stone, and the quality of the pulp produced in cooking is influenced by the extent of impurities in the stone. The author outlined detailed methods of analysis for the determination of insoluble carbonaceous matter, silica, insoluble inorganic matter, iron, aluminum oxide, calcium oxide, magnesium oxide, alkali metal oxides, carbon dioxide, sulphur trioxide, sulphur as sulphide, hygroscopic moisture and combined water. In addition to the above it is sometimes desirable to know the mineralogical constitution of the stone, or at least determine the form in which the calcium and magnesium carbonates exist.

REVOLUTION IN PAPER MACHINE DRIVE

"A Revolution in Paper Machine Drive" was described by Stephen A. Staege. He noted that heretofore paper machines have been driven entirely by a mechanical system and the application of a sectional individual motor drive has never met with success. It is not because of any disinclination on the part of the paper industry to accept individual motor drive that the old mechanical systems have been so long continued in use, but because of the inability of the electrical apparatus heretofore available to meet the exacting speed regulation required of this type of sectional drive. The disadvantage of the mechanical system is that it requires

too much space, power, and repairs for its installation, and in the past few years great effort has been concentrated on the problem of so controlling the speed of sectional motor drives that their relative speeds should not vary more than 0.1 per cent. This has been accomplished and it has been demonstrated that with sectional individual motor drive the variable speed line of the paper machine can be driven with approximately half of the power required where mechanical drive is used on account of the great reduction in power losses. It is also possible greatly to increase speed and production.

Advantages of Liquid Sulphur Dioxide in Sulphite Pulp Manufacture

"Advantages of Liquid Sulphur Dioxide in Sulphite Pulp Manufacture" was discussed by Vance P. Edwards. He noted that the production of liquid sulphur dioxide from smelter smoke has long been recognized as a possibility, but previous to the World War no liquid sulphur dioxide from any source was produced in this country. Prior to 1914 the Forest Products Laboratory was using liquid sulphur dioxide obtained from Germany in cylinders of approximately 200 lb. capacity. There are now, however, at least two concerns manufacturing this material on a small scale from the element sulphur and one smelter producing something in the neighborhood of fifty tons of liquid sulphur dioxide per day.

Smelters operating upon pyritic ores discharge gases carrying from 0.5 to 3 per cent sulphur dioxide out of the main stack. However, from certain of the smelting operations, such as sintering, roasting and converting, gas of much higher concentration is obtained. Gas from this source is naturally selected for liquefaction, inasmuch as high concentrations of sulphur dioxide require less total amount of gas per pound of product.

The gas is first cooled, then passed through scrubbers or precipitators which remove nearly all the suspended solids and much of the sulphuric acid mist. After leaving, the gas is passed into absorption towers, where a strong aqueous solution of sulphur dioxide is made. In actual operation the strength of this solution is in the neighborhood of 1 per cent. The dissolved gas is next removed by agitation and heat, then cooled, dried and compressed to 60 to 70 lb., again cooled to 20 deg. C., at which temperature and pressure it is liquefied. Depending upon local conditions, it is estimated that liquid sulphur dioxide can be produced at a cost of about $10 per ton. To this must be added tank car equipment and transportation charges.

The value of liquid sulphur dioxide for acid making and its advantages in cooking are to a certain extent unknown quantities, though it can certainly be assumed that it is worth in excess of its equivalent weight in sulphur. That is, if sulphur cost $24 a ton at the mill, liquid sulphur dioxide is worth more than $12. Neglecting any of the chemical advantages due to the use of liquid sulphur dioxide, it is estimated that the lower handling charges and simplified mechanical operation alone would permit $15 being paid for this material.

In addition the author feels that liquid SO_2 has other and more important advantages over elemental sulphur when used in acid making. Briefly enumerated, these are: freedom from sulphuric acid and sublimed sulphur; elimination of burners and coolers; smaller piping necessary, and that may be of iron; stronger acid and shorter make-up time due to the more concentrated gas, and in the summer the acid plant may be independent of cooling water.

Sulphuric acid most frequently causes a loss of 20 lb. of sulphur per ton of pulp in addition to the cost of the lime which is precipitated. On the above basis this amounts to 35 lb. of calcium oxide per ton. The material loss from these items alone can easily amount to 35c. a ton of pulp made, and in many cases more. Indirect and more serious losses are incurred due to the cost of cleaning and the rapid depreciation of such equipment. A saturated solution of clear cooking acid can carry about 20 lb. of calcium sulphate in the liquid per ton of pulp. This is precipitated at cooking temperatures and could easily form a protective coating over the ends of the chips, effectually plugging the pores and seriously retarding penetration by the cooking acid, thus causing unevenly cooked pulp.

The relative advantages arising from the use of stronger acid in cooking have been repeatedly proved. It would be expected that increased yield, due to more even penetration, would be obtained, together with a shorter cooking time and lower bleach consumption. Such experiments as Mr. Edwards has made indicate that an acid containing double the SO_2 concentration usually employed decreases the time by 25 per cent, and increases the normal yield 10 per cent. Using the above as a basis of calculation, a digester making two cooks a day would add three cooks a week to the next output. The increased saving due to greater yields would amount to about 100 lb. on a cord of wood; in other words, one would be getting 1,100 lb. for the present cost of 1,000 lb. In the case of a 10-ton digester, the weekly output due to shorter cooking would be increased from 120 to 150 tons, while the higher yield would add 15 tons, bringing the total to 165 tons, or a 37½ per cent increase.

Liquid sulphur dioxide upon expansion absorbs 94 B.t.u. per lb., and it is conceivable that the cooling water for relief lines could be used to supply at least part of this heat. Also it would be possible to pass the cooled relief gases directly into the acid system, regulating the flow of gas from storage tanks to suit conditions. This, of course, would be impossible if the gas supply was obtained from burners. The reclaimed liquor would be collected in a separate tank and there would be no raw acid tanks.

Against these advantages must be charged the various alterations necessary and the enlarging of the recovery system to handle the greatly increased amount of gas from the digesters.

Production of Metals in Mexico Since 1916

Statistics showing the production of metals in Mexico from 1916 to September, 1919, have been published in *Iniciativa de la Ley de Ingresos* for the fiscal year 1920. The following table, taken from the publication mentioned, gives the production for 1916, 1917, 1918, and 1919 (January to September) (1 kilo = 2.204 lb.):

Metals	1916 Kilos	1917 Kilos	1918 Kilos	1919 (Jan.-Sept.) Kilos
Gold	11,748	23,543	25,313	17,208
Silver	926,142	1,306,988	1,944,512	1,462,255
Copper	28,411,218	50,985,923	70,223,454	38,170,209
Lead	19,970,986	61,121,752	98,837,154	50,533,765
Zinc	37,449,226	14,757,333	20,698,995	6,499,060
Antimony	828,767	2,646,544	3,268,546	470,778
Tin	292	9,214	13,537	1,588
Tungsten	12,250	187,637	149,486	21,969
Molybdenum	.....	.....	27,371	1,767
Manganese	.....	73,387	2,878,383	2,137,484
Mercury	.....	33,132	163,598	85,399
Arsenic	.....	1,284,820	1,881,011	1,611,250
Amorphous graphite	470,313	420,046	6,190,849	3,758,714

Consumption of Inorganic Nitrogen in the United States

A Study Prepared in the Nitrate Division of the Ordnance Department in an Effort to Forecast the Future Consumption of Inorganic Nitrogen in the United States, Based on Conditions During the Last Twenty Years

By Major D. P. GAILLARD
Nitrate Division, Ordnance Department, U. S. A.

EDITOR'S NOTE. This is the first of two articles prepared by Major Gaillard. The second will discuss in detail the supply of inorganic nitrogen in the United States, and will contain a summary in which the probable consumption and expected supply will be compared.

THE consumption of nitrogen has been increasing so rapidly, not only in the United States but throughout the world, that in order to study it intelligently it is not satisfactory to consider merely one year, and study conditions during that year, but the trend of conditions from year to year must also be studied.

Statistics are available giving the total supply of nitrogen in this country during each of the last twenty years. As to just how this nitrogen was used, equally reliable information is not available, but a fairly accurate estimate can be made for each year. There are sometimes appreciable stocks of nitrogenous materials carried over from one year to be used up in the next. In this study, however, the consumption for each year has been assumed to equal the supply for that year. If in one year by this method the consumption is too high, the next year it will be correspondingly too low, and any relatively small errors so introduced will neutralize themselves in studying the general trend of conditions over a period of years.

The consumption of nitrogen may be broadly divided into three parts, the agricultural, the industrial and the military. The nitrogen exported must also be included with the consumption.

In this study each of these broader divisions will be considered separately, leading finally to a consideration of the resultant conditions as to total consumption and supply.

Nitrogen Consumed in Agriculture

General

Nitrogen, together with phosphorus and potassium, is essential to the growth of plant life, and all fertilizer contains one or more of these elements, and most fertilizers contain all three. Of these, nitrogen is as important as any and, in the proportion ordinarily used, is the most expensive of the three.

In the United States it is customary for the fertilizer manufacturer to mix, in various given proportions, materials containing these three elements, which are bagged and sold as mixed fertilizer to the farmer, probably 80 per cent of the fertilizer used in this country being in the form of mixed goods.

The nitrogen in fertilizers is derived from two classes of materials: organic, or animal and vegetable materials, and inorganic, or mineral and chemical materials. The most important organic materials are cottonseed meal and animal tankage, the latter a waste product of the meat-packing industry. Other organic materials used are garbage, fish scrap, hair, horns, scrap leather, etc. The inorganic materials are Chilean nitrate and sulphate of ammonia—the form in which nitrogen is usually recovered from the coke ovens; to a much less extent cyanamide—one of the forms in which nitrogen is fixed from the atmosphere—and a very small amount of other chemicals.

In 1917, according to statistics gathered by the Department of Agriculture, a little less than half of the total nitrogen in mixed fertilizers was furnished by inorganic materials, Chilean nitrate supplying about three-fifths of this, sulphate of ammonia about one-third and miscellaneous materials the remainder. If we include the Chilean nitrate sold for separate application to the soil, about 60 per cent of the nitrogen sold for fertilizer would come from inorganic materials. Of the organic nitrogen about equal quantities were furnished by cottonseed meal and tankage, the two together supplying about 60 per cent of the organic nitrogen.

Use of Fertilizer in the Past

Commercial fertilizers first began to be used in this country about fifty years ago, and their use has increased steadily since that time. By 1904 the value of the fertilizers sold was ten times their value in 1869. From 1904 to 1914 the growth was very much more rapid, the value of the products in 1914 being three times, and the total tonnage of fertilizers manufactured being approximately two and a half times, the amounts in 1904.

Statistics available on the manufacture of fertilizer in the United States in the past are as follows:

FROM U. S. CENSUS STATISTICS

Year	Tons of Fertilizer Manufactured	Per Cent of Increase for 5-Yr. Period	Per Cent of Increase for 10-Yr. Period	Per Cent of Increase for 15-Yr. Period
1899	2,887,000			
1904	3,592,000	24		
1909	5,618,000	57	94	
1914	8,432,000	50	135	192

FROM THE AMERICAN FERTILIZER HANDBOOK AND FROM DEPARTMENT OF AGRICULTURE BULLETIN NO. 798

1909	4,900,000	1914	*7,626,000
1910	5,737,000	1915	5,783,000
1911	6,332,000	1916	5,583,000
1912	6,105,000	1917	6,592,000
1913	6,760,000	1918	†7,011,000

* 56 per cent increase over 1909. † 26 per cent increase over 1916.

It is to be noted that in the ten years prior to 1914 the use of commercial fertilizers more than doubled, the rate of growth in each 5-yr. period being substantially the same. 1915, owing to the influence of the war, with the abnormally low price received for the cotton crop and the demoralization of the fertilizer industry, the consumption of fertilizer decreased very

considerably. There was a still further slight decrease in 1916, but since that time the consumption has been increasing at approximately the rate that prevailed from 1909 to 1914. Exact figures for 1919 are not yet available, but it is estimated that the consumption last year was in the neighborhood of 7,500,000 tons, and while the 1920 consumption may actually be smaller than that last year, it will be due to the extreme shortage that has prevailed and is prevailing in all fertilizer materials, a shortage that has caused the abnormally high price of fertilizer materials now obtaining. It is evident that the demand for fertilizer is not being met and the present consumption is a matter of present supply rather than of present demand.

Although the South has been and is the principal user of fertilizer, in the last few years having taken about 60 per cent of the total production, the Middle West has shown the largest rate of growth from 1910 to 1914 and since 1916, and now uses over 10 per cent of the total. New England, which uses about 6 per cent, has shown the next most rapid growth, and the Middle Atlantic States, using a little less than 20 per cent, have a growth slightly greater than that of the South.

Need for Fertilizers

This very rapid growth in the use of fertilizers in the United States is only repeating what has taken place in Europe. As the land has become depleted, the crop yields have fallen off and to bring the soil back to its original fertility it has been necessary to supply fertilizer to make up the deficiency. This tendency was first felt in the South and the East, as the soil there had been under cultivation for a longer period, and was particularly marked in the South, where conditions made rotation of crops very difficult and where cotton is usually planted on the same land year after year. A large part of the soils in the corn belt of the Middle West is now or will soon become depleted in nitrogen and the use of fertilizers in that section must inevitably increase even faster in the future than in the past.

If the price of fertilizer were low enough, there is for practical purposes almost no limit to the amount that could be advantageously used. It has been estimated by Dr. Lipman, director of the New Jersey Agricultural Experiment Station, that the annual loss of nitrogen from all land under cultivation in the United States which is not replaced by manure, by the nitrogen supplied by plowing under leguminous crops, by atmospheric precipitation in the form of rain and snow and by the present use of commercial fertilizer amounts to between 3,000,000 and 4,000,000 tons of nitrogen, to replace all of which would take from 15,000,000 to 20,000,000 tons of sulphate of ammonia, or from 150,000,000 to 200,000,000 tons of ordinary commercial mixed fertilizer.

It would not pay now or in the immediate future to use fertilizer to any such extent on all of the land under cultivation, but these huge figures represent the upper limit to the use of nitrogen in fertilizer, and show how far from that limit the present consumption is.

At present it will pay to use fertilizer in many cases where it did not pay before the war; the value of land in most agricultural sections of the country has increased very considerably; the cost of farm labor has increased even more rapidly; and the value of the farm products in general is much higher than before the war. The use of fertilizer which causes a greater production per unit of land and per unit of farm labor, provided this fertilizer can be secured at a reasonable price, must therefore inevitably increase, and, assuming that a sufficient supply is available, it is entirely reasonable to assume that it will increase even faster than it did before the war.

Future Use of Fertilizers

It will be seen that from 1899 to 1914 the consumption of fertilizer in the country practically tripled, an increase substantially equivalent to an increase each year of 7½ per cent over the previous year. The growth during the last five years of this period was at an even greater rate, and since the slump in 1915 and 1916 the recovery has been practically at this same rate. It is therefore conservative to assume, in view of the factors mentioned before, which favor the increasing use of fertilizer even more than was the case before the war, that this growth will continue at this pre-war rate of 7½ per cent per year at least until 1924; that is, that there will be an average increase each year in the next five years of 7½ per cent over the preceding year. This would give a total fertilizer consumption for 1924 of 10,500,000 tons, a figure which, it is to be noted, is only about 25 per cent higher than the figure as actually reported by the census statistics for 1914—ten years earlier. The rate of growth from 1924 to 1930 has been assumed to continue uniformly at a somewhat slower rate, an increase little less than 800,000 tons a year, which gives for 1930 a total consumption of 15,200,000 tons.

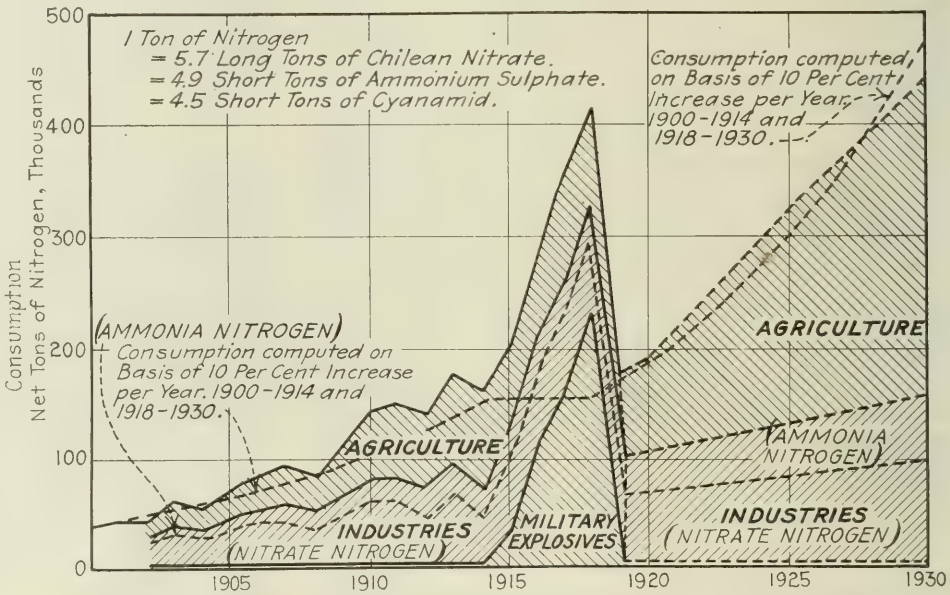


CHART SHOWING CONSUMPTION OF NITROGEN IN THE UNITED STATES

All of the organic nitrogenous materials are the byproducts of other industries, principally the meat-

packing and cottonseed oil industries. Although there has been a steady growth in these industries in the last twenty years, this growth has not been nearly so great as the growth in the consumption of fertilizer. Moreover, there has been a steadily increasing use both of cottonseed meal and animal tankage for feeding purposes, this use increasing especially rapidly in the last three or four years. The net result of this has been to make available for fertilizer use a slowly increasing amount of organic nitrogen up to two or three or four years ago, since which time there has been a considerable decrease—a decrease especially marked in the last year. During the past few months, garbage tankage from cities like Pittsburgh and Baltimore, which was formerly used exclusively for fertilizer purposes, has been entirely withdrawn for feeding purposes.

It is to be noted that at present the price of cottonseed meal is approximately the same as corn meal, about three-fourths that of oatmeal, and about two-thirds that of wheat flour. At these relative prices, it will naturally be evident why cottonseed meal is going into feed rather than into fertilizer.

Figures compiled by the Department of Agriculture show that in 1917 and 1918 about half of the high-grade animal tankage was being used for feed and about two-thirds of the cottonseed meal. Since then this proportion has undoubtedly increased. That these materials are now primarily feeds and only secondarily fertilizers is shown further by the course of their prices in the last year or so, during which time their prices have been controlled by the feedstuff market rather than by the prices of their competitive fertilizer nitrogenous materials, Chilean nitrate and sulphate of ammonia.

Increasing Use of Inorganic Nitrogen in Fertilizers

Some figures may help to show just how these tendencies have affected the proportions of organic and inorganic nitrogen used in fertilizers. In 1899, statistics indicate, about five-sixths of the nitrogen in mixed fertilizers, together with that used separately, came from organic nitrogenous materials; in 1904 about three-quarters; in 1909 slightly over half; and in 1914 slightly under a half, and in 1919 somewhat over a third. It is estimated that in 1924 this proportion will not be more than a fifth, and in 1930 not more than a tenth, as in 1924 there will be available not more than 45,000 tons of nitrogen from organic sources, about 60 per cent of the amount available in 1917, and in 1930 not more than 28,000 tons of nitrogen, about 40 per cent of the amount available in 1917.

Future Use of Inorganic Nitrogen

The estimated consumption of 10,500,000 tons of fertilizer in 1924 will require approximately 217,000 tons of nitrogen, not more than 45,000 tons of which can come from organic materials, leaving 172,000 tons of inorganic nitrogen to be supplied.

The estimated consumption of 15,200,000 tons of fertilizer in 1930 will require approximately 315,000 tons of nitrogen, not more than 30,000 tons of which can come from organic materials, leaving 285,000 tons of inorganic nitrogen to be supplied.

In other words, inorganic nitrogen must supply not only all the nitrogen requirements in addition to those as present existing, but must replace in 1924 about 40 per cent, and in 1930 over 60 per cent of the organic nitrogen now being used.

Nitrogen Consumed in Industries

Uses of Nitrogen in Industry

In the chemical industries of the country, in which is included the manufacture of domestic explosives, nitrogen plays a very important part. This nitrogen is consumed in two forms, as nitric acid made from Chilean nitrate and ammonia derived from the gas works and the byproduct coke ovens. At present about two-thirds of the nitrogen is consumed in the form of nitrate and about one-third in the form of ammonia.

Somewhat more than half of the nitrate used goes into the manufacture of industrial explosives, such as dynamite, blasting powder, etc., which are used not only for practically all mining and quarrying operations but to a rapidly increasing extent for road building, clearing land, digging ditches, and other labor-saving purposes. Somewhat less than half of the nitrate goes into other chemical industries, principally the production of the several nitrocellulose products which include artificial leather now almost universally used for automobile upholstery, photographic films, imitation ivory, and all forms of celluloid. It is also used to some extent in the glass industry.

Of the ammonia approximately one-quarter is used in connection with the operation of cold storage plants and for the manufacture of artificial ice, about one-third is used in the quantity production of staple chemicals, principally soda ash, ammonium chloride and sodium cyanide, about one-eighth goes into the explosive industry, principally for the manufacture of ammonium nitrate, and the remainder is used for miscellaneous purposes including the manufacture of household ammonia.

Estimates of Past Consumption

In estimating the amount of Chilean nitrate used in the industries in each of the several years the estimated amount consumed in fertilizers has been deducted from the imports for that year and the remainder taken to be the nitrate used in the industries. Of course, during the World War the military consumption has also been deducted.

In the case of ammonia, for the most of the years statistics are available from the U. S. Geological Survey, giving the total production of ammonia from byproduct coke ovens and giving that part of the production which is in the form of sulphate of ammonia. The difference between these two plus the entire ammonia output of the gas works has been taken to be that portion of the ammonia consumed in chemical industries. The relatively small part of the ammonia production from gas works which goes into the manufacture of sulphate of ammonia may be assumed, without serious error, to balance that small part of the sulphate going into the chemical industry.

The figures thus determined show that there was from 1902 to 1914 a steadily increasing use of both nitrate and ammonia in industry, the use of nitrate increasing each year by approximately 20,000 short tons (17,850 long tons), containing 3,125 tons of nitrogen, and the use of ammonia increasing each year by approximately 2,125 tons, containing 1,750 tons of nitrogen. The normalized consumption of ammonia in industries during 1919 is estimated at 42,500 tons, containing 35,000 tons of nitrogen, a figure obtained by assuming the pre-war growth to have continued to 1919. In the case of nitrate, however, the normalized consump-

tion in 1919 has been taken to be 400,000 short tons of Chilean nitrate, containing 62,500 tons of nitrogen, approximately the normalized consumption in 1914, and somewhat greater than the actual consumption in 1913. By normalized consumption is meant the consumption assuming that in 1919 the nitrogen-using industries were normally busy. The total consumption in industries of both nitrate and ammonia estimated for 1919 is then 97,500 tons of nitrogen.

The use of both nitrate and ammonia has been assumed to continue to increase from 1919 to 1930 at the pre-war rate of about 4,875 tons of nitrogen a year. It is believed that this is a very conservative estimate, as this rate of increase at the beginning of the period amounts to only 5 per cent and at the end of the period to only 3½ per cent a year. On this basis there would be consumed in industry in 1924 approximately 500,000 tons of Chilean nitrate and 53,000 tons of ammonia, together containing 120,000 tons of nitrogen, and in 1930 the estimated consumption would be 600,000 short tons of Chilean nitrate and 64,000 tons of ammonia, together containing 150,000 tons of nitrogen.

In the above discussion it has been assumed that in the future the requirements for ammonia nitrogen and for nitrate nitrogen are distinct, but developments during the war have shown that the conversion of ammonia nitrogen to nitrate nitrogen is entirely practicable and should ammonia be relatively more plentiful than nitrate and, therefore, its price appreciably lower, there is no question that a considerable part of the requirements for nitrate nitrogen would be supplied by the conversion of ammonia nitrogen.

Nitrogen Consumed in Military Explosives

Prior to the outbreak of the World War the total consumption of nitrogen in this country for military explosives increased from a few hundred tons in 1900 to between 1,000 and 2,000 tons in 1914. Exact statistics on the consumption during this period are not readily obtainable and since the use of nitrogen for this purpose is such a very small part of the total consumption, exact figures are not necessary.

In the latter part of 1915 the manufacture of explosives for the Allies began, and from then on until the armistice, in 1918, the production of military explosives increased at a tremendous rate in this country. In 1918, the year of maximum consumption, it is estimated that somewhat less than 150,000 tons of nitrogen was actually consumed in the manufacture of military explosives. At the same time a military reserve stock of Chilean nitrate was slowly being built up with the object of ultimately accumulating a sufficient quantity to last for six months should all imports be cut off; and a smaller stock of ammonium sulphate was being accumulated for the manufacture of ammonium nitrate. As a result, at the end of 1918 approximately 80,000 tons of nitrogen was on hand in the form of these stocks of material. In other words, the accumulation of these essential reserves, together with the actual consumption, required in 1918 in the neighborhood of 230,000 tons of nitrogen, equivalent to more than 1,300,000 long tons of Chilean nitrate, a quantity of nitrogen more than a third greater than the consumption for all purposes in the highest year before the World War.

The future consumption of nitrogen in military explosives so long as the United States is not involved in war will be but little larger than was the case before the war, and in fact, it may actually be even less owing to the large amounts of powder and explosives now in storage. In any event the peace-time consumption of nitrogen for military explosives will be a negligible part of the total consumption. So long, however, as this country is so largely dependent on imported nitrogen, conditions will be similar in case of a future war, and nitrogen will have to be supplied not only to meet the actual consumption, but to establish a sufficient reserve to safeguard against an enemy completely cutting off all imports.

Nitrogen Exported

In the past but little inorganic nitrogen has been exported, as this country itself has been such a heavy importer of nitrogen. A large part of the little inorganic nitrogen exported was contained in mixed fertilizers manufactured here.

However, since the practical cessation of sulphate exports from Europe, and particularly in the last year, the United States has been exporting a fairly considerable amount of sulphate of ammonia to the West Indies and to the Far East. Although no statistics are available, it has been estimated that the exports last year of inorganic nitrogen may have amounted to nearly 10 per cent of the total domestic consumption.

The question as to what may be expected in nitrogen from this country in the future is most uncertain and in this study no allowance will be made for any future exports. Undoubtedly there will be some exports, and it is very desirable that there be exports both from a commercial and a military point of view, but as these will tend to increase the requirements for nitrogen in the United States and serve only to accentuate the deficiency of the domestic supply, they will not be included.

Relation Between Mechanical Hardness and Grain Size of Carbon Steels

An investigation on this subject by the Bureau of Standards has now been completed. It shows that there is no simple relation between grain size and hardness in carbon steels such as exists, for example, in the alpha brass and other one-constituent alloys. Grain size is a factor of minor importance. The amount of distribution of the structural constituents determines the hardness to a far greater extent. The work already completed throws some light incidentally upon the magnitude of the stressing of low-carbon steel by cooling and work in order to effect the subsequent growth of grain upon annealing below the critical temperature. It is planned to extend this investigation to include a study of the effect of grain size upon other mechanical properties.

Japanese Encouraging Beet-Sugar Industry in Manchuria

As the annual sugar production of Japan is little more than half of the amount locally consumed, and as the action of Java in prohibiting the exportation of sugar for the next six months emphasized the possibilities of future shortage of sugar in Japan, the Japanese are realizing the necessity for developing a more dependable source of supply, says the *North China Commerce*. To this end they have offered rewards to the farmers of Manchuria for large crops of sugar beets, thus encouraging them to plant beets instead of customary crops.

Microstructure of Iron and Mild Steel at High Temperature*

Pronounced Decarburization Occurs When Metal Is Heated in Vacuo, Consequently Heat-Etching of Polished Surfaces Represents Largely Structure at Surface—Nature of the Surface Patterns Is Also Discussed

By HENRY S. RAWDON and HOWARD SCOTT
Physicists, Bureau of Standards

THE method of demonstrating the structure existing in a metal or alloy at high temperatures, by etching a polished sample after it has been heated to the desired temperature, is quite familiar to metallographists. The usual procedure[1, 2] is to heat the specimen, previously polished for microscopic examination, to the desired temperature, in a neutral atmosphere (hydrogen or nitrogen), then admit the etching gas (chlorine, hydrochloric acid or similar gas) for a few seconds, and finally, after flushing out the etching gas with the neutral one, cool the specimen in the neutral atmosphere. The pattern produced by etching at a definite temperature is usually taken as a record of the microstructure prevailing at that temperature. It has frequently been pointed out that changes in composition of the surface metal occur during the preliminary heating in the neutral atmosphere, so that the appearance produced by the etching at high temperature may not exactly represent the condition of the interior of the specimen. To overcome this uncertainty, the heating has sometimes been done in vacuo,[3] the etching gas being admitted when the desired temperature was reached, then pumped out and the specimen cooled in vacuo.

The studies of Rosenhain, Humfrey, and other workers[4, 5, 6, 7, 8] demonstrate that surface changes in the steel occur even when the specimens are heated in vacuo. Such changes in themselves are sufficiently pronounced to record, in the appearance of the surface, the microstructure prevailing at the temperature at which the change took place. The surface configuration or pattern thus produced, to which various names, "heat-relief," "heat-etching" and "vacuum-etching," have been applied, has been explained by Rosenhain as being due to volatilization of the surface metal. This is more marked along the crystal boundaries than over the face of the crystal itself. The change in composition of the layer immediately adjacent to the surface of a steel sample when heated in vacuo or in a neutral atmosphere has also usually been attributed to volatilization. Howe[9] has offered an entirely new and striking explanation for this phenomenon, namely, that the change in composition of the surface layer is only local and the average composition of the specimen does not change. Upon cooling a sample of steel from a high temperature, the free constituent (ferrite or cementite as the case may be) is expelled to the outside of the mother austenite crystal and thus to the surface of the specimen in those crystals which form the exterior. By repeated heatings, the layer of expelled ferrite (in the case of low-carbon steels) is augmented until the specimen has the appearance of being decarburized at the surface.

The examinations here described were made for the purpose of showing to what extent the change in composition of the surface layer, which usually accompanies heating in vacuo, affects the results of tests which may be made to reveal the microstructure existing at high temperatures. The results also throw some additional light upon the nature of the change in composition of the surface layer and also upon the formation of the surface pattern under "heat-relief" etching.

Method of Revealing Structural Changes Occurring at High Temperatures

Pure iron and low-carbon steel were chosen as typical materials for demonstration, since both materials show pronounced changes in structure accompanying some of the transformations which occur upon heating. The normal structure of each is familiar, and the microstructure at high temperature has been demonstrated by means of the etching method.

Pure Iron

A remelted electrolytic iron having the following composition was used: Carbon, 0.03 per cent; sulphur, 0.002 per cent; silicon, 0.009 per cent. By thermal analysis, the material was shown to have the following thermal characteristics: Ac_2, 768 deg.; Ac_3, 910 deg.; Ar_3, 900 deg.; Ar_2, 768 deg. C. The specimens, which were of the size used for thermal analysis (approximately 3 g.), were mounted on the end of a platinum platinum-rhodium thermocouple and heated in the evacuated tube of a differentially heated furnace of the Rosenhain type[10] to the following temperatures: 950 deg. C., above A_3; 880 deg. C., between A_3 and A_2; 700

Copyright, 1920, by the American Institute of Mining and Metallurgical Engineers, Inc.

*A paper read at the winter meeting of the American Institute of Mining and Metallurgical Engineers, February, 1920.

[1]N. Gutowsky: Über die Structur des Stahlen bei hohen Temperaturen: *Metallurgie* (1909), vol. 6, p. 743.

[2]H. Hanemann: Über das Atzen in Hoher Temperatur. *Inter. Zeit. Metallographie* (1912-13), vol. 3, p. 176.

[3]N. Tschischewsky and N. Schulgin: *J. Iron and Steel Inst.* (1917), vol. 95, p. 189.

[4]W. Rosenhain and J. C. W. Humfrey: "The Crystalline Structure of Iron at High Temperature." *Collected Researches*, Natl. Phys. Lab., Teddington (1910), vol. 6, p. 189.

[5]W. Rosenhain and J. C. W. Humfrey: "The Tenacity, Deformation and Fracture of Soft Steel at High Temperatures." *J. Iron and Steel Inst.* (1913), vol. 87, pp. 219-315.

[6]J. C. W. Humfrey: "The Intercrystalline Fracture of Iron and Steel." *Collected Researches*, Natl. Phys. Lab., Teddington (1913), vol. 10, p. 113. Also Iron and Steel Inst., *Carnegie Sch. Mem.* (1912), vol. 4, p. 80.

[7]W. Rosenhain and D. Ewen: "Intercrystalline Cohesion in Metals." *Collected Researches*, Natl. Phys. Lab., Teddington (1913), vol. 10, p. 91. Also *J. Inst. Metals* (1912), vol. 8, p. 149.

[8]Adolphe Kroll: "The Crystallography of the Iron-Carbon System." *J. Iron and Steel Inst.* (1910), vol. 81, p. 304.

[9]H. M. Howe: "The Position of Ac_3 in Carbon-Iron Alloys. Discussion." *Trans.*, A. I. M. E. (1913), vol. 47, p. 659.

[10]H. Scott and J. R. Freeman, Jr.: "Use of Modified Rosenhain Furnace for Thermal Analysis." *Bull.* A. I. M. E., No. 152, (August, 1919). A description of the furnace and the auxiliary apparatus is given. See also page 811 of this issue for synopsis.

deg. C., below Ac_1 (of steels). In each case the specimen was held for approximately 30 min. at the maximum temperature and then cooled in the evacuated furnace at an approximate rate of 0.15 deg. per second by moving the specimen to the cold end of the tube. The surface of the specimens, after heating, showed no evidence of oxidation. In most cases, particularly those heated to the highest temperatures, the surface had a slightly roughened or matte appearance.

Fig. 1 shows the surface pattern produced by heating the iron above the Ac_3 transformation. Two distinct patterns are to be seen superimposed one upon the other. One of the patterns is similar in appearance to that of pure iron as ordinarily etched at room temperature; the other network prevailing above A_3 contains numerous straight lines and many of the enclosed "grains" have the appearance of twinned crystals. This is clearly shown at *A-A* and *B-B*. The long narrow crystal is the twinned layers of a much larger crystal. Another network, outlining a second system of grains, is superimposed upon the twinned crystals.

The network delineating the straight-sided polyhedral twinned crystals is a record of the structure of the γ iron, i.e., the form existing above the A_3 transformation. The second network belongs to the crystal structure prevailing below this transformation, as seen in specimens heated to a temperature below A_3. Only one network is developed under such treatment, and this is identical with the second pattern of specimens heated above A_3. The specimen shown in Fig. 2 illustrates this, and also shows that no characteristic crystal form corresponds to the so-called β range. The appearance is the same as that of specimens heated to a temperature well below A_2 (Fig. 3) and also of samples polished and etched under ordinary conditions. This observation confirms that of Rosenhain and Humfrey, in this respect.

Fig. 3 shows the surface of a polished specimen heated to 700 deg. C. The network outlining the arrangement of the crystals appears faintly even at this relatively low temperature.

The surface of freshly heated specimens often has a "matte finish" appearance and, when viewed at an oblique angle, is seen to be considerably roughened. The volatilization occurring at high temperatures, as shown in Fig. 1 accounts partly for the matte finish. It was noted that the volatilization develops rather well defined "etching pits" on the surface, by means of which the structural orientation within the twin crystals relative to the mother crystal is plainly shown [in micrographs not reprinted]. The roughened appearance is largely due to a "buckling" of the surface of the individual crystals. In Fig. 4, a section perpendicular to the polished surface which was exposed to the heat, is demonstrated the distortion that occurs; the boundary, i.e., the trace of the polished flat surface, originally rectilinear, now consists of a series of undulations. Specimens heated to a temperature a little below A_3 show an irregular branching network within the grains themselves (Fig. 2). This is often seen in pure iron after ordinary etching for microscopic examination, particularly if the sample has been strongly heated previously, for example, specimens which have been heated several times for thermal analysis curves. Whether this bears any relation to the β change has not yet been determined.

Low-Carbon Steel

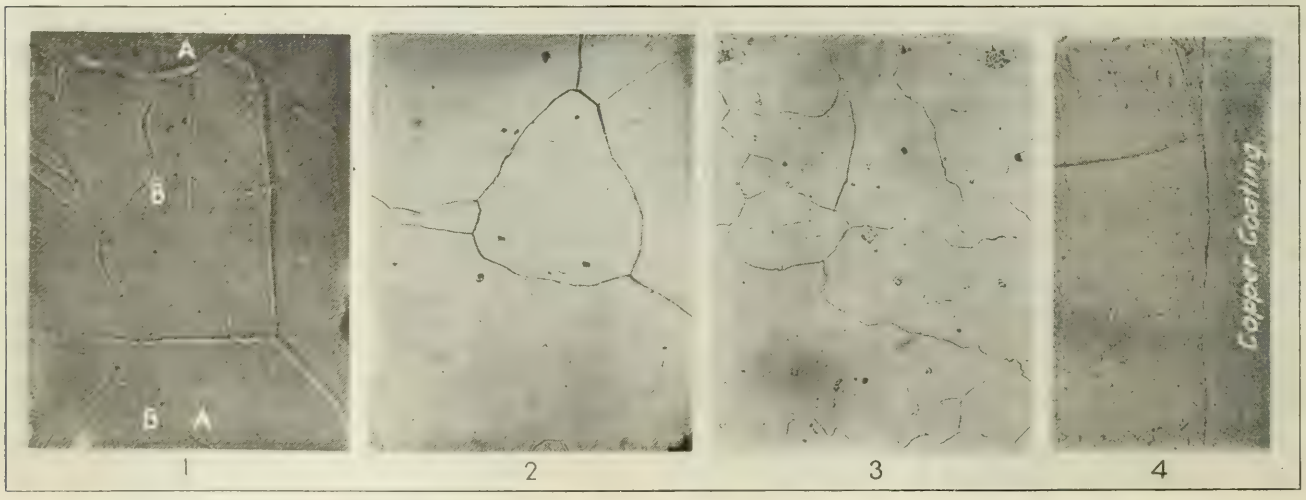
A synthetic low-carbon steel[11] having the following composition was selected as representative of this class of material: carbon, 0.18 per cent; silicon, 0.007 per cent. It had the following thermal characteristics: Ac_1, 738 deg.; Ac_2, 769 deg.; Ac_3, 840 deg; Ar_3, 792 deg.; Ar_2, 769 deg.; Ar_1, 700 deg. C. The specimens, first polished for microscopic examination, were heated in vacuo in the same manner as the pure iron, to the following temperatures, and were held approximately 30 min, at the maximum temperature: 950 deg. C., above Ac_3; 760 deg. C., above Ac_1; 700 deg. C., below Ac_1.

The slight roughening of the surface, due to the slipping, still persists at this temperature and shows that no marked volatilization has occurred at the surface. Even at this temperature the heat-relief has been sufficient to indicate clearly the islands of pearlite.

Fig. 5 is a specimen which, after polishing, was distorted enough to develop slip bands and then heated to 700 deg. C., just below the transformation Ac_1.

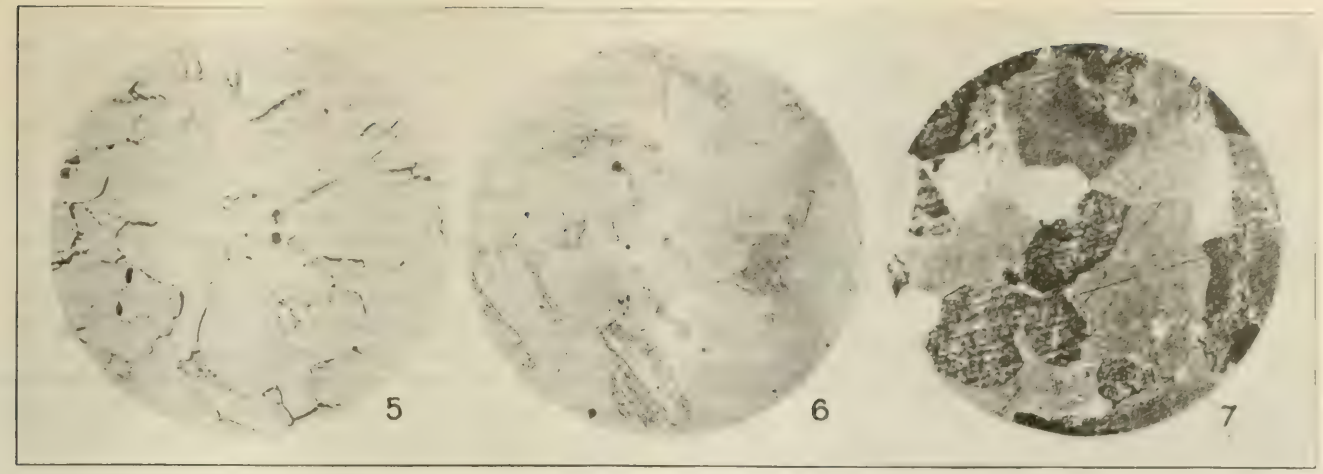
Fig. 6 shows the specimen of Fig. 5 after it had been

[11] An alloy of iron and carbon prepared according to the method given by U. S. Bureau of Standards. *Sci. Paper* 266.



FIGS. 1 TO 4

Fig. 1. Microstructure of pure iron above the Ac_3 transformation. Polished surface heated for 30 min. at 950 deg. C. Heat-etched. × 300. Fig. 2. Microstructure of pure iron between A_2 and A_3 transformations. Polished surface heated for 30 min. at 880 deg. C. Heat-etched. × 300. Fig. 3. Microstructure of pure iron just below the transformation temperatures. Polished surface heated for 30 min. at 700 deg. C. Heat-etched. × 300. Fig. 4. Undulating surface of heat-etched iron. Fig. 1 electroplated, cross-cut, polished and etched with 2 per cent nitric acid in alcohol. × 300.



FIGS. 5 TO 7. SOFT STEEL JUST BELOW Ac_1

Fig. 5. Polished specimen slightly distorted and heat-etched 30 min. at 700 deg. C. × 100.

Fig. 6. Fig. 5, slightly polished and etched with 2 per cent HNO_3 in alcohol. × 100.

Fig. 7. Unstrained steel, polished, heat-etched 30 min. at 700 deg. C., and then etched with HNO_3. × 100

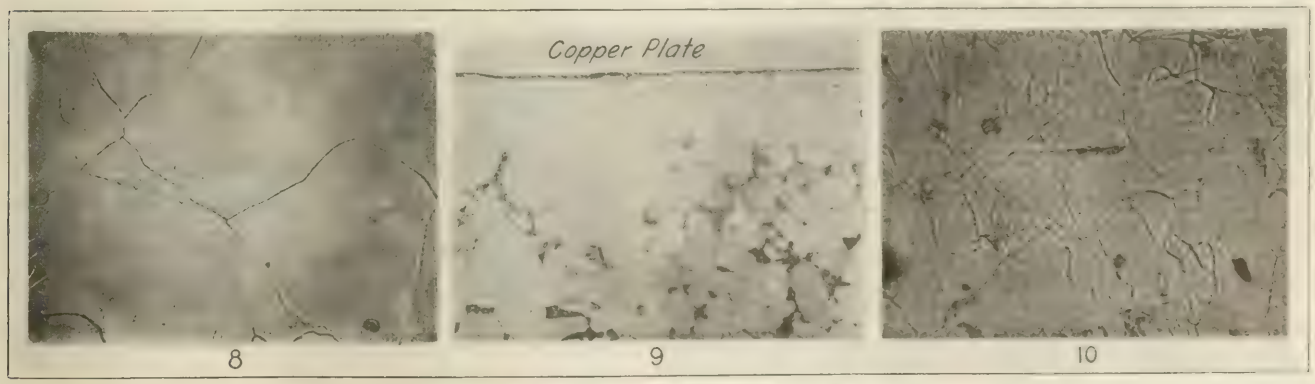
polished slightly to remove the effects of the heat-relief and then etched; it has the usual appearance of low-carbon steel. When the specimen is etched directly after heating, without any supplementary polishing, the surface darkens almost immediately and gives the appearance shown in Fig. 7. A similar pronounced darkening of ferrite, upon etching, is often observed when a specimen is finished on a polishing wheel which has been allowed to become dry, so that the surface heats considerably.

Upon heating a polished specimen of this synthetic steel above the Ac_1 transformation, the surface takes on the appearance shown in Fig. 8, which is very similar to that produced by heating below Ac_1; the position of the pre-existing pearlite islands is clearly indicated. It will be noted that the network which marks the boundaries of the ferrite crystals is now continuous *through* the pearlite areas instead of around them. When the surface is etched, without any polishing, the appearance is the same as is shown in Fig. 7. However, when the surface is slightly polished and then etched, no darkening results nor is there left any trace of the pattern developed by heat-relief. The material constituting the surface is pure ferrite; all the pearlite has been removed to a considerable depth, as is shown in Fig. 9, a section of the specimen perpendicular to the polished face, the normal appearance of the material being seen in the lower portion of the micrograph. The boundary between the outer, or carbonless, metal and the inner normal material is clearly defined, showing that the change from the outer zone to the unchanged metal of the interior is very abrupt.

If such a specimen as shown in Fig. 9 is heated for 30 min. at 950 deg. C., that is, above the Ac_3 transformation, a more clearly defined network, corresponding to the γ condition, is superimposed upon a less distinct one which shows the characteristic outlines of the α crystals. This is plainly seen in Fig. 10. The polished specimen in this instance was etched to reveal its initial structure and then heated for 30 min. at 1,000 deg. C., or well above the temperature of the Ac_3 change. The roughening of the surface, corresponding to the islands of pearlite shown by the initial etching, still persists. Upon this pattern two others are superimposed, showing respectively the crystalline condition above Ac_3 on heating, and below Ac_3 on cooling. The twin crystal which had its origin when the steel was in the γ state is seen to cut through the pre-existing islands of pearlite and to bear no relation to them. It should be borne in mind, however, that the carbide has been removed from the surface material, probably before the change to the γ state was brought about, as has been described above.

Nature and Extent of the Surface Changes Upon Heating

The magnitude of the change (apparently decarburization) which occurs in some samples (Fig. 9) makes the explanation offered by Howe mentioned at the outset



FIGS. 8 TO 10. SOFT STEEL ABOVE Ac_1

Fig. 8. Polished specimen heat-etched 30 min. at 760 deg. C. × 300.

Fig. 9. Fig. 8, electroplated, cross-cut, polished and etched with 2 per cent HNO_3 in alcohol. × 60

Fig. 10. Fig. 9, heat-etched 30 min. at 950 deg. C. × 100

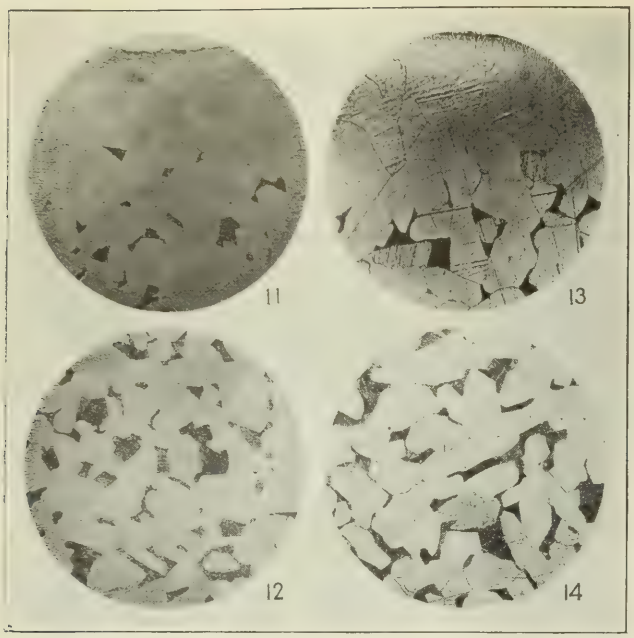


Fig. 11. Surface changes in soft steel produced by 4 hr. at 990 deg. C. Electroplated, cross-cut, polished and etched with 2 per cent HNO_3 in alcohol. × 250. Fig. 12. Structure of Fig. 11 at center of specimen. Fig. 13. Same as Fig. 11, but after four reheatings to 950 deg. C. for thermal analysis. Fig. 14. Structure of Fig. 13 at center of specimen.

appear inadequate. In order to show clearly the nature of the change, and to test his explanation, a series of specimens of the low-carbon steel previously used were heated for 30 min. in vacuo at the following temperatures: 760 deg. C., above Ac_1; 820 deg. C., just below Ac_3; 890 deg. C., above Ac_3. The specimens were cooled in the furnace at the same rate as the previous ones. In each case the carbonless layer varies considerably in thickness on the same specimen. In the specimen heated at the lowest temperature, the decarburized layer is more pronounced than in those heated for the same period at higher temperatures. This is not to be attributed to a greater loss of carbon at the lower temperature, but rather to an increased rate of diffusion of carbide in iron at higher temperatures, by which any change at the surface, due to loss of carbon, is masked by a replenishment from the interior.

Fig. 11 shows the condition at the surface and Fig. 12 near the center of a specimen (low-carbon steel previously used) heated continuously for 4 hr. above Ac_3, 990 deg. C. being the maximum temperature. The structure of a sample of the same material, previously used for a series of four thermal curves, which had been held above the Ac_3 temperature for a total of 4 hr., is shown in Figs. 13 and 14. The thickness of the altered surface layer of the sample heated intermittently is somewhat greater than that of the specimen heated continuously for 4 hr. above the Ac_3 transformation temperature. The carbon content of the interior, however, as estimated from the structure, is slightly less in the specimen heated continuously than in the other one. This apparently contradictory behavior of the more strongly heated specimen is to be interpreted as further evidence of the part played by diffusion in masking the change which occurs at the surface. By comparing micrographs it was noted that a much more marked change is produced in the surface metal by a short period at the lower temperature (30 min. at 760 deg. C.) than by prolonged heating at a higher temperature (240 min. at 990 deg. C.). Whether this difference in the rate of diffusion is due entirely to temperature or partially to the allotropic condition of the iron, α or γ, can only be conjectured.

Fig. 15 shows the surface change induced in a high-carbon steel by heating four times in vacuo to a temperature above the Ac_3 transformation (950 deg. C.). The steel had the following composition: carbon, 1.28 per cent; manganese, 0.23; phosphorus, 0.017; sulphur, 0.017; silicon, 0.23 per cent. The cementite grain-envelopes do not extend entirely to the surface, as they did originally, but gradually diminish in thickness and disappear at some distance below the surface. In no case was an accumulation of cementite found, such as Howe's explanation would require. In a few areas a very thin layer of ferrite was found to have formed, as shown in Fig. 16. The conclusion is evidently warranted that the change of structure of the surface metal heated in vacuo represents loss of carbon.

Interpretation of Results

It may properly be asked, To what extent are the etching indications of steel at high temperature vitiated by changes of composition that occur in the surface metal upon heating? The results previously described show that no decarburization below the temperature of the A_1 transformation can be detected. This is due to the physical form in which the carbon exists; not until the carbon (as carbide) is in the state of a solid solution in the iron, i.e., above A_1, is there any appreciable change in the exposed surface metal. Below the A_1 transformation, the carbon occurs as a definite crystalline compound and the loss upon heating may be entirely neglected.

A very marked change, however, occurs upon heating a specimen just above the A_1 transformation, when the carbon passes from the form of crystalline cementite to a solution (of cementite) in the iron. In this form it quite readily volatilizes from the surface, so that a pronounced carbonless layer is soon formed in specimens (low-carbon steel) that are held for periods no greater than 30 min. at this temperature. The method of "heat-etching," however, serves to record the structure both before and after the change has taken place. The pronounced differential expansion of pearlite and ferrite at the A_1 transformation will account partially for this. The fact that at temperatures below A_1 the structure is clearly revealed by heat-etching, however, shows that this is not the sole cause, but that the slight general volatilization which occurs, together with the slight differences in the rate of thermal expansion of pearlitic

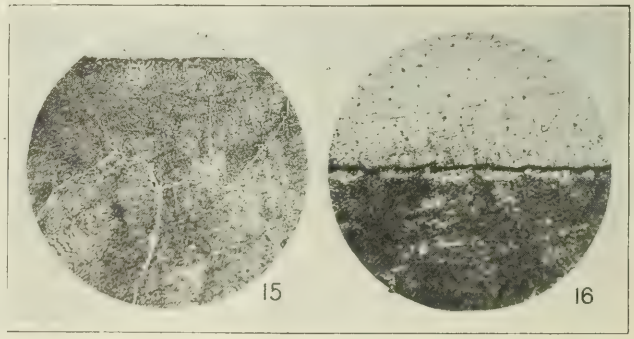


Fig. 15. Average surface condition of high-carbon steel after heating four times in vacuo to 950 deg. C. Electroplated, cross-cut, polished and etched with 2 per cent HNO_3 in alcohol. × 250.
Fig. 16. Exceptional surface condition of Fig. 15. Etched with hot sodium picrate, which turns cementite black. × 250.

steel and iron (ferrite) are sufficient to record clearly and definitely the structure of the metal. The volatilization of iron is sufficiently pronounced at the crystal boundaries to show them clearly, but across the face of the crystals there is very little loss, as is proved by the persistence of slip bands, upon heating. That the ferrite is changed somewhat is shown by its increased tendency toward oxidation. Upon slight etching with nitric acid, a distinct oxide film readily forms, coloring the ferrite very dark.

Specimens heated to temperatures higher than the A_1 transformation show a carbonless layer, which becomes thinner as the temperature is increased. This is properly to be attributed to the increased rate of diffusion of carbide in iron, by which the change at the surface is masked. The results obtained by etching specimens at the higher temperatures (heat-etching or otherwise) are more truly indicative, therefore, of the structure of the interior than those at lower temperatures, e.g., just above A_1. That the loss of iron by volatilization across the face of the crystals is very slight, even at high temperatures, is proved by the persistence of the slight roughening due to preliminary etching throughout the entire period of heating. The loss by volatilization is of a magnitude sufficient to show the crystalline structure by the production of "etching pits"; at the crystal boundaries the loss is much greater. In addition, the carbide is removed to an appreciable depth on all the exposed faces of the specimen.

Summary

1. When polished metal specimens are heated in vacuo, a record of the structure existing at the particular temperature used is inscribed on the polished surface of the specimen. This record consists of a slight roughening due to volatilization and to a slight "buckling" of the surface, due to the volume change accompanying the transformation. The terms "heat-relief," "heat-etching" and "vacuum-etching" have been applied to this method of developing the microstructure.

2. By means of heat-relief the structure of iron and steel at high temperatures is readily revealed. This is a much simpler method than the high-temperature etching often used. It appears probable that much of the effect usually attributed to etching at high temperature is due to the heating itself.

3. An appreciable change of composition and structure of the surface metal occurs in steel, upon heating. This is strongly marked just above the A_1 transformation, and becomes less so upon heating to higher temperatures, due to the increased rate of diffusion of carbon (as carbide) in iron. The structure revealed on the surface by heat-relief, or by high-temperature etching, is less representative of the interior at temperatures just above the A_1 transformation than at any other temperatures.

4. The change in composition of the surface layer of steel heated to high temperatures in vacuo is to be explained as due to volatilization of the carbide. No appreciable change takes place until the carbide enters into solid solution, i.e., above the A_1 transformation.

5. The volatilization of iron from the surface, upon heating, is very slight. Polished specimens of iron and steel, etched before being heated, retain the slight roughening due to the etching, even after pronounced heating. The volatilization of iron at the crystal boundaries is more rapid than across the face of the crystal.

Development of the Italian Chemical Industry

Owing to its close territorial proximity to Germany and to the strong foothold that Germany had obtained in its economic life, Italy was largely dependent upon Germany for many chemical products prior to the war, its own chemical industry not having reached a high stage of development. Consequently, when the outbreak of the war interfered with its usual supply, a serious shortage of chemicals occurred, and as early as November, 1915, six months after Italy's entrance into the war, the Italian Minister of Industry, Commerce and Labor called a conference to discuss ways and means of overcoming this deficiency. In June, 1916, a permanent Committee for the Chemical Industry was appointed, which has been making a thorough study of the situation and compiling data regarding Italy's production, exportation, and importation of chemicals. From the first report of this committee, which has just been published, have been taken most of the figures which are given below. While in some instances these figures are only approximate, they indicate the progress which has been made by the Italian chemical industry and the degree to which Italy has been able to free itself from its former dependence upon foreign sources of supply.

The following table illustrates clearly the great strides made in Italy during the last few years:

Chemical Products	Average Monthly Production in 1914-15 Tons	Average Monthly Production in 1918 Tons
Fatty acids	285	520
Citric acid	75	150
Nitric acid	1,525	7,150
Concentrated ammonia liquors		1,484
Anilin and derivatives		110
Crude anthracene	15	38
Crude benzol		382
Pure benzol	9	358
Carbonate of lime	20	50
Carbonate of magnesium	14	92
Mineral tar		4,139
Vegetable tar	25	50
Chlorate of sodium	16	670
Liquid chlorine	15	75
Chloride of magnesium	3	20
Chloride of zinc		63
Mineral colors:		
Lead white	230	310
Zinc white	157	247
Minium	176	838
Ultramarine		13
Others	47	102
Total	610	1,510
Artificial organic colors:		
Sulphur colors	2	152
Other colors	2	13
Total	4	165
Tanning extracts	850	1,950
Sulphuric ether	56	315

Chemical Products	Average Monthly Production in 1914-15, Tons	Average Monthly Production in 1918, Tons
Phenol:		
Pure crystallized, synthetic phenol		408
Crude, for distillation of tar	[illegible]	25
Total	[illegible]	433
Crude phosphorus		50
Hyposulphite of sodium	20	100
Sublimated naphthalene	20	61
Nitrate of ammonia		655
Nitrate of lead	1	20
Nitrate of potassium	180	350
Oxide of aluminum	147	275
Wood pulp	100	650
Concentrated caustic soda	270	1,150
Caustic soda solution	660	2,360
Sulphate of ammonia	1,150	3,300
Sulphate of magnesium	87	125
Sulphate of copper	6,500	8,400
Anhydrous sulphate of sodium	1,150	1,460
Crystallized sulphate of sodium	770	900
Sulphite of sodium	2	30
Carbon disulphide	185	325
Acid tartrate of potassium (cream of tartar)	70	115
Carbon tetrachloride	10	74
Toluol		110
Xylol		18

The Gutta-Percha Industry

GUTTA-PERCHA is a jungle product, obtained from trees growing wild in tropical forests. Borneo, particularly Sarawak, supplies the largest quantities, although Sumatra and the Federated Malay States furnish a certain amount. Some efforts have been made to cultivate the gutta-percha tree on estates, but they do not appear to have been successful, which is due to the fact that the tree can thrive only in certain localities possessing the requisite humidity or rainfall and good drainage such as afforded by foothills, and these conditions occur very seldom outside of certain jungle areas. So far as can be learned there is only one district in Sarawak where gutta-percha trees have been cultivated with any success. This plantation has now been in existence about thirty years and is only just beginning to yield supplies in marketable quantities. In this connection it may be stated that about twenty years are required before the trees are in a fair way to produce. If trees are tapped earlier, the production is small and a great risk is run of the trees withering and dying before fully matured. This fact in itself would discourage the investment of any large capital in the industry, to say nothing of the extreme difficulty in successfully cultivating the trees outside of their native jungles.

Methods of Collection—Increase in Production

The milk of the gutta-percha is obtained by tapping, but in many cases the trees are cut down in order to obtain larger quantities. While this process does not actually destroy the life of the tree, inasmuch as new shoots will in time spring from the stump, it effectually cuts off the source of supply for many years. For this reason the felling of gutta-percha trees has, it is understood, been prohibited in Sarawak.

The latex is collected by natives, brought down to various villages, and bartered to the Chinese for rice, tapioca, salt, etc. At the present time, owing to the high cost of rice, the natives must collect considerably more than in former years in order to secure needed supplies of this staple article of diet.

The production of gutta-percha in the various districts in this section is estimated to have been between 450 and 500 long tons in 1918, while in 1919 it was between 600 and 700 tons. The production is regulated according to existing values, and, should prices advance, it is to be anticipated that for 1920 it will amount to 800 or 900 tons. It is known that the production of gutta-percha is stimulated by further special inducements being made to the natives, who are the actual collectors. Without such inducements it is not probable that any appreciable increase in the present output of the commodity will be effected.

Prices, and Factors Influencing Prices

As an example of the upward tendency in the prices asked for gutta-percha, it may be stated that "Pahang Red," which five years ago cost approximately $158 per picul (133⅓ lb.), rose to $312 at the close of 1919, with supplies even at this price practically unobtainable. Similarly, "Banjirmassin" increased from $85 to $142 during the same period, and this may be taken as a fair average of the advances made on all grades of gutta-percha during the past five years. It will thus be seen that increases of 80 to 100 per cent have taken place.

The local, as well as neighboring, press has recently published articles to the effect that projects were on foot looking to the construction of Pacific cables, in one instance from the United States to the Philippine Islands, and in another from the United States to Japan. Neither report has as yet been confirmed, but it is not unlikely that even rumors of this nature will have a tendency to stiffen the market, not only in view of the considerable quantities of gutta-percha that such an undertaking would require, but as a result of the keen competition that would set in.

Another point to be carefully borne in mind with regard to the production and cost of gutta-percha is the constantly increasing area of land under rubber, cocoanut, and tapioca cultivation. These new estates are well regulated and offer every inducement to the coolie type in the way of compensation and better standards of living. This class of work will, therefore, undoubtedly attract the native and coolie labor away from the jungle, and the clearing of so many tracts of land may mean the diminution of jungle areas and a consequent decrease in jungle products.

Imports and Exports at Singapore

Gutta-percha to the amount of 1,469 long tons, valued at $1,468,792, was imported into Singapore during the year 1918. Of this amount 1,372 tons, at a value of $1,358,764, were imported from the Dutch East Indies, while only 91 tons, valued at $107,431, were imported from British North Borneo, Sarawak, and the Federated Malay States.

Of gutta inferior, 5,243 tons, valued at $518,975, were imported into Singapore during the year 1918, most of which came from Dutch Borneo and Sarawak, Sumatra furnishing only 300 tons.

The following table shows the quantities, values, and countries of destination of gutta-percha and gutta inferior exported from Singapore during 1918:

Gutta-Percha

Countries of destination	Quantity Tons	Value
United Kingdom	1,596	$1,556,357
Canada	138	44,895
France	113	43,909
Italy	30	11,447
Japan	33	22,755
United States	1,230	362,736
Total	3,140	$2,042,099

Gutta Inferior

United Kingdom	99	9,539
Canada	71	6,365
Australia	17	1,797
Other British possessions	1	42
France	10	1,022
Japan	144	16,009
United States	834	89,959
Other foreign countries	2	227
Total	1,178	124,960

Copper Production in Sweden

The Swedish Government Board of Trade states that the production of copper in that country during 1918 amounted to 3,261 tons. Of this amount 4,740,651 lb. was of refined copper, made from "cement copper," valued at 14,542,340 crowns ($3,898,750 at normal rate of exchange); 1,769,570 lb. refined copper made from "bessemer copper," valued at 6,057,258 crowns ($1,626,610); and 12,969 lb. electrolytic copper, valued at 39,957 crowns ($10,712). These values are what may be called factory prices. The production of individual mines cannot for the present be stated.

A New Type of Catalyzer for Hydrogenation*

A Description of a Method of Preparing Finely Divided Nickel Catalyzer by Mechanical Grinding—Scientific Aspects of Abraded Nickel Catalyst—Water-Ground Material Superior

By W. D. RICHARDSON

THIS paper contains a description of mechanically prepared catalyzer for the hydrogenation of oils and for other processes in which metallic catalyzers are used, invented by Benjamin W. Elder, developed by W. B. Allbright of the Allbright-Nell Co., Chicago, and put on a practical operating basis in the writer's laboratory.

This catalyzer differs fundamentally in its method of preparation from catalyzers previously used and is not only of importance in a practical way but is of perhaps even greater scientific importance as a contribution to the theory of catalyzer activity. The process and product are covered by the Elder patents, assigned to the Allbright-Nell Co. of Chicago, Nos. 1,331,903, 1,331,904, 1,331,905 and 1,331,906 of Feb. 24, 1920, and by pending applications.

In March, 1917, there appeared at the laboratory of Swift & Co. a short, stocky, bronze-complexioned man of middle age who was introduced by W. B. Allbright, his companion, as Benjamin W. Elder, recently of Torreon, Mexico. This meeting was the result of previously made arrangements according to which Mr. Elder's process was to be further developed and worked on a practical commercial scale.

Mr. Elder brought with him the simple and primitive appliance which was one of those by which he first proved that an effective and active nickel catalyzer for the hydrogenation of oil could be made by the action of an abrasive upon bulk nickel.

Initial Work on Grinding Nickel

This apparatus consisted of a nickel plate about 12 in. square and $\frac{1}{16}$ in. thick, firmly fixed by screws placed at the corners to a wood block of the same dimensions and $\frac{3}{4}$ in. thick. The other member of his apparatus consisted of a metal sheet or plate measuring about 2 x 2½ x ⅛ in. and screwed to a wooden handle. In order to operate with this apparatus Mr. Elder coated the plate with an oil, such as cottonseed oil, placed thereon a sufficient amount of abrasive, such for example as 200-mesh ground sand or silica, and then, by a process of rubbing the small plate upon the large one with the oil and abrasive between, produced in time finely divided, mechanically prepared, metallic nickel, which upon trial proved to be an active and effective catalyzer for the hydrogenation of oils.

This was not actually the very first apparatus used by Mr. Elder. An earlier one is described in a letter to the writer dated at Los Angeles, April 6, which reads in part as follows:

> It was the unpleasant and dangerous experiences that I had encountered in reducing catalyzers that first made me think of trying to produce "nickel in a finely divided state" mechanically.
>
> Observing closely the oil from a journal bearing encouraged me to give more thought to the subject. I noted that the abraded metal in the waste oil was so fine that it was difficult to thoroughly remove it from my hands.
>
> I finally concluded that what I would really have to do was to design some method of grinding the nickel in the oil that I intended to harden while the oil was hot in a tank that was supplied with hydrogen. I was living in Torreon at that time and Villa was making things so hot that I concluded to get out if possible to the States, but I only got as far as Monterey, where I met a student at one of the colleges, who offered to get me a piece of sheet nickel from the college laboratory.
>
> I finally completed my apparatus, which consisted of a small tank that could be heated externally. In the bottom of the tank I fastened the piece of sheet nickel. Resting on the nickel was a carpenter's oilstone which could be turned by a shaft that passed through the top of the tank. There were the necessary valves for oil and hydrogen, etc. With this crude apparatus I made four or five trials, using about 3 gal. of cottonseed oil before I got things in shape and the apparatus tight. The last trial I made with this apparatus, I think, I had a peon turning the crank that actuated the stone and watching the temperature, while another was attending the gas producer. I think I kept this going three days, as the oil was getting darker each day from the fine nickel that was present, and when the sample of the third day cooked down I was sure that the oil had apparently hardened somewhat.
>
> The next day Carranza attacked the town and my little laboratory was burned down, but several days later I removed some of the wreckage and secured some of the oil from the tank, and then I knew for sure that I had done some work.
>
> Shortly afterward I returned to the States, and it was while I was working for the Allbright-Nell Co. that I mentioned to W. B. Allbright my experiences in trying to produce a nickel catalyzer mechanically. Mr. Allbright offered to finance me if I would continue the line of investigation and I accepted his very kind offer.
>
> After several months trying all kinds of abrasives, I suddenly remembered the black oil from the journal box, and it was not long before I was grinding a mixture of oil and finely ground quartz. After several trials I was sure I was on the right track. I next secured a sheet of nickel about 12 in. square and with a piece of old anode for a rubber or scrubber I was able to produce a catalyzer that would harden cottonseed oil in five or six hours.
>
> During all this time I was greatly encouraged by the cheerfulness of Mr. Allbright, and many very interesting experiments that he suggested were carried out. I think he suggested to me to use an ordinary closed tumbler or tube mill filled with grain nickel, oil and finely ground quartz. In the tumbler we tried out an atmosphere of hydrogen, also carbon dioxide.
>
> There were some features about the catalyzer that we did not fully understand, and at this stage of the game we applied to W. D. Richardson, chief chemist of Swift & Co., to assist in putting on the finishing touches and rounding off the corners that had troubled us so sorely towards the end.
>
> The time I spent with Mr. Richardson and his assistants satisfied me that they were as enthusiastic as Mr. Allbright and myself regarding the possibilities of a mechanically produced catalyzer, and especially was I satisfied that what I had set out to do had been accomplished.

At this point I should like to make a few observations in retrospect upon the Elder process. In the first

*A paper read at the St. Louis meeting of the American Chemical Society, April, 1920, Division of Industrial Chemists and Chemical Engineers, and published by permission of the Society.

place, you will notice that Mr. Elder had the courage of his convictions, which the great majority of chemists have not. We have been talking for years about finely divided nickel and other metals as catalysts, but no one before Mr. Elder had the sagacity and courage to prepare finely divided nickel by the simplest and most practical means. In short, we have all talked about finely divided nickel and finely divided metals as catalysts, but did not produce catalysts in the way suggested by our words, namely, by taking bulk metal and subjecting it to a process which would actually finely divide it in the precise meaning of those words. On the contrary, our so-called finely divided catalyzers have been produced in the past by a reduction in a chemical way of metallic salts, oxides and other compounds.

As a second observation, it appears after Mr. Elder's invention that whenever anyone of us took the trouble to whet his pocket-knife upon an oilstone he produced catalytic material, in this case catalytic iron, and furthermore, that all used lubricating oils which have been used to lubricate the surfaces of iron and more noble metals contain after a period of time finely divided catalytic material, although probably in most cases contaminated by carbon, sulphur and other substances sufficient to reduce the catalytic activity by a considerable amount.

Mr. Elder used the catalytic nickel prepared by him with the simple apparatus I have described to hydrogenize cottonseed oil in a laboratory way. The catalytic material produced in this small apparatus consisted naturally of a suspension of the finely divided metallic catalyst in oil, together with a certain amount of the abrasive. The longer the rubbing or abrading process was continued, the greater would be the relative portion of metal contained in the suspension. If the abrasive action was continued for a short time only, then the abrasive would predominate in the mixture. Mr. Elder also prepared catalyzer in dry form by abrading nickel surfaces with a suitable dry abrasive in the absence of oil. This catalyzer was found to be active, but not as active as catalyzer prepared in oil.

Grinding With Counter Rotating Disks

Naturally the amount of catalyst which could be produced by man power applied to Mr. Elder's first apparatus within a reasonable length of time was very small, and hence Mr. Elder approached Mr. Allbright with the view of making arrangements for working upon a larger scale. With this end in view an apparatus was made consisting of two disks of nickel made to rotate in opposite directions by mechanical means and to the opposed surfaces of which hot oil could be supplied. The friction of one plate upon the other caused finely divided nickel to be rubbed off into the oil and thus catalytic material was produced, but the amount was too small within a reasonable length of time to make this method of production a practical one.

Tube Mill With Nickel Shot

As a further step a cast-iron tumbling mill was then made in which nickel shot was placed, together with a suitable abrasive and oil, and the entire mill rotated until a sufficient amount of catalytic material was obtained. This cast-iron mill was of a special shape designed to give maximum abrasion. It measured about 3 ft. in diameter and was 2 ft. long, measured along the shaft. It was soon found that the cast-iron mill did not produce the most desirable catalyzer for the reason that the abrasive acted not only upon the nickel shot contained in the mill but upon the sides and surfaces of the mill itself to such an extent that the final catalyzer obtained might contain as much as 60 parts of cast iron and carbon derived therefrom to 40 parts of nickel. This was the extent of the development of Mr. Elder's process as carried on by W. B. Allbright working with Mr. Elder in the plant of the Allbright-Nell Co., Chicago. The process was then turned over to the writer for further development in the Swift & Co. laboratories and plant.

After preliminary trials in the laboratory with small porcelain pebble mills, larger tumbling or pebble mills of the Abbé type were installed and these, in order to avoid contamination by iron admixture, were lined with porcelain brick. These mills measured about 5 ft. in diameter by 5 ft. long and were capable of holding a considerable charge of nickel shot.

Several Types of Abrasives Tried

In the laboratory and also in the larger mills all sorts of abrasives were tried—ground quartz of various mesh, ground pumice, carborundum, alundum, diatomaceous earth, etc. It was even found that a first-class catalyzer could be obtained with no abrasive at all, the friction of nickel shot on nickel finally resulting in the production of excellent catalytic material. During the course of the tumbling it was to be expected that a certain amount of the porcelain lining would become abraded and mixed with the catalytic material and abrasive. This admixture was not harmful to the catalytic activity of the finely divided metal, but from time to time the mills had to be relined. No attempt was made to separate the catalytic metal from the admixed abrasive. Many batches of oil were hydrogenized with the catalytic material just as it was removed from the mills and no adverse results were experienced from the presence of the abrasive or abraded mill lining. Mechanical catalyzer was prepared by the Elder process both in the presence of air and of hydrogen and no great practical difference in activity in the two cases resulted.

Since a semi-drying oil was generally used in the mill, any atmospheric oxygen in the mill was usually absorbed by the oil during the course of the run, so that by far the greater portion of the catalytic material was actually prepared in the presence of nitrogen only, in this case. One other method of preparation, namely, by grinding in the presence of water instead of in the presence of oil, was made use of, and this produced a more active catalyzer, as will be described further on after a consideration of the original Elder catalyzer ground in oil.

A Nickel Mill

An ideal mill for the preparation of metallic catalyzer by abrasion would be constructed with a lining of the same kind of metal as the charge and the desired catalyzer. For the preparation of nickel catalyzer, the lining of the mill would consist of nickel plates, preferably of sufficient thickness so that they could be wedged into place against the circular periphery of the mill. The side plates would have to be screwed or bolted on, and if thinner plates were used, these plates would naturally have to be screwed or bolted to the casing at all surfaces. Such a mill would undoubtedly produce a very much larger yield of active catalyzer than a

porcelain-lined mill and would have the further advantage of avoiding additional contamination of silica or silicates from the lining. Although this contamination does not injuriously affect the catalyzer, it necessarily does dilute it beyond the dilution which would be determined by the introduced abrasive alone. The metallic linings would have to be replaced from time to time when they were worn too thin, but there would be no loss of nickel, since the removed plates could be cut into small cubes or melted into shot and reintroduced as a part of the charge.

The Elder Nickel Catalyzer

Under the microscope the Elder catalyzer is seen to consist of minute, opaque metallic particles usually but not invariably characterized by straight line edges and sharp angles. They are of various sizes, depending on the abrasive used and the length of time used in their preparation. Often they appear to be in the form of thin plates and some of them remain unattached, while others clump themselves into groups or lines. The particles have a distinctly metallic appearance as contrasted with the translucent or transparent appearance of some chemically prepared catalyzers of extremely high activity.

In activity the Elder catalyzer ranks very high, and this apparently can be increased indefinitely by long-continued abrasion. It is obvious, however, that there is a practical time limit to the operation and under ordinary operating conditions this cannot with economy be exceeded. It varies according to the type of mill used, the abrasive used, the amount of oil used, etc. It can be made to approach very closely to chemical catalyzer of the highest activity, although it is probable that chemical methods produce somewhat more active catalyzer under practical working conditions than that capable of being produced mechanically. However, it is very much superior to slow-acting chemically prepared metallic catalyzer and to much of the catalyzer that has been used in the past regularly for hydrogenation as well as for other purposes.

Action of Mechanically Prepared Nickel Catalyzer

The action of mechanically prepared nickel catalyzer in the hydrogenation of oils is somewhat different from that of other catalyzers of the same activity. The chemically prepared catalyzers for the most part when introduced into an oil in the presence of hydrogen show almost their highest activity at the start, that is, they may increase in activity by a small amount only, before the activity curve begins to fall. As contrasted with this form of curve, the Elder catalyzer activity curve shows a considerable rise at the commencement of hydrogenation which may last for some time before the curve reaches its peak and begins to decline.

The catalyzer can be used over and over a number of times like other active catalyzer. The usual method of recovery for re-use is by means of filter pressing. In the case of highly refined edible oils, the catalyzer may be recovered and used again for from five to ten or even twenty runs; in the case of lower grade oils, the catalyzer is killed after a much shorter period of use in the same manner as other metallic catalyzers and doubtless by the same means. There always seems to be a noticeable amount of combined sulphur present in dead catalyzers, and without doubt sulphur is one of the active poisoning agents.

The final recovery of the nickel catalyzer made by the Elder process is by means of fusion in a small oil- or gas-fired furnace. The filter pressed catalyzer with its attendant abrasive is first freed of fat by extraction or by burning, then mixed with a suitable flux and introduced into the furnace. The nickel becomes molten and can be recovered in the form of shot by running into water in the usual manner.

The fact that the abraded portions of the bulk nickel or nickel shot consist of catalytic material naturally suggests as a corollary that the abraded surfaces of the nickel shot or bulk nickel itself are also catalytic, and this is the fact. The shot, therefore, after abrasion could be used for hydrogenation in a hydrogenation tower and could be reactivated by the very simple process of removal from the tower and introduction into the abrasion mill.

Simultaneous Grinding and Hydrogenating

Mr. Elder, in one of his patents, describes another ingenious application of his process. He maintains the catalytic material in a state of continued activity by conducting the hydrogenation process in the abrasion mill itself. Under such circumstances a continuous supply of active catalytic material is afforded and the activity of the catlyzer therefore cannot run down. The rate of chemical action is limited only according to the law of mass action and not by the poisoning of the catalyzer. I do not mean to suggest by this that poisoning does not occur, but only that it is not effective, inasmuch as a fresh supply of active catalytic material is continuously furnished.

Scientific Aspects of Abraded Nickel Catalyst

The type of catalyzer which I have described is not only of the greatest interest and importance in a practical way for the hydrogenation of oils and for other industrial catalytic reactions, but may be considered perhaps even more important for the theory of catalysis. That theory, particularly wherein it deals with metallic catalyzers, has emphasized the fact that the catalytic action was a surface action and presumably proportionally to the total surface of the catalytic metal or metal particles. Nevertheless, in the past metallic catalysts have been made universally by chemical means and while it was known that when working by reduction processes metallic catalysts in a very fine state of subdivision were obtained, the extent of the surface was to a large degree beyond control and it would have been difficult working by chemical means to obtain catalysts consisting of graded particles of different sizes and with different ratios of surface to mass. By the abrasion method catalysts of every degree of activity can readily be obtained from coarse, slowly acting catalysts to those of the utmost fineness, surface extension and activity.

Another point of the greatest interest is the fact that when the abrasion method is used there can be no doubt about the metallic character of the product. In the case of nickel catalyzer designed for hydrogenation and prepared by the chemical methods, it has been claimed by one school of theorists that the active particles do not consists of metallic nickel but of a sub oxide of nickel and that in the true metallic condition finely divided nickel is unsuited for the purpose of hydrogenation.

The abrasion method for preparing nickel catalyst

proves beyond question that finely divided metallic nickel obtained from bulk nickel by purely mechanical means is an active catalyst for the hydrogenation of oils and other hydrogenation reactions. The nickel particles so prepared (as described above) are decidedly opaque and metallic in appearance under the microscope. They also become decidedly magnetic when placed in a magnetic field and thereafter tend to group themselves end to end in chains as might be expected, while, under the influence of a bar or horseshoe magnet, the particles group themselves along the Faraday lines of force as do iron filings.

Effect of Temperature on the Activity of Metallic Catalyzer

The statement has been made and reiterated in the chemical literature that nickel catalyst must be prepared at a low temperature to be active, the temperature favored for the reduction of nickel oxide, for example, being about 300 deg. C. and preferably lower if effective reduction conditions can be maintained at a lower temperature. The facts in the case of chemically prepared reduced catalyzer are well established. If high temperatures are used for the production of such catalyzer, an inactive product is obtained, but the underlying assumption that heat treatment in and of itself must of necessity produce an inactive catalyst appears unwarranted in the light shed by Mr. Elder's discovery. The nickel shot or the nickel plates used for the production of this catalyst have been subjected to a temperature above the melting point of nickel, let us say above 1,470 deg. C. All of the catalyzer particles have been heated to this temperature, but it has not had the effect of deadening their activity. Our views, therefore, in regard to the effect of high temperatures on metallic catalyzers will have to be modified in conformity with these new facts established by mechanically prepared metallic catalysts.

Water-Ground Catalyst More Effective

I should like to conclude my paper at this point, having shown definitely and conclusively that nickel catalyzer prepared by the abrasion process and in the metallic condition and having been subjected to a high temperature is a decidedly active catalyst, but as a matter of fact, working in our laboratory and plant on the development of mechanically prepared catalysts, we were able to produce a still more effective catalyst by substituting water in the abrasion mill for oil. Catalyzer prepared in the presence of water has the disadvantage of necessitating the removal of the water and the substitution of oil therefor prior to the introduction of the catalyst into the hydrogenation apparatus or converter. This, however, was not especially difficult or expensive. The catalyzer produced in the presence of water was definitely, decidedly and invariably more active than that prepared by grinding in oil. Various explanations for this increased activity may be assumed:

1. That in the presence of water the abrading action produced a more finely divided catalyst.

2. That there would not likely be any catalyzer poisons in the water which might on the other hand be present in any oil produced.

3. That by grinding in water and in the presence of air a film of sub-oxide is formed on the catalyzer particles.

The last explanation may be the true one[1] and if so we are once more confronted with the importance of the sub-oxide theory and forced to conclude (if this explanation is correct) that while nickel in the metallic condition will catalyze hydrogenation reactions, nickel coated with a sub-oxide layer will catalyze at a still more active rate. However, a comparison should be made at this point between mechanical catalyzer prepared in water and by dry abrasive in air with no fluid medium present. In the last-mentioned case an active catalyzer was produced, but one much less active than the two other types mentioned. Apparently, therefore, too much oxidation during preparation is injurious, and if a sub-oxide film increases the activity of nickel catalyzer, this film must be kept within the narrowest limits if the most active type of catalyst is desired.

Sub-Oxide Theory

In considering the sub-oxide or oxygen-layer theory, it should be remembered and emphasized that we are dealing with a hyrogen reaction and that to bring this reaction about, the catalyst, whether nickel or palladium or other metal, must have, or does have, large volumes of hydrogen occluded on its surface and below the surface. It is difficult to believe that any oxygen or oxide could long persist under this condition and at the relatively high temperature employed in hydrogenation, but on the other hand, the reduction of the oxide or oxygen-layer might result in an increase of surface by roughening or furrowing, and if this hypothesis is correct, metallic nickel would still be the active agent, a larger surface having been obtained by alternate oxidation and reduction. Again, the oxygen might have the effect of offsetting the influence of certain poisons such as sulphur (sulphides), which when exposed would not again be reduced under the conditions of the reaction, as is well known. Sulphates, such as calcium sulphate, sodium sulphate, nickel sulphate, etc., have been found to be quite without adverse effect or any effect at all in the hydrogenation of oils.

Conclusion

In this paper I have not attempted to give a complete exposition of the preparation of metallic catalyzers by mechanical means, but only to touch upon the more important points. They are comparatively new in industry and have not as yet had the widest use. They must commend themselves for the simplicity, certainty and directness of their preparation and for their necessary uniformity. They will undoubtedly prove useful in developing the theory of catalytic activity.

In conclusion, acknowledgment is made to Paul Escher and G. W. Phelps of the Swift & Co. laboratory force for assistance in developing the catalyzer.

Laboratory of Swift & Co.,
Chicago, Ill.

[1] In this connection compare Rupert: "The Effect of Surface Oxidation on Some Metallic Catalysts," *J. Am. Chem. Soc.*, vol. 42, p. 402, March, 1920. References to the previous literature are given.

Sheffield Uses Films to Push Steel Trade

Sheffield, the great center of British engineering, is utilizing the film to promote the British steel industry and to develop British export trade in steel products.

A series of films will be shown this year in eighty-six of the principal cities of western Europe, America and the British colonies, which, experts consider, will be a fine advertisement.

Volatilization in Assaying*

Losses Often Ascribed to Volatilization Caused by Excessive Temperatures Are Usually Due to Dusting and Other Mechanical Causes—A Review of the Literature Published on Losses Due to Volatilization for Gold, Silver, Lead

BY FREDERIC P. DEWEY†

IT IS common to blame irregular assay results upon volatilization, and much has been written upon the subject, but there is no real evidence that in a properly conducted assay, the loss of either gold or silver by volatilization is sufficient to affect appreciably the result, even when arsenic or antimony may be present. Bulk assays of flue dust from assay muffles have been published, but the data given are totally insufficient to even approximate the volatilization from a single assay; and such figures as we have indicate the volatilization to be extremely small. Diligent search in the literature and wide inquiry among assayers and instructors have failed to produce a single case where the litharge volatilized in making an assay has been collected and assayed for gold and silver. Having attempted to do this, with most indifferent success, I am not surprised that this has not been done.

While various textbooks give volatilization as a cause of loss in cupellation, it may safely be said that in the rare cases where the volatilization is sufficient to affect appreciably the result it is due to excessive temperature. Percy[1] says, "The loss of silver by volatilization during cupellation is very slight (unless the temperature has been much too high), and may be disregarded." This statement is repeated by the Beringers[2] and Smith,[3] who include gold and silver. Mitchell[4] says that litharge fume rarely contains over one ten-thousandth of silver. Campredon[5] says that at a proper temperature no silver is lost by volatilization.

Primarily, excessive temperatures may be due to too high general temperature in the muffle; but it may often be due to temperature localized within the bead by oxidation of the metals, and this may be influenced by other causes than the general temperature. I have shown an extreme case of local temperature,[6] resulting in the burning of zinc with its characteristic flame and variations in bead temperatures with uniform pyrometer readings. Volatilization from a bath of mixed metals is not the simple question of vapor pressures of the contained metals. Based entirely upon vapor pressures, Richards,[7] in speaking of the distillation of zinc from Parkes crust, says, "Successively larger amounts of lead, silver and gold come over the higher the temperatures," but I have shown that more silver goes with the zinc in the early stages of the operation than later.

The possible volatilization of the precious metals in cupelling is the most complex proposition. It may be due to the vapor pressure of the individual metals, the vapor pressure of alloys or possible metallic compounds, of compounds of metals with metalloids or with non-metals, particularly oxygen. Also it is not possible to draw a sharp line between true volatilization due to vapor pressure and the drag of a volatilizing body exerted upon a less volatile associate, against which is the counter-drag, or stabilizing effect, of the non-volatile upon the more volatile, all of which are influenced by concentration and association. The temperature conditions of the cupelling beads vary constantly, which may change any or all of these conditions. The oxygen supply influences them. Even more important, perhaps, is the extent to which the surface of the metal is covered and protected by the litharge formed. At moderate heats much of the button surface is covered by the litharge and the opportunity for direct volatilization of the metals reduced. Intimately connected with this is the question of secondary volatilization, oxide of lead being volatile, oxide of silver may be dragged along, even if it is not covolatile. No one knows how much, if any, of the lead, or any other metal, present in cupel fumes volatilized before oxidation.

Rose[9] suggests that gold and copper go off as "vaporized alloy" and Mitchell[10] says silver is much more volatile when alloyed with lead. Wright[11] bessemerized silver bullion high in arsenic and the arsenious oxide produced showed about 800 oz. silver per ton. I have roasted rich arsenide ores[12] at a very low temperature and the arsenious oxide given off showed only a few ounces of silver per ton. Mitchell[13] says the litharge fume in cupelling is "produced by the vapor of lead burning in the atmosphere," but gives no data.

Again, other questions of molecular physics are involved. Keller[14] has shown that gold travels into copper on prolonged heating of the alloy below its melting point. So the rate at which the precious metals withdrawn into the cupelling bead must affect the drag. Gillett[15] says that on heating brass, loss of zinc depends, in part, "on the rate of diffusion of zinc from the body of the melt into the surface that is losing zinc."

LOSS THROUGH DUSTING

Many statements regarding volatilization in assaying are based upon data obtained under conditions entirely different from cupelling, and much that has been written

Copyright, 1920, by the American Institute of Mining and Metallurgical Engineers, Inc.

*A paper read at the New York meeting of the A. I. M. E., February, 1920. Published by permission of the Director of the Mint.

†Assayer, Bureau of the Mint.

[1]John Percy: "Metallurgy—Silver and Gold." Pt. I, p. 249. London, 1880.

[2]C. and J. J. Beringer: "Text-book of Assaying," p. 101. London, 1908.

[3]Alfred E. Smith: "Sampling and Assay of Precious Metals," p. 170. London, 1913.

[4]John Mitchell: "Manual of Practical Assaying," p. 484. N. Y., 1872.

[5]L. Campredon: "Guide Partique du Chimiste Métallurgists et de l'Essayeur," p. 305. Paris, 1909.

[6]*Trans.*, A. I. M. E. (1918), vol. 58, pp. 85, 89.

[7]*J. Frank. Inst.* (1919), vol. 187, p. 595.

[9]*Eng. & Mining J.* (1919), vol. 108, p. 87.

[9]*J. Chem. Soc.* (1893), vol. 63, p. 723.

[10]*Op. cit.*, p. 484.

[11]*Eng. & Mining J.* (1918), vol. 107, p. 263, from *Trans.* Can. Min. Inst. (1918), p. 992.

[12]*Eng. & Mining J.* (1919), vol. 108, p. 87.

[13]"Manual of Practical Assaying," p. 558. 1881

[14]*Bull.* 145, A. I. M. E. (January, 1919), p. 83.

[15]U. S. Bureau of Mines *Bull.* 73 (1916), p. 125.

fails to distinguish between volatilization and dusting, which is purely mechanical. In practical operations, losses are often ascribed to volatilization that are largely, if not entirely, due to dusting and other mechanical causes.

In modern practical work, there is now probably very little straight cupellation of lead. Where works have lead rich enough to cupel, advantage is generally taken of this to work up other high-grade products, rich ores, slimes, etc. Much of the extremely rich silver ore from Cobalt, Ont., has been treated in this way. These additions, particularly very fine slimes, favor dusting and high silver in fume or dust collected from cupelling furnaces does not prove high volatilization. Iles[16] gives many figures on fumes and dusts from various sources. A mixed cupel fume showed 85.90 oz. silver per ton; this might indicate volatilization, but the fact that it was only 72.50 per cent lead showed dusting, oxide of lead containing 92.83 per cent lead.

Mr. Dieffenbach[17] has furnished a month's record of the results from the Cottrell condensers on the cupel furnaces. The fume collected weighed 24,659 lb. and contained 9,863 lb. lead, or approximately 40 per cent, indicating much dust. This is accounted for by the fact that about 70 tons of slimes was treated on the lead bath. The fume contained 5,830.11 oz. silver, or 0.64 per cent of the silver charged. In view of so much mechanical dusting of rich stuff, the actual volatilization must have been very small. The slimes charged contained nearly 555,000 oz. silver. In a negative way, the figures show that there was practically no volatilization of gold, for notwithstanding the dusting, only 12.07 oz. gold was found in the fume out of 16,855 oz. charged, of which over 13,000 oz. was in the slimes.

Condensation of Assay Muffle Fumes

Various persons have reported the finding of gold and silver in the fumes condensed in the flues of muffles, but these generally show only minute quantities of the precious metals and all lack quantitative significance. Smoot[18] says, "We assayed the condensed fumes from the muffle ventilation pipe and found only a very small amount of silver and practically no gold," and "This seems to indicate, in a qualitative way, that only a negligible amount of silver is lost in the lead fume."

The best figures that I know of regarding the condensation of assay muffle fumes have been supplied by Donald M. Liddell. One muffle was used only in pig copper assay by the combination method. It carried very close to 90 oz. per ton, and the residue from one assay-ton, after burning off the paper, was scorified with one assay-ton lead down to about 7 g., which was cupelled in the same muffle. The muffle had a small forced-draft apparatus at the back and all fume passed through an iron pipe, which formed a fairly efficient condenser. This pipe was cleaned out every six months, during which time about 5,500 assays were made, yielding about 175 g. of litharge. One lot of 175 g. gave 142.7 mg. silver, but not enough gold to weigh. This would roughly mean the volatilization of about 0.026 mg. silver per assay, or approximately 0.03 per cent. It would seem fair to divide this between the scorification and cupelling, estimating the cupel volatilization as 0.015 per cent.

[16] *Sch. Mines Qr.* (1899), vol. 20, p. 397.
[17] Superintendent of the Balbach Smelting & Refining Co., Newark, N. J.
[18] Personal letter.

Johnston[19] has published a most valuable review on the vapor pressure and volatility of several high boiling-point metals, giving many references, particularly of exact scientific investigations. The ultimate object of this paper was to devise a formula for determining the approximate volatility of various metals at different temperatures. The data regarding gold, however, were too scanty for this. There is absolutely no connection between melting point, vapor pressure, and boiling point. Various metals show vapor pressure below their melting point. Tin, with a melting point of 232 deg., is said to boil at about 2,300 deg., while copper, with a melting point of 1,083 deg., is said to boil about 100 deg. above tin.

Volatility of Gold

Varied statements have been made regarding the volatility of gold. Gmelin[20] says, "It exhibits a scarcely perceptible volatility at the strongest heat of a blast furnace, in the focus of a burning mirror, and in a flame fed with oxygen gas." Napier[21] appears to have been the first to make systematic tests and is often quoted, but his figures are small, about 0.1 per cent, and the time of heating long, 3 to 8 hr. Makins[22] is often quoted, but his figures are extremely small, even though an extraordinary heat was used in the cupellations; there is no connection with the amount of gold operated on; he simply found 0.087 g. of gold in 1,000 g. of flue dust. The volatility of gold before the extreme heat of the blowpipe is described in Crookes.[23]

Seamon and Parker[24] heated beads of gold, 1 to 20 mg., varying periods of time, to temperatures from 1,000 to 1,650 deg. Losses were observed only twice and were attributed to unobserved errors of manipulation. Under the conditions of a cathode-ray vacuum, on prolonged heating, Krafft and Bergfeld[25] were able to observe volatilization of gold at 1,070 deg. Moissan[26] places the boiling point at 2,530 deg. Mostowitch and Pletneff[27] state that in oxygen, nitrogen, carbon monoxide, and carbon dioxide at 1,400 deg. volatilization is not appreciable, but is noticeable at 1,250 deg. in hydrogen. Kern and Heimrod[28] made extensive tests on the volatility of gold and silver, obtaining some interesting results, but their conditions were quite different from cupellation. Many hours heating in contact with carbon did not volatilize silver from copper, but did volatilize gold from copper, possibly by the formation of a carbide of gold. Incidentally, their quotation from Napier is faulty. Wurtz[29] gives a review of early information.

T. K. Rose has been a prolific investigator of this subject and his books and papers contain many references. In 1893 he stated[30] that volatilization of gold begins just below 1,100 deg. and at 1,250 deg. the loss per min. was four times as great as at 1,100 deg., the loss on a charge of 1,200 oz. was figured to be 0.02 per cent per hr.; the volatilization in cupellation was insignificant. Later he says[31] that the loss in an ordinary melting furnace is

[19] *J. Ind. Eng. Chem.* (1917), vol. 9, p. 873.
[20] Leopold Gmelin: "Handbook of Chemistry," tr. by H. Watts; vol. 6, p. 205. London. 1852.
[21] *J. Chem. Soc.* (1858), vol. 10, p. 229.
[22] *J. Chem. Soc.* (1861), vol. 13, pp. 98-9.
[23] "Select Methods," p. 443. 1886.
[24] *Bull.* Missouri Min. Club (1895), vol. 1, p. 16.
[25] *Ber.* (1905), vol. 38, p. 254.
[26] *Compt. Rend.* (1905), vol. 141, p. 977.
[27] *J. Russ. Met. Soc.* (1915), p. 410, Abs. Met. & Chem. Eng., (1917), vol. 16, p. 153.
[28] *Sch. Mines Qr.*, vol. 33, pp. 34-64.
[29] *Eng. & Mining J.* (1885), vol. 40, p. 126.
[30] *J. Chem. Soc.* (1893), vol. 62, p. 714.
[31] *Ann. Rpt.* British Mint (1906), p. 60; Abs. *Eng. & Mining J.* (1907), vol. 84, p. 297.

seldom over 0.01 per cent on 1,200 oz. and is influenced by temperature, metal surface exposed, and time, and is increased by air passing over the metal and by impurities. Still later[32] he says, "True volatilization of gold is so small as to be negligible at the temperature of industrial melting furnaces, say 1,000 to 1,300 deg. It is difficult to measure with accuracy the infinitesimal amounts volatilized at these temperatures." "Even in a strong draft the amount volatilized remains exceedingly small" provided the nature of the gas does not change. Alloys, however, may take up and eject gases with spurting, which may give globules less than 0.001 mm. in diameter, which may be carried away by even a slight draft and are difficult to recover. The first table of results, p. 4, is an excellent illustration of a fact I have often met in the literature and in my own experience with gold; that is, the effect of unrecognized conditions leading to erratic results when expecting regularity.

In a paper on accuracy in assaying, Rose[33] attempted to follow the course of the gold and gives results from which he concludes that while final loss is shown in each case it does not represent the amount volatilized with certainty, errors of five determinations being accumulated here. I would add that he determined the silver and other metals left in his cornets in a lump by a reassay, which must have been subject to all the errors of the original assay.

Hillebrand and Allen[34] give some figures upon volatilization, but they exhibit serious irregularities. On gold alone two cupel recoveries exceeded the total loss and the volatilization figure on No. 4 cupel was more than twice No. 6, two cupels behind. In series B, Table IX, 15 mg. gold, 45 mg. silver, No. 3 showed a higher figure for gold volatilization than No. 6, three cupels behind it in the furnace, and on silver No. 4 showed more than No. 6. While the total losses show considerable regularity from front to back of the furnace, the ratios between volatilization and absorption are erratic. The possibility of losing gold mechanically in decanting and washing was not provided for in the volatilization tests.

Schneider[35] attempted to determine volatilization by cupelling 450 mg. gold, 50 mg. copper, 1,200 mg. silver, 4 g. lead, recupelling the resulting bead with 4 g. lead and repeating eight times. When properly carried out, this method might give a good approximate, but Schneider generalized as to some of his figures and assumed that no gold went into his nitric acid, although he assayed the ten cupels for gold and silver absorbed.

I have done considerable work in trying to arrive at a figure on volatilization of gold in cupellation by the examination of the products of the operation. No determination of volatilization depending in any way on the weight alone of a bead or cornet can be convincing. The normal bead is never pure precious metal. Cornets always carry silver and copper and often lead. Gold goes into the parting acid and into the cupel. After actually determining these items and balancing the results, we get a figure which might be called volatilization, but it is a different figure and bears the errors, both plus and minus, of much analytical work; therefore it must be handled with judgment. Sometimes the figure indicates an appreciable loss; sometimes it gives practically a balance, indicating no loss; a gain also has been shown.

All these points are shown in one test. The San Francisco mint prepared an ingot of standard gold, 900 gold 100 copper, for test purposes. It was extremely close to 900 fine in gold. Three sets of nine assays, three rows of three, were run at three temperatures, the regular heat for this work, very low, and very high. The regular heat showed a slight loss of gold. The very low heat showed a gain. The very high heat, which should have favored volatilization of the gold, gave practically a balance, the figures showing a loss of only 0.005 mg. for the set. The figures are as follows:

	Regular Heat, Mg.	Very Low Heat, Mg	Very High Heat, Mg
Silver in cornets	3 51	3 55	3 02
Copper in cornets	0 31	0 23	0 32
Lead in cornets	trace	trace	trace
Total in cornets	3 82	3 78	3 34
Cornet weight	1 575+	2 35+	2 425–
Gold lacking	2 445	1 23	5 765
Gold from solution	0 125	0 20	0 200
Gold from cupels	2 14	1 49	5 56
Balance	0 18	0 46+	0 005–

From these figures it is evident that there is no necessity for running coin gold, and by fair inference fine gold, at such a heat as to favor the volatilizing of gold during cupellation. The high loss of weight of the cornets at the very high temperature could not be tolerated as a regular practice and such a temperature would not be used regularly.

Volatility of Silver

Silver is far more volatile than gold. Gmelin[36] states that it boils by the burning mirror when it rises in white fumes and that it volatilizes in an open crucible at incipient white heat, but not if covered with charcoal dust. In a cathode-ray vacuum, Krafft and Bergfeld[37] observed volatilization at 680 deg. Johnston[38] gives its melting point at 960 deg. and its boiling point at 2,090 deg. He calculates that it has a vapor pressure of 10^{-3} mm. at 920 deg. and 1 mm. at 1,320 deg. In his atomic-weight work, Stas[39] distilled silver to purify it.

Richards[40] proposed to separate silver from blowpipe beads by volatilization. Over 95 per cent of the silver was to be removed by heating before a sharp-pointed oxidizing flame to 1,100-1,200 deg. estimated and the balance removed at about 1,500 deg. estimated, at which temperature the gold begins to volatilize. In a subsequent paper,[41] on measuring buttons, he said, "It is difficult to drive off all the silver, as the last 5 to 10 per cent volatilize slowly and probably also take a little gold with them," furnishing an excellent illustration of the drag of a volatilizing metal upon a less volatile associate as well as the stabilizing effect of a less volatile metal upon a volatilizing one.

In a little-known and short-lived journal,[42] Seamon and Parker describe extensive tests on cupellation. As a preliminary, they made many tests on beads of silver 999 fine, of various weights up to 80 mg., for various times up to 4 hr., at various temperatures 900 to 1,600 deg., by simply heating them in cupels. At the conclusion of the heating all the cupels showed a brownish spot

[32] Inst. Min. Met, March 20, 1919, see *Eng. & Mining J.* (1919), vol. 107, p. 839.
[33] *J. Chem. Soc.* (1893), vol. 63, p. 700.
[34] *Bull.* 253, U. S. Geol. Survey (1905), pp. 20, 21.
[35] *Oesterr. Z. Berg.- u. Hüttenw.* (1906), vol. 54, p. 98.
[36] *Op. cit.*, p. 138.
[37] *Op. cit.*
[38] *Op. cit.*
[39] *Mem.*, Acad. Roy. de Belgique (1865), vol. 35. See Cooke's "Select Methods," p. 282.
[40] *J. Frank. Inst.* (1898), vol. 141, p. 447.
[41] *J. Am. Chem. Soc.* (1901), vol. 23, p. 209.
[42] *Bull.* Missouri Mining Club (1895), vol. 1, p. 16. It should be noted that in this paper per cent losses are figured upon the weight of the resulting bead and not on the weight of silver taken.

below the beads. Several cupels were tested qualitatively for silver, which was always found. They proposed to make qualitative determinations of the silver absorbed, but I have not found such results published. The results are somewhat irregular. In one set of eight, on beads 5.09 to 22.50 mg., at 900 deg. to 1,000 deg. for one-half hr., each one showed a loss of 0.02 to 0.07 mg., while another set of six, 20 to 80.06 mg., at the same temperature for 1 hr., showed no losses. They conclude that at 1,000 deg. "the loss appears to be mainly due to the oxidation of the silver and absorption of the oxide by the cupel," but at high temperatures volatilization may become important. Under their conditions 960 to 1,020 deg. barely gave feathers in cupellation.

I have done much work in checking up and extending this line of tests. Seamon and Parker appear to consider 999 silver as entirely satisfactory, but it is far from being pure and the impurity might influence the result. I used five grades of silver: proof of the highest purity, parting silver of high grade but not up to proof, ordinary silver reduced from the chloride by zinc, 50 g. parting silver melted with 50 mg. lead, 50 g. parting silver melted with 50 mg. copper. Under small beads it was only with the copper sample that the stain was plainly visible. With large beads four of the silvers stained the cupel and sometimes adhered closely to it: parting silver was not tested on large beads. Both large and small beads often showed a white coating. The figures showed irregularities and were larger than Seamon and Parker found, but I was forced to the conclusion that it was futile to expect to obtain exact or even comparative figures and discontinued the tests.

Exposure of molten silver to the air leads to a mixed result. There is oxidation of the silver and maybe volatilization. The oxidation products may be absorbed by the support in part only and part may remain in or on the metal. The loss shown by weighing the silver before and after such exposure cannot lead to definite results on any point.

Relations of Silver and Oxygen

Many and most contradictory statements have been made regarding the relations of silver and oxygen, both chemical and physical. The subject is greatly in need of clarification. It is apparent that they unite in various proportions.[43] While Ag_2O loses oxygen at very low temperatures and is said to be entirely decomposed[44] below 350 deg., pure silver prepared in the ordinary way gave off oxygen at 400 to 500 deg. for 6 hr. at the rate of 57 c.c. for a kilo of silver.[45] Silver and oxygen certainly combine at much higher temperatures and separate on lowering the heat.[46] Watts[47] says there is an oxide of silver volatile at high temperatures. Possibly this is based upon Plattner,[48] whose statements are questioned by Percy[49] and were further investigated by Christy.[50] Wartenberg[51] found silver appreciably more volatile in oxygen than in nitrogen and attributes this to the formation of silver oxide at high temperature, which may then possibly exist as a gas owing to its high heat of vaporization. Various writers have stated that sublimed silver often contains oxide of silver. Troost and Hautfeuille[52] say protoxide of silver exists in the very hot gases. Gmelin says, "Silver at a white heat decomposes aqueous vapor . . . taking up oxygen," but on the next page says, "Silver does not oxidize in dry or moist air at any temperature below its boiling point." He also says silver "is less oxidized than platinum by fusion in the air."

T. K. Rose[53] says, "Even platinum was much more readily oxidized than silver," but in a previous paper[54] on refining by blowing air through molten bullion and fluxing the oxides produced he brought bullion 354 fine in gold and 621 fine in silver up to 885 gold and 103 silver. In comparing his process with cupellation, he says, "Later, when the percentage of silver is high, it is freely oxidized in both processes, and the oxidation is at its maximum when the silver is practically pure." He says the "whole trend" of his work "is to show that it is silver that carries oxygen to base metals" and does not consider base metals oxygen carriers to silver. In this he appears to be dominated by theoretical considerations regarding normal oxides, Ag_2O and PbO for instance, and to overlook the possible interaction of other oxides.

The well-known spitting of silver in solidifying has been generally assigned to the evolution of oxygen, but it has also been ascribed to the compression[55] of the solid crust on the molten interior. Having cooled large buttons, 7 to 10 g., with extreme slowness and having obtained projections in the general form of a large irregular, inverted, hollow cone, in some instances only one cone on a button, I am satisfied that compression contributes to the spitting of solidifying silver. I have also produced spitting by the sudden cooling of a bead by contact with a mass of cold iron. In this connection it is certainly significant that silver melts and solidifies at a lower temperature in oxygen than in a reducing atmosphere.[56] Aside then from the natural cooling and solidifying of the surface first, the interior retains a lower melting point and remains liquid longer than the exterior, which has lost oxygen with the consequent raising of the melting point. The non-spitting of silver containing other metals may be due to changed differentials in the melting points.

Volatility of Lead

Johnston[57] gives the boiling point of lead as 1,640 deg. and the vapor pressure as 1 mm. at 960 deg. Krafft and Bergfeld[58] give 335 deg. as their lowest observation of volatilization of lead in a cathode ray vacuum. Schuller[59] and Kahlbaum, Roth and Siedler[60] distilled lead *in vacuo*, and the latter obtained a crystalline product. Roberts[61] showed that with proper care there was no appreciable volatilization of lead in melting assay samples of base bullion. From the distillation of alloys, Moissan and Watanabe[62] announced that the order of distillation is lead, silver, copper, tin. The litharge cloud

[43] Watts *Dict.*, vol. 5, p. 302; Roscoe and Schorlemmer, vol. 2, pt. 1, p. 367; Brown: *Trans.*, Am. Electrochem. Soc. (1916), vol. 30, p. 327; Weber: *Idem.* (1917), vol. 32, p. 391.

[44] Percy: *Op. cit.*, p. 8 et seq.: Thorpe's *Dict.*, vol. 4, p. 700.

[45] Watts *Dict.*, vol. 8, pt. 2, p. 1,798.

[46] Percy: *Op. cit.*; Donan and Shaw: J. Soc. Chem. Ind. (1910), vol. 29, p. 987. Watts *Dict.*, vol. 5, p. 278 and others.

[47] *Dict.*, vol. 5, p. 278.

[48] "Röstprozessen," p. 121 (1856).

[49] *Op. cit.*

[50] *Trans.*, A. I. M. E. (1888), vol. 17, p. 67.

[51] *Z. Electrochem.* (1913), vol. 19, p. 482; *Z. anorg. Chem.* (1912), vol. 79, p. 76. See *J. Am. Chem. Soc.* (1914), vol. 26, p. 234.

[52] *Compt. Rend.* (1877), vol. 84, p. 948.

[53] *Trans.*, Inst. Min. and Met. (1913-4), vol. 23, pp. 173-4.

[54] *Idem.* (1904-5), vol. 14, pp. 377, 420, 440-1.

[55] Mitchell: "Manual of Practical Assaying," p. 480 (1872).

[56] Ruer: "Metallography," tr. Mathewson, p. 296.

[57] *Op. cit.*

[58] *Op. cit.*

[59] *Wied. Ann.* (1883), vol. 18, p. 321.

[60] *Z. anorg. Chem.* (1902), vol. 29, p. 278; *Bu. H. Zeit.* (1902), p. 296.

[61] *Trans.*, A. I. M. E. (1898), vol. 28, p. 425.

[62] *Compt. Rend.*, vol. 144, p. 16.

that is given off during cupellation is very deceptive. It makes an impressive showing in the muffle, but the actual weight of oxide of lead is slight.

More than fifty years ago Mitchell[63] announced that in the ore-assay cupellation "not more than 2 to 3 per cent of lead is volatilized"; I have abundantly verified this statement. By weighing the cupels before and after use, I have found that it is quite possible to run an ordinary 20-g. button with the volatilization of about 0.5 g. of lead. This, however, involves some risk of freezing and requires much attention. At only a slightly higher temperature, with an increase of the volatilization to 0.75 g., there is no risk of freezing and the operator may simultaneously look after other things. When the volatilization rises to 1 g. there is but slight feathering unless special condensing arrangements are used. In one test, three cupels of the front row showed less than 2.75 per cent volatilized and the fourth froze, while the second row of four showed from 5.5— to 6— per cent volatilized and there were few feathers. With larger buttons, 50 to 60 g., seven cupels showed less than 2 per cent volatilized, with a minimum of 1.4 per cent. In the cupellation of bullion,[64] where necessarily a higher temperature is used, the volatilized lead should not exceed 10 per cent.

Most contradictory statements have been made regarding the volatility of oxide of lead. The assayers' daily experiences disprove the statements of various textbooks as to its volatilizing only at a high temperature. The books appear often to be speaking of boiling[65] rather than simple volatilization. However, the boiling point, 870 deg., given by Mott[66] is palpably much too low. Doeltz and Grauman[67] say volatilization was slight at 800 deg., increased rapidly to 900 deg., when it became liquid, not so rapidly to 950 deg. and was not tested above 1,000 deg. By changing the ratio of surface to mass, they varied the loss from 8.8 to 0.04 per cent at 900 deg.

Feathering as an Indication of Temperature Conditions

Feathering is not always a sure indication of the temperature conditions of the bead. With high bead temperature and an abundant air supply the cupel may show good feathers, while the same bead temperature with limited air supply would not. Lack of feathers, particularly on inside cupels, may be due to lack of cooling conditions above the cupel, instead of high bead temperature. In two well-feathered cupels, Hillebrand and Allen[68] found 0.05 mg. loss of gold on 10.67 mg. cupelled, but only 0.03 mg. on 15.56 mg. The cupels immediately behind these showed 0.06 and 0.17 mg. losses, respectively. It is possible that lack of feathers may also be due to a leaky muffle.

Effect of Other Metals on Volatilizing of Gold and Silver

When true volatilization occurs in quantity, the volatilizing metal exerts a drag upon its less volatile associates, but the real data upon the subject indicate that in the vast majority of cases this drag is but slight. Bodemann and Kerl[69] say silver is often disposed to volatilization by arsenic, antimony, zinc and lead.

T. K. Rose[70] says that the presence of zinc, arsenic, antimony and other volatile metals is believed to greatly increase the volatilization of gold, but gives no data. Hellot[71] says an alloy of one part gold and seven parts zinc volatilizes completely at a high heat, but Friedrich[72] investigated the subject and reported fifteen tests, from which he concluded that the loss was mainly due to mechanical action and it is only with rapid volatilization of zinc that the gold volatilization becomes appreciable. Up to 1,500 deg., the loss was so slight as to warrant the conclusion that zinc has no influence in promoting the volatilization of gold below this temperature. I have shown[73] that in distilling the zinc out of Parkes crusts, very little silver goes over in proper work and that volatilizing lead carries but slight amounts of silver. I have also shown[74] that irregular assay results may be due to zinc carrying the precious metals to the surface of the cupel. It may well be that arsenic and antimony cause irregular assays in the same way rather than by volatilization. I have shown, too, that[75] the roasting of rich arsenide ores at a low heat produced arsenious oxide practically free from silver. In some recent tests we have obtained much more concordant results than those reported on arsenical bullion.[76] The assays were run in sets of six, two rows of three cupels with proofs in the center; two sets were run on 5 g. lead and one on 8 g. on each bullion. The results were:

No. 1		No. 2	
Gold	Assays	Gold	Assays
665.5 fine	1	811.3 fine	1
665.6 fine	2	811.4 fine	2
665.7 fine	4	811.5 fine	3
665.8 fine	4	811.6 fine	1
665.9 fine	6	811.7 fine	3
666.1 fine	1	811.8 fine	5
		812.0 fine	3
	18		18

The arsenic in No. 1 was high but unknown, in No. 2 it was about 10 fine with, approximately, 90 each of silver and copper.

It is often claimed that tellurium promotes volatilization in cupellation, but T. K. Rose[77] carried on an extensive series of tests under many conditions and in only one was gold found in the condensed tellurium. Holloway and Pearse[78] say, "Loss by direct volatilization is very slight under proper conditions of working," and on cupelling beads containing tellurium with proofs without tellurium in side by side cupels some tellurium beads lost less than the proofs.

In retorting gold amalgam, Rose[79] states that about one grain of gold goes over per lb. of mercury. Although outside the scope of this paper, it may be mentioned that the recent volumes of *Transactions* of the American Electrochemical Society contain much interesting information regarding the action of metals, alone or mixed, at the very high temperature of the electric arc; and in 1907, Watts reviewed the work of Moissan.

Determination of Silver by Cupellation

The method I used in following up the course of the gold in a bullion assay is not applicable to silver. The determination of silver by cupellation[80] is quite unreliable and with large amounts the absorption of silver by

[63] *Op. cit.*, p. 484. Tests are given by Lodge: "Notes on Assaying," p. 56, and Liddell, *Eng. and Mining J.* (1910), vol. 89, p. 1,264.
[64] *Trans.*, A. I. M. E. (1918), vol. 59, p. 214.
[65] Wagner: "Die Metalle," p. 111 (1866).
[66] Am. Electrochem. Soc. pamphlet, 1918.
[67] *Metallurgie* (1906), vol. 3, p. 406.
[68] *Op. cit.*, p. 21.
[69] "Assaying," tr. Goodyear, p. 103 (1878).
[70] *J. Chem. Soc.* (1893), vol. 63, p. 714.
[71] Gmelin-Kraut: "Handbuch anorg. Chem.," vol. 3, p. 1,029.
[72] *Z. anorg. Chem.* (1893), vol. 16, p. 269.
[73] *Eng. and Mining J.* (1919), vol. 108, p. 87.
[74] *Trans.*, A. I. M. E. (1918), vol. 58, p. 85.
[75] *Op. cit.*
[76] *Trans.*, A. I. M. E. (1909), vol. 40, p. 795.
[77] Br. Assn. Rpt. (1897), pp. 623-4.
[78] Inst. Min. and Met., vol. 17, p. 171.
[79] "Gold," p. 141.
[80] *J. Ind. & Eng. Chem.* (1914), vol. 6, pp. 650, 728.

the cupel[81] is most erratic. On the other hand the determination of the base metals left in small beads is unsatisfactory unless we have an exceedingly large number of identical beads. In another connection, I have shown[82] that the straight assay of a silver bullion showed 987 fine, which corrected for the cupel absorption became 998.5 fine, while cupellation with proof showed 999.3 fine. Liddell[83] gives some very interesting tests on cupellation, but he determined the "fineness" of his beads, and this was subject to the errors of the original assay. Both these tests lack conclusiveness.

L. Campredon's book[84] says that all the silver lost is absorbed by the cupel, but the tests lack the determination of base metals in the beads. G. Campredon[85] made three tests in duplicate at a high temperature, one set using five times as much copper as silver, but he made no examination of his buttons. His result varied from nothing to 2.10 per cent on 100 mg. silver. He made two assays of his cupels; one for beads on the surface, which varied from 0.40 to 1.50 per cent, and one for absorption. Various other indirect tests have been made, but all lack important data. Some tests show a gain even when the recoveries of silver were not complete.

It remains then that the only way to determine the volatilization of silver in a cupellation is to collect the litharge volatilized and assay it for silver. Manifestly this is also the only real way to ascertain the volatilization of gold under assaying conditions. I started out to do this without interfering with the normal conditions of cupellation, but found it impossible to do so in an ordinary muffle in constant use for regular work. Various arrangements of temporary baffle plates proved inefficient condensers and in many cases the condensed litharge entered into combination with the plate material. While it is possible by the use of special cooling arrangements to grow a large crop of feathers on the cupel, once the fume got out of the cupel it was practically impossible to stop it. Of course with a small muffle provided with special condensing flues, such as a Cottrell tube, and running a large number of identical assays a good approximation may be obtained, but I did not have these conditions. Again, with the low rate of volatilization of the lead in a proper cupellation of an ordinary 20- to 30-g. button, the best feather-growing arrangements will yield only insignificant amounts of litharge. Feathers are most deceptive; they bulk large but weigh light.

After various tests I made a very deep cupel with straight sides. In the early tests the condensation of litharge was erratic, varying from 0.2 to 1 g. and considerable experimenting was required to develop a satisfactory procedure. With 100 g. lead and 1 g. silver 0.605 g. litharge condensed, yielding 0.055 mg. silver; with 5 g. silver 0.735 g. litharge gave 0.26 mg. silver; with 133 g. lead and 6 g. silver, 0.97 g. litharge gave 0.26 g. silver; with 140 g. lead, 2.11 g. copper, 8.33 g. silver, 0.465 g. litharge gave 0.27 mg. silver. By using large amounts of lead, placing the cupel close to the front of the muffle and filling in around it so as to force all the draft over the cupel, and by protecting the cupel from radiation from the muffle top, I was able to condense a gram or more of litharge for assaying. This is none too much, even when cupelling very rich lead.

A most serious objection to this method is that in time the surface of the bullion sinks out of sight. As one cannot see the end of the cupellation, careful watching and much judgment is required in turning off the gas. In ten tests, six buttons weighed more than the silver taken, the maximum being 3.4 g. on 1 g. taken and the minimum 0.13 on 5 g. taken. Of the four losses, the maximum was 0.46 on 5.81 g. and the minimum 0.04 on 5.045 g.

In general, 140 g. of lead was taken, the smallest amount of gold used alone was 140 mg., which would correspond to 20 oz. per ton in a 20-g. button from an assay-ton fusion. The largest was 1.4 g., or 200 oz. per ton. The following results were obtained. In the last test only 105 g. of the lead was oxidized.

Gold Taken, g.	Litharge Recovered, g.
1.40	1.45 containing 0.09 mg. gold
1.40	1.176 containing 0.02 mg. gold
0.70	0.876 containing 0.01– mg. gold
0.140	1.213 containing trace
0.140	0.725 containing speck

A sample of the celebrated Mercur bullion, about 884 fine in gold and less than 8 fine in silver, 1.6 g. yielded 1,185 g. litharge containing 0.03— mg. gold. Samples of miscellaneous bullion, most of them presenting unusual difficulties in ordinary assay work, yielded the following results:

Bullion weight, Grams	Fineness		Recovered		
	Gold	Silver	Litharge Grams	Gold, Mg.	Silver, Mg.
3.5	808	34	0.92	None	Slight trace
2.5	585	95	1.45	Speck	0.02
2.5	585	316.5	1.312	Very slight trace	0.015
4.0	361	228.5	1.32	0.01	0.08
4.2	343.5	443	1.13	0.005	0.16
6.75	211	225	0.95	0.005	1.26

In the last test, a scum appeared early and crystals were slow in forming; probably some of the scum adhered to the feathers recovered.

With 1 per cent, 1.4 g., gold, and 3 per cent, 4.2 g., silver, 1.27 g. feathers showed a very slight trace of gold and 0.21 mg. silver. In one test the lead carried about 1 per cent arsenic, but the cupel cracked. With 0.5 per cent arsenic and 1.4 g. gold, 1 g. litharge was collected and the gold obtained was estimated at 0.002 mg.

Three grades of base bullion were tested—good, bad, and very bad for assaying. Using 159.5 g. of the first gave a button weighing 1.24 g., 0.762 g. litharge was collected, which gave a bead of 0.08 mg. The second would not cupel direct, but 20.03 g. was run with 152.45 g. proof lead and gave a button weighing 3.475 g.; 0.975 g. litharge was collected giving a bead of 0.08 mg. In a second test, the figures were bullion 20.62 g., lead 142.45 g., button 3.422 g., litharge 1.322 g., bead 0.28 mg. Probably the high litharge and bead were due to the early formation of an unabsorbed scum on the cupel, upon which later feathers formed, particles of which adhered to the litharge recovered. The third sample yielded the highest recovery of litharge of any test made, 1.50 g., due perhaps to the same causes. The figures were, bullion 20.79 g., lead 139.06 g., button 3.25 g., litharge 1.50 g., bead 0.30 mg. Extreme tests were made on three grades of silver—proof, 900 silver 100 copper, 750 silver 250 copper. Starting with 2 and 3 per cent actual silver on the 140-g. lead buttons, the results were:

	2 Per Cent Silver Litharge		3 Per Cent Silver Litharge	
	Weight, g.	Silver, Mg.	Weight, g.	Silver, mg.
Proof	1.04	0.24	1.28	0.26
900	1.16	0.20	0.97	0.26
750	1.24	0.21	0.71	0.21

[81] *Trans.*, A. I. M. E. (1918), vol. 59, p. 191.
[82] *J. Am. Chem. Soc.* (1894), vol. 16, p. 514.
[83] *Eng. and Mining J.* (1910), vol. 89, p. 1,264.
[84] *Op. cit.*, p. 307.
[85] *Rev. Univ. des Mines* [4] (1904), vol. 8, p. 210.

Legal Notes

By Wellington Gustin

Cherokee Fertilizer Company Wins Judgment

From Georgia comes a case wherein the Cherokee Fertilizer Co. brought an action on a note against one J. A. Smith, recovering a judgment thereon in the lower court which was affirmed on appeal (100 S. E., 719). Justice Luke delivered the court's opinion.

It appears from the evidence that the fertilizer company had a suit pending against Smith for several thousand dollars, and a settlement of that case was had between the parties, and the case marked settled upon Smith paying certain money and delivering certain stock to the company. The payment was made and received in full settlement of that claim, and a receipt given and marked in full payment of all claims to date.

Subsequently the present suit was instituted upon a note signed by Smith and another which was not mentioned by either of the parties at the time of the settlement. In fact, the attorneys representing both testified that neither of them knew about the note. The defendant Smith pleaded that there was a full settlement because of the receipt in the settlement above indicated.

The court said that if one who had several different demands against another accept payment of one or more and gives a receipt therefor, there being at the time no mention of the other demands, a mere recital in the receipt that it is full payment of all claims to date is without consideration so far as relates to an unsettled note signed by the party making the payment, and another which was not mentioned or in the minds of the parties at the time of such settlement and the signing of the receipt, does not estop the holder of the unsettled demand from asserting that demand, nor does the signing of the receipt render it incumbent upon the holder of that demand to refund the money received upon the settlement as to the disputed claims.

Detroit Chemical Works Wins Case

The Supreme Court of Michigan has affirmed the judgment in favor of the Detroit Chemical Works of Detroit, in the action brought against it by the Dow Chemical Co. of Midland, Mich. The parties had entered into a written contract whereby the latter agreed to purchase 900 net tons of sulphuric acid, commercial grade, of approximately 60 deg. Bé. strength, from the former company according to certain terms and conditions as stipulated. This contract was executed on June 8, 1915; the price was $12 per ton, f.o.b. vendor's tank cars, Detroit, Mich., less freight to Midland; the deliveries were to be made at the rate of about seventy-five tons per month beginning Jan. 1, 1916; the terms of payment were net cash in ten days.

The conditions in the contract pertinent to this case were: "Each shipment to be treated, for the purpose of settlement, as a separate and independent sale, but if buyer fails to make payment for any materials furnished by vendor according to terms of sale, said vendor may defer additional shipments until payment is made, or may cancel this contract at his option. . . . The vendor reserves the right to decline to make deliveries on this contract except for cash whenever said vendor shall have any doubt as to buyer's responsibility and so informs buyer. Deliveries to be renewed according to contract terms when buyer shall have satisfied vendor as to his responsibility."

Facts Out of Which the Suit Arose

On Jan. 20, 1916, the Dow Chemical Co. wrote to the Detroit Chemical Works: "There is due on our contract seventy-five tons of 60 deg. acid this month. This is approximately two cars. Please make shipments about three or four days apart." On Jan. 22 the defendant replied: "We are shipping you one car today, in compliance with your request, and a second car will follow the latter part of next week, which we trust will be satisfactory." The first car was shipped and invoiced as of that day, the invoice reaching plaintiff on Jan. 27, the car arriving in Midland on Jan. 29, and was not delivered at plaintiff's plant until Jan. 31.

On Feb. 3 plaintiff wrote: "Please rush shipment of the balance of sulphuric acid due on our contract for shipment during January. Also get the February quota out for us. These cars may be distributed approximately in even shipments over this month." On this same day and before receiving this letter, defendant had shipped the second car. It was billed out as of Feb. 3, but did not reach Midland until Feb. 8. It was not received by plaintiff until Feb. 19. This was considered by both parties as in fulfillment of the January quota.

On Feb. 7 defendant wrote plaintiff a letter, declaring its election to cancel the contract between the parties. It sets out that payment for the first shipment of Jan. 22 matured Feb. 1, and no remittance had been received to cover. This reached plaintiff on Feb. 10 and on the same day its agent went to Detroit and paid defendant for the first car shipped, and on Feb. 12 plaintiff paid for the second shipment of Feb. 3.

Contentions of Defendant and Plaintiff

Defendant refused to make further shipments as requested by plaintiff, claiming it had cancelled the contract by its letter, and that it had the right to do so. Plaintiff was compelled to buy acid in the open market, and brought this suit to recover the damage it sustained by reason of the failure of defendant to furnish the acid according to the contract.

It was the contention of plaintiff that it was not required to pay for the acid, according to the terms of the contract, until ten days after its delivery to it at Midland and a reasonable time allowed for the inspection thereof. Also it contended that by making the shipment on Feb. 3 defendant waived the default of plaintiff in not having paid for the car shipped within ten days after Jan. 2, and that thereby it became estopped from canceling the contract as it attempted on Feb. 7.

Court Construes Contract of Sale "Net Cash in Ten Days"

Over plaintiff's objection defendant offered proof of a general custom of trade by which the language of the contract, "Terms of payments: Net cash in ten days," was construed to mean payable in cash within ten days after date of invoice or shipment. After the evidence was all in, the court directed a verdict for the defendant, holding that it was justified in terminating the contract for the reasons stated, and that there was no waiver of its terms which prevented it from relying on such cancellation as a defense in this suit.

On the appeal the two major questions presented to the Supreme Court were: When was the payment due

of the invoice of Jan. 22? And if the right to cancel the contract accrued to the Detroit Chemical Works by reason of the delay in the payment of the invoice, did this company by its conduct waive that right?

JUDGMENT FOR DEFENDANT AFFIRMED

The Supreme Court said that in view of the uniform sales act as adopted under contract of sale of sulphuric acid of a certain grade, deliverable in installments f.o.b. vendor's tank cars at vendor's city, less freight to buyer's city, terms net cash in ten days, the ten days' time began to run on delivery on board vendor's tank cars at its city and consignment of the car to the buyer; for the contract provision as to deduction of freight to buyer's city did not amount to naming such city as the point of delivery, and the right to inspect, implied from the specification of a particular grade of acid, did not postpone delivery and passage of title until inspection and acceptance, as title to goods may pass even though the right to acceptance be reserved.

Again, under the uniform sales act, where the installment sale contract expressly gave the seller the option to cancel for default in any payment, such right to cancel was not affected by a provision that each shipment was to be treated, for the purpose of settlement, as a separate and independent sale.

On the question of waiver the court said that where payment on an installment sale contract was due Feb. 1, shipment by seller of another installment on Feb. 3, not knowing whether payment due Feb. 1 was in the mail, would be held not a waiver of failure to pay Feb. 1, for "waiver" implies the intentional abandonment of a right by a person entitled to exercise it, who has at the time full knowledge of the existence of the fact on which the right depends, and the facts relied on must also show that such intent was communicated to and understood by the party claiming the waiver; it being, in effect, the abandonment of a particular obligation and an agreement to substitute another in its stead.

Neither was the seller prevented, because of its own default, from taking advantage of its right to cancel installment contract of sale for failure of buyer to make payment due Feb. 1, where although seller had not made the last January shipment during that month, it made such shipment Feb. 3; it not knowing until about the date of its cancellation, which was after Feb. 3, that the Feb. 1 payment was not mailed by buyer on Feb. 1, so that the seller was not in default when it exercised the right of cancellation or knew of facts justifying cancellation. Judgment for defendant was therefore affirmed.

A Controversy in Pig Iron Sales

A judgment for E. C. Humphreys Co. and against Rathbone Mfg. Co. has been affirmed by the Supreme Court of Michigan. The former is located in Detroit and sells pig iron on a commission basis, while the latter manufactures soft gray iron castings at Grand Rapids. On Nov. 19, 1917, plaintiff sold defendant a car of No. 1 iron to be paid for not later than Jan. 20, 1918. It was delivered to defendant, in Grand Rapids, who refused to accept because it did not grade up to No. 1 iron. Subsequently by agreement the price was reduced 50c. a ton, and defendant accepted it, but never made payment for same. About Jan. 5, 1918, or later, defendant purchased from plaintiff, by telephone, a car of "high-silicon iron," which was delivered. Defendant took exception to the quality of this car and it was resold to other parties by plaintiff. On Nov. 19, at time the first-mentioned car was contracted for, the parties entered into a written contract by which paintiff sold to defendant 850 tons of iron of various grades, to be delivered monthly over the first half of the year 1918. No iron was ever delivered under this contract.

These contracts were separate and independent of each other. The plaintiff being unable to get its pay for the first car delivered, it began this suit on April 17, 1918, to recover therefor and also to recover damages for defendant's failure to accept and pay for the car of "high-silicon iron." Defendant set off as damages plaintiff's failure to deliver iron under 850-ton contract. On trial the jury returned a verdict for plaintiff, $1,672.70, which was due on the car delivered and accepted, but refused to award defendant any damages on its matters of set-off. Defendant appealed its case.

Now, on the trial defendant conceded it owed plaintiff $1,672.70 for the car it accepted. The trial court held that plaintiff could not recover damages by defendant's refusal to accept the car of "high-silicon iron," because this was an oral contract, the order given by telephone, and involved more than $100 and was void under the statute of frauds. The only question to be decided by the Supreme Court was that relating to plaintiff's refusal to deliver iron under the 850-ton contract.

TIME OF DELIVERIES CONTINUED

This contract provided with reference to time of shipment: "Shipments: In about equal monthly quantities over the first half of 1918, buyer to give seller the quantity of each grade to be shipped on or before Dec. 1, 1917."

Very soon after making this contract, on Nov. 19, 1917, defendant ordered several cars of iron on the contract, notwithstanding it did not obligate the plaintiff to begin shipments until January. But defendant urged plaintiff to fill the order. Plaintiff advised that the terms of the contract would have to be changed from thirty days' time to ten-day drafts, subject to a discount of one-half of one per cent, applying to the whole contract. Defendant did not consent to this change until Jan. 4, 1918, and ordered three cars of No. 1 and No. 2 iron. It charged that plaintiff promised shipments would begin immediately if consent was given to the change in the terms, thereby waiving the time fixed in the contract for the shipments to begin. However, the order for three cars was subsequently countermanded or merged in an order for three cars on Jan. 25. The Supreme Court held plaintiff's failure to ship this last order placed it in default as to that, but it could not be liable on any of the previous transactions. And the jury failed to find any damages for this default.

Under the provision of the contract as to shipment, quoted above, the court held that plaintiff was under no obligation to begin shipments before Jan. 1, 1918, and that if it made shipment upon the last day of the month it was a compliance with the contract.

French Duties on Chemicals

The *Journal Officiel* of March 2, 1920, publishes a new status of chapters ex-XVIII (chemical products), ex-XIX (prepared dyes) and ex-XX (colors) with their coefficients of increase in specific rates of duties established in accordance with the new nomenclature specified by the law of Nov. 7, 1919, these new chapters being substituted for the corresponding ones in the table of coefficient increases as specified in the decree of July 8, 1919.—*The Review*, March 15, 1920.

Ozone in the Chemical Industries

By Chester H. Jones

WHILE a large amount of data has been published covering a number of installations where ozone is employed in air and water sterilization and purification, and while there has been considerable promotion propaganda using results of laboratory experiments with ozone in chemical applications, there has on the whole been little information available on commercial uses of ozone involving purely chemical reactions. It is known that a number of companies have purchased ozonators of the commercial type and are running them continuously in chemical plants, but definite information concerning their performance has been consistently withheld from publication.

Apparatus

There is now on the market a standard apparatus which is reliable as to both continuous operation and uniform output of ozonized air. Fig. 1 illustrates the three-tube laboratory unit and Fig. 2 a two-unit bank of six tubes per unit. The table herewith will show guaranteed output of this apparatus as listed from the three-tube laboratory type up to the ten-unit type consisting of six tubes per unit.

AIR FLOW AND OUTPUT OF SPRAGUE LABORATORY AND INDUSTRIAL OZONATORS

Number of Units		60 Cycles				133 Cycles			
		Grams O_3	Watts	Air per Hr. Cu.M.	Cu.Ft.	Grams O_3	Watts	Air per Hr. Cu.M.	Cu.Ft.
1	3-tube	2½	75	1	35				
1	6-tube	6½	200	2½	90	13½	400	5	180
2	6-tube	13	400	5	180	27	800	10	360
3	6-tube	19½	600	7½	270	40½	1200	15	540
4	6-tube	26	800	10	360	54	1600	20	720
5	6-tube	32½	1000	12½	450	67½	2000	25	900
6	6-tube	39	1200	15	540	81	2400	30	1080
7	6-tube	45½	1400	17½	630	92½	2800	35	1260
8	6-tube	52	1600	20	720	108	3200	40	1440
9	6-tube	58½	1800	22½	810	121½	3600	45	1620
10	6-tube	65	2000	25	900	135	4000	50	1800

Maximum concentration:
3-tube, 2.5 g. per cu.m.
6-tube, 2.6 g. on 60 cycles, 2.7 g. on 133 cycles.

The general type of tube that is employed in the construction of these ozonators is illustrated in Fig. 3. Alternating electric current for the operation of this machine is first led to a transformer, where it is stepped up to a voltage of about 10,000 to 12,000. One of the transformer leads is then brought to the busbar of the machine and the other to the frame, so that a complete circuit may be traced from the transformers through the inner cylinder, across the air gap, and through the glass tube which forms the dielectric to the copper plating on the outside of the glass tube, which is in turn grounded to the frame and then back through return leads.

As the high-voltage current passes through the air gap, it does so in the form of a brush discharge which forms a purple ring completely filling the annular opening. This is not a spark, but a true so-called "silent discharge," although as a matter of fact it is accompanied by a rushing sound.

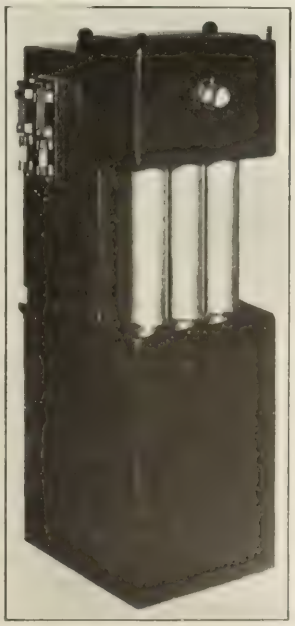


FIG. 1. STUBE OZONATOR

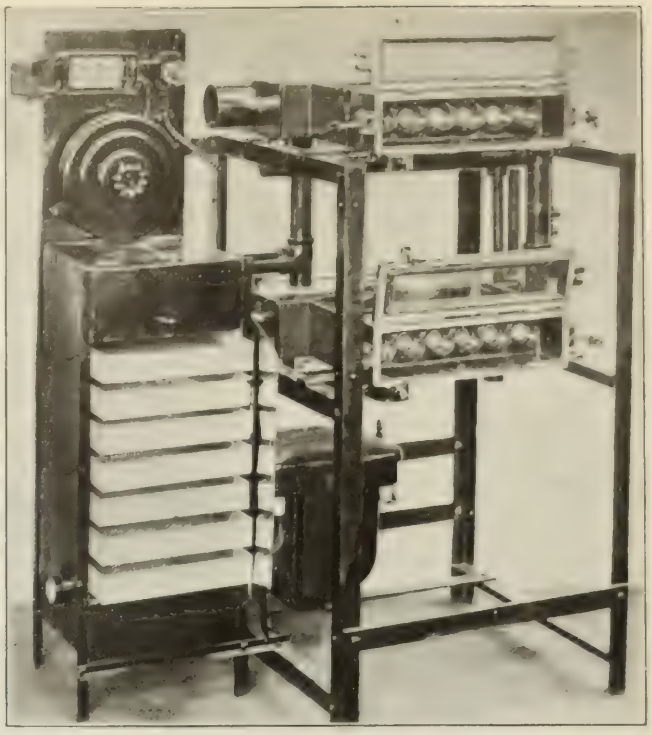


FIG. 2. A TWO-UNIT BANK OZONATOR, FOR OPERATION ON 110- AND 220-V., 60-CYCLE A.C.-OPEN

The copper tube which is shown surrounding the glass tube is employed for the protection of the glass, and while entirely non-essential as far as the operation of the machine is concerned, it is of great practical importance, preventing the frequent breakages and shutdowns which would occur in case the glass surface were left exposed.

The water shown surrounding the tubes is employed for the purpose of keeping down the temperature, which becomes quite high when the machine is in operation. As will be seen in this type of ozonator, the generating tubes are mounted in a casing so formed as to provide a chamber at each end of the open tube. Air is admitted under light pressure or subject to suction into the chambers at one end of the tube, and passes through the brush discharge and the annular space between the inner and outer electrodes. Passing through this discharge a portion of the oxygen in the air becomes ozonized and this ozonated air is conducted through piping to the point of application.

Referring to Fig. 2, trays with a wire gauze bottom shown are filled with a layer of calcium chloride. All the air going into the generating tubes is passed through the calcium chloride, thus giving a dry air and insuring successful operation of the ozonators.

The actual amount of ozone that can be generated in a tube of this kind is nearly proportional to two factors, namely, the voltage and the frequency of the electric current forming the discharge. Actual determination of these factors has been arrived at by observation rather than by any theoretical basis. The most practical limit of voltage has been found to be from 10,000 to 12,000 volts, the limitation being caused by the difficulty of securing adequate insulation when this limit is exceeded. With this voltage as a maximum,

most of the small outfits are operated at a frequency of sixty cycles, which is now standard central station supply. On medium-sized plants 133 cycles is often used, thus securing the double output from each tube. Up to now the highest frequency found in practical use in the largest installations is 500 cycles, which is employed in European countries and to some extent here.

Wax Bleaching

The Theodore Leonard Wax Co., of Haledon, N. J., has installed a twelve-tube unit industrial ozonator with a capacity of 12.5 g. per hr., and operates it continuously for the bleaching of wax, as shown in outline in Fig. 5. It will be noted that the air is forced through the ozonators and the ozonized product bubbles through about a 25-lb. (11.3-kg.) charge of wax contained in the tub. This charge of wax is kept molten by steam pipe introduced in a single turn through the tub. When ozone is passed at the rate of 12½ g. per hr., a charge of wax is bleached in a period of 4 to 5 hr.

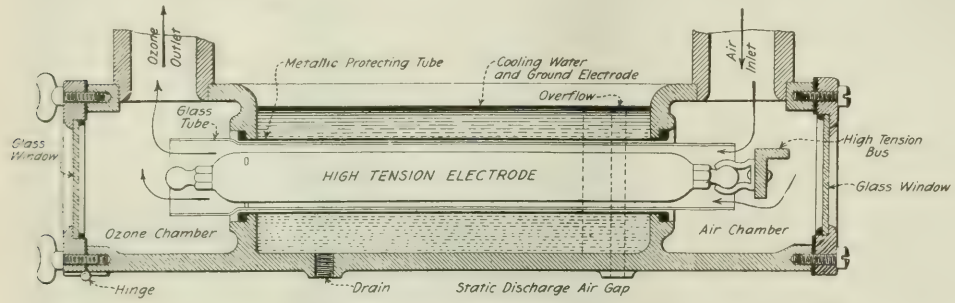


FIG. 3. SECTIONAL VIEW INDUSTRIAL OZONATOR TUBE

Bleaching Textiles, Fabrics, Etc.

While considerable industrial work has been done along these lines, it has been surrounded with so much secrecy that definite data on installations are not available. Some knowledge of the research work done, however, should be of value.

In the bleaching of textile fibers and textures, a series of operations, the object of which is not only to decolorize the fibers but also to bleach them of any foreign substances, is performed. The bleaching or decolorization comprises the destruction of the natural colorizing matters or of the accidental colorizing matters which may be attached to the fibers through direct or indirect oxidation phenomena. To obtain this decolorization the oxygen of the air, chlorine in its different states, chlorate, bichromate, permanganate or ferricyanide of potassium and barium peroxide are used. For instance, the product called "ozonine," commonly employed in bleaching, is possibly composed of about 125 parts of resin, 200 parts of turpentine oil, 25 parts of hydrate of potassium which is dissolved in 40 parts of water, and 90 parts of ozonized water. Ozonized water in turn could be replaced by peroxide, such as peroxide of sodium.

At first the bleaching of textile fibers was obtained by exposure to the air. In this action oxygen, or better, ozone, oxidizes the colorizing matters and makes them soluble in a dilute alkaline solution. This bleaching, obtained by air or even by ozonized air, requires the action of solar light, according to A. and P. Buisine. If textile fibers are subjected to the action of ozone alone for a certain length of time, that is, until the bleaching obtained is satisfactory, the fibers become fragile and their resistance to wear is lessened to a large degree.

If, on the contrary, instead of ozone artificially obtained, chloride of lime alone is used, the bleaching obtained is insufficient, but the strength of the fibers is less affected than by ozone.

Bleaching by ozone alone takes place at a regular rate, but at a certain period the decolorizing action decreases and at the same time destruction of fiber becomes imminent. The moment at which bleaching is sufficient is consequently to be carefully watched and the action of ozone is then to be promptly stopped. If at this period the fibers are immediately put into a weak solution of chloride of lime, bleaching begins again. This action increases with a greater intensity than that by the use of chloride of lime alone.

Perfect bleaching of textile fibers can therefore be rapidly produced by using short ozonizations, followed by weak solutions of chloride of lime, without having to make use of slow bleaching by exposing on a flat surface. After this treatment the fibers are found to have kept their primitive strength.

From observations made by M. Frohlich, the Siemens and Halske Societies and the Freiffenberger Bleich-u.-Appretur Anstalt, it has been possible to bleach textile fibers satisfactorily by the combined action of ozone and of chloride of lime. Usually gray threads or yarns, after they have been prepared according to the usual methods by boiling in a washing bath of soda, are simply immersed in a concentrated solution of chloride of lime, removed and exposed to ozone and again placed for a few hours in a weak solution of chloride of lime. On being removed from the latter the fibers are rinsed, partly dried and placed again in the ozone room in a damp state. By this process the strength of the agents of bleaching is gradually diminished. The operations are performed in succession and repeated until the required degree of bleaching is obtained.

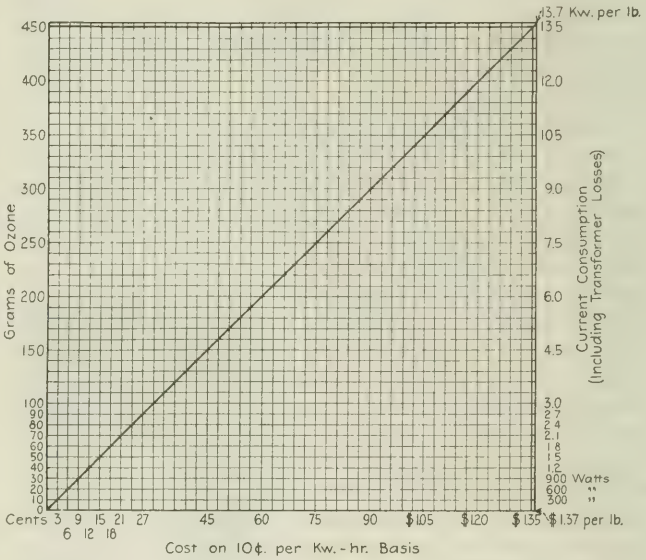


FIG. 4. CHART SHOWING COST OF MAKING OZONE

The ozone room must be constructed in such a way as to have all the parts of the yarns or threads submitted in turn and uniformly to light. Light of arc lamps can be used for this purpose. Currents of ozone must also act successively and uniformly on all the parts of the fibers. To obtain this result ozone must come into the room through as many apertures as possible, disposed in a uniform manner, which is effected by the use of perforated pipe protected by shellac or paraffine. In addition to this the textile fibers must be kept in motion so as to have their various parts placed under the action of ozone. This result can be obtained by means of a drum-shaped apparatus which is made to rotate and on which the fibers are placed.

If, after having prepared fibers according to the usual method, textiles are immersed in certain weak solutions of ammonia, of turpentine and ammonia emulsion, of turpentine essences, of soap or resin and ammonia, or of commercial indigo, and subsequently placed under the action of ozone, white fumes of aid to the bleaching process are formed. These fumes, the result of the oxidation of the substances with which the fibers are impregnated, in addition to compounds formed on

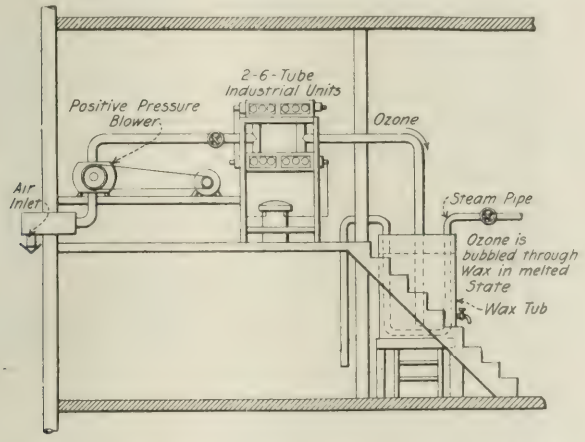


FIG. 5. OZONATOR FOR BLEACHING BEESWAX

the texture itself, facilitate the oxidation when placed in a slightly acidified bleaching bath.

Usually the textile substances under process after having been prepared in the usual way are immersed in solutions made of the chemical products enumerated above. After this operation they are taken out and partly dried, when they are placed in the ozone room for a certain length of time, then immersed in weak solutions of chloride of lime, partly dried and again placed in the ozone room. During these operations the effects of the bleaching are watched and the operations stopped at the proper point. Usually two rooms are used for the treatment and ozone is alternately introduced at intervals of a half hour. This saves loss of time and permits ozone to act gradually.

Bleaching by ozone is more or less rapid according to the nature and the condition of the fiber to be treated. It is economical of time and results in superior bleaching than that obtained by the old process of spreading textiles in the sunlight. The consumption of ozone is also variable according to the nature, the condition, the time of exposure, and also the volume of textiles to be treated, as well as according to the chemical substances which are used in conjunction.

Flax, hemp, jute, cotton, paper pastes, etc., can be bleached in a similar manner.

Flax texture is first placed in a mixture containing 15 g. of caustic soda at 36 deg. Bé. and 15 g. of ozonized oil per liter. After this has been boiled for 12 hr. the texture is washed and passed into neutralizing acid, and finally rinsed with clear water. A bleaching bath (peroxide of sodium) is then prepared. It is composed of the following formula:

Water, liters	1 000
Ozonized oil, kg	5
Peroxide of sodium, kg	7 5
Sulphuric acid, 60 deg., kg	10

This bath is made alkaline, and after the flax has been immersed it is heated to 80 or 90 deg. C. The bath is properly agitated during this treatment and at the end of 4 hr. the textures are taken out, washed, passed into acid and finally rinsed. The operation is continued until the desired bleaching result is obtained.

Bleaching Paper Pulp

Ozone is said to produce excellent results on paper pastes. The bleaching is not only perfect, but rapid and economical. It is said that the use of anti-chlorine such as hyposulphite of soda and nitrate of soda as used in the present processes may be avoided. Usually a current of ozone is sent through the bath of chloride of lime in which the paper paste is being bleached. This increases the action of the chloride and reduces the quantity used.

Sponge Bleaching

In the bleaching of sponges the raw sponge is first soaked in a solution of sulphuric acid to loosen the dirt and organic coloring matter. After wringing out the water, the damp sponge is placed in a strong ozone atmosphere, approximately 3 to 4 g. per cu.m. for a period of 3 to 7 hr., the time required depending upon the kind of sponge and not the size.

After a pale light-colored bleach is obtained, the sponge is rinsed in a solution of sodium carbonate to remove the free oxidized coloring matter and to neutralize the nitric acid formed during the treatment. This alkaline bath darkens the sponge somewhat to a canary yellow and its action is checked and tempered by again rinsing in a weak sulphuric acid solution followed by a thorough washing in plain water to remove all the chemicals and to secure a neutral condition.

A commercial plant along these lines was put in operation during the war when the price of the more usual reagent, potassium permanganate, was high, a two-unit 500-cycle plant being employed. This was discontinued, however, simultaneously with the drop in the permanganate market.

Drying Varnishes and Paints

The so-called drying of paint oil, such as linseed, is not caused by evaporation, but by oxidation, and when driers are mixed with paints or oils they are used simply to hasten this oxidation. By producing a partial oxidation of the oil before it is applied the drying is greatly hastened and more thoroughly accomplished and the process may even be continued after application by drying in the presence of ozonized air.

On examining a coating of oil paint on any surface it is found that the surface hardens over in a thin skin which shuts out the air from the lower layers and often requires a long time for the hardening to become deep seated and completed. If, on the other hand, the paint is treated with ozone previous to application, the ozone will apparently cause the oxidation to occur throughout

the entire thickness of the layer and a more thorough drying is thus secured.

An application of these ideas is shown in Fig. 6, giving a layout at the Heinze Electric Co., Lowell, Mass., where ozone is introduced into the drying ovens containing automobile magnetos. The armatures, after being wound, are subjected to impregnation with oil under vacuum. The oil thoroughly penetrates the windings, but when dried it hardens on the surface, leaving the interior in a soft condition. When magnetos are

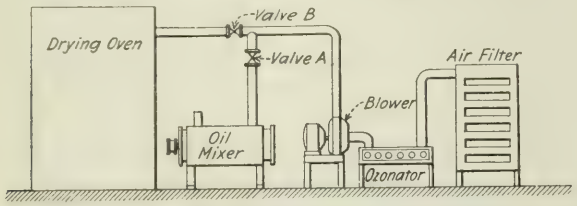


FIG. 6. PAINT DRYING APPARATUS

operated the armature is run at high speed and the centrifugal force is often sufficient to throw off this soft oil, thus spoiling the impregnation of the winding. This is remedied by ozonizing the oil before using.

The oil is first placed in a mixer where it is stirred up by a dasher, while the stream of ozonized air passes through the mixer and is brought into intimate contact with the oil by which the ozone is absorbed. After a few hours the oil is so charged with ozone that it may then be applied to the armatures with the certainty of its hardening thoroughly throughout. The armatures are then dried in the ovens, shown at the left of the sketch, which are also charged with ozone to hasten and improve the surface drying. Several musical instrument manufacturers have installed ozonator systems for furnishing ozonized air to drying rooms; Fig. 7 shows the layout at the Schubert Piano Co.

Since ozone oxidizes with enormously greater speed than oxygen, its value in paint and varnish drying is evident. In the painting of automobile bodies hurried drying is demanded by the crowded condition of the factories. Recent tests with ozonized air showed after 2 hr. an increase in weight of the painted body of 3.34 per cent, while with ordinary air the corresponding increase was only 1.51 per cent. This increase was due to the absorbed oxygen and fairly measures the relative rapidity of the two drying methods.

Oil Oxidation

Little data are available on the subject of oil oxidation. It is known that the Standard Oil Co. is making experimental tests with laboratory equipment, while some of the vegetable and animal oil producers are proceeding in like manner. There is every reason to believe that this will eventually be one of the largest fields for the employment of ozone. Oil may be completely solidified by treatment extending over a period of about three weeks, and the gummed oil, after it has been ground, is used in the manufacture of linoleum. Cottonseed oil may also be decolorized by the use of ozone.

For treatment of linseed and similar oils for bleaching, bodying and solidifying, the practice at present is to allow ozone, $\frac{1}{8}$ g. per liter per hr.; air, $\frac{1}{8}$ cu.m. per liter per hr. The oil should be treated in a mixer in which it is continually agitated by revolving paddles. Simply bubbling the ozone through the oil is not satisfactory and requires a much longer time for similar results.

Rapidity of thickening depends upon the temperature in which the oil is treated. Raw oil when run at 65 to 90 deg. C. thickens rapidly, solidification being secured in 6 to 8 hr., but the oil becomes darkened. When run at temperatures below 40 deg. C., the thickening proceeds more slowly (8 to 10 hr. for solidification), but the oil is bleached.

For bodying paint or varnish a run of 6 hr. is usually sufficient. For linoleum the average run for solidification is 8 to 10 hr.

Cold Storage Application

Ozonators have a wide use in the deodorizing and purification of air for cold storage chambers. While the activities of the bacteria which cause decay and mold growth in food materials are very largely checked by keeping the surrounding air properly dried and near the freezing point, the addition of ozone to destroy the odor carried in the air has achieved remarkable results. It furnishes a means of purifying the air of the storage room without ventilation and consequent loss of refrigeration required to cool newly admitted air. Thus, it is claimed that eggs in cold storage will

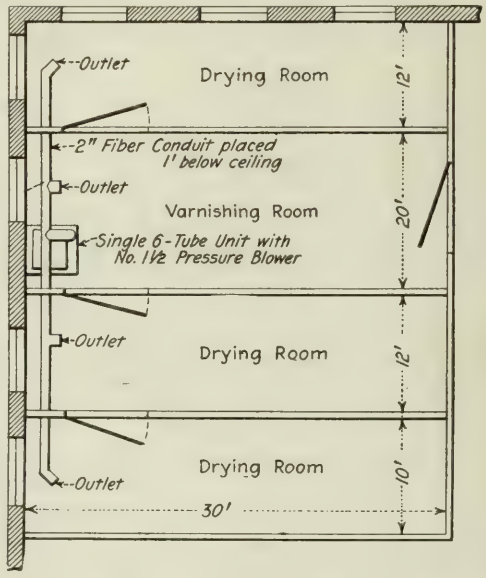


FIG. 7. OZONATOR FOR DRYING VARNISH ON PIANO CASES

carry much better in ozonized air. Not only is the average quality of eggs taken out much better, but if there are any cracked eggs in the cases, the cracks, instead of becoming moldy, will be dried up just as if they had been exposed to sunlight and air.

Future Developments

The future outlook for the use of ozone in the chemical application is promising. Ozonized air of high ozone content is available in such quantities as to permit commercial employment in the oxidation of the more rare organic chemical processes. Where larger quantities are required, a solution is suggested by the statement of Georges Claude that liquid oxygen at low temperatures is easily transformed by efflux into ozone.

Large plants exist in this country capable of producing oxygen at a few cents per thousand cubic feet. It requires no great imagination to see gaseous ozone produced from simple mechanical apparatus in the near future. Ozone thus cheaply prepared for the market opens up unlimited possibilities in chemical industries.

Report on Test of New Brunswick Oil Shales in the Wallace Retort

THE summary report of the Mines Branch of the Department of Mines of the Dominion of Canada for the year 1918 contains a report on the test of New Brunswick oil shales in the Wallace retort, together with a description of the Wallace retort, from which the following is abstracted:

Description of Retort

The new type of retort for the carbonization of coal and retorting of oil bearing shales is the invention of W. G. Wallace, superintendent of the St. Claire Gas Co., of East St. Louis, Mo. The essential idea of the retort is that of removing the volatile products without subjecting them to a temperature higher than that at which they are liberated from the shale. The design is illustrated in detail in Fig. 1. The distilling chamber *A* is cylindrical in cross-section and of less diameter at the upper than at the lower end, this chamber being surrounded by a circular combustion chamber *B*. A perforated take-off duct *C* is centrally located, the products of distillation being removed at the bottom through the pipe 2. The pipe 2 can be disconnected from the outlet of the take-off duct, permitting the bottom of the distilling chamber together with the perforated takeoff duct to be removed downwardly for the removal of the retorted shale. The perforated take-off duct is preferably of uniform circular cross-section, so that the annular space between it and the wall of the distilling chamber will diminish gradually in area from the lower to the upper end, thereby causing a uniform distribution of heat through the material within the annular space. This design of retort causes the products of distillation to pass through the cool material away from the heated wall of the retort, and thus materially aids in preventing the formation of unsaturated hydrocarbons which are produced at high temperatures and formed to a greater or less extent in usual types of retorts, where the products of distillation are brought into contact with the heated walls or the heated material within the retort from which the volatile products have already been removed.

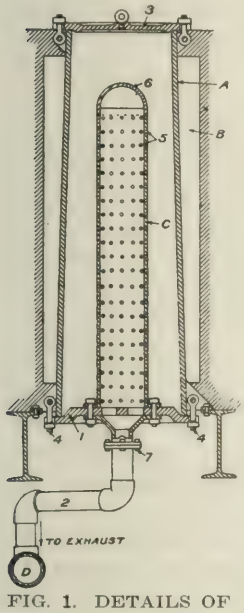


FIG. 1. DETAILS OF WALLACE RETORT

This design secures the advantages of low-temperature distillation in that the volatile products are given off at a minimum temperature, immediately cooled and removed from the influence of heat. It is further claimed that this method of distillation produces a larger yield of oils due to the fact that the vapors are not subject to excessive heating which causes the breaking up of the oils into permanent gases.

Tests on New Brunswick Oil Shale

The shale was taken from an opening on seam 1, Frederick Brook, Alberta mines, and represented a fair average of the seam, which was 4½ ft. in width. Two tests were conducted, the samples weighing 81 5/16 and 80 lb. each, the shale being crushed to ½-in. size.

Test No. 1. Before charging with the shale, the retort was brought to a cherry-red heat, while the temperature of the combustion chamber was 1,450 deg. F. (787 deg. C.). Pyrometers were placed in the combustion chamber, in the retort between the outside walls and take-off duct, and in the bottom of the eduction pipe, and the temperatures throughout this run were recorded at these points, at 15-min. intervals. The results are shown in Table I, together with the quantity of oil and gas recovered during these periods. The oil recovered contained a small quantity of water which was not determined.

TABLE I. RESULTS OF TEST NO. 1

Time	Temp Combustion Chamber, Deg. F	Temp Retort, Deg. F	Temp Reduction Pipe, Deg. F	Cu Ft Gas	Weight of Oil, Lb	Oz
9:20 a.m.	1,480		1,100			5
9:35 a.m.	1,480	240	600	30	2	11
9:50 a.m.	1,490	280	500	50	2	6
10:05 a.m.	1,510	510	540	20	2	7
10:20 a.m.	1,520	620	650	25	2	6
10:35 a.m.	1,540	720	700	25	2	3
10:50 a.m.	1,530	820	810	25	1	

Summary of Results

		Per Ton of Shale
Shale charged	81 lb., 5 oz	
Oil recovered	13 lb., 6 oz	43 U. S. gal.
Gas	175 cu ft	4,290 cu ft
Spent shale	52 lb., 15 oz	1,297 lb

TABLE II. RESULTS OF TEST NO. 2

Time	Temp. Combustion Chamber, Deg. F.	Temp. Off-Take Duct, Deg. F.	Quantity of Oil, Lb.	Oz
11:25 a.m.	1,360	740		
11:40 a.m.	1,400	330		14
11:58 a.m.	1,410	400	1	3
12:10 p.m.	1,420	510	1	8
12:25 p.m.	1,430	630	2	1
12:40 p.m.	1,440	710	2	6
12:55 p.m.	1,450	800	2	3
1:10 p.m.	1,460	900	1	8
			0	3

Summary of Results

		Per Ton of Shale
Shale charged	80 lb	
Oil recovered	11 lb., 14 oz.	39.6 U. S. gal.

Test No. 2. The temperatures of the combustion chamber and retort before charging were considerably lower than that which obtained for the first test, consequently the yield of oil at the end of the first 15-min. period was less. The temperature of the combustion

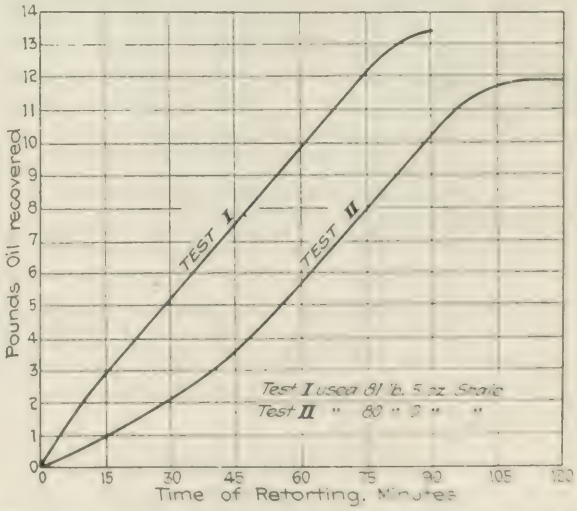


FIG. 2. CURVES SHOWING AMOUNTS OF OIL DISTILLED AT 15-MIN. INTERVALS

chamber and of the take-off duct were recorded and no record was made of the gas produced, since an air leak developed during the run. The results are given in Table II. The yield of oil of both tests are plotted against the time of distillation in Fig. 2.

Analysis and Results of Test of Sample of Oil Shale Sent to Fuel Testing Station

In order to check the results obtained with the Wallace retort, a general sample representing the entire quantity of shale retorted, and a sample of the spent shale were tested in the laboratories of the Fuel Testing Station. The results are given in Table III.

TABLE III. RESULTS OF CHECK TEST ON SAMPLE OF SPENT SHALE IN THE LABORATORIES OF THE FUEL TESTING STATION

Analysis:	As Received	Dried at 105 Deg. C.
Moisture	0.9	....
Ash	61.1	61.6
Volatile matter	33.9	34.2
Nitrogen	0.9	0.9
Distillations	No. 1 Without Steam 740 Deg. C.	No. 2 With Steam 550 Deg. C.
Yield of crude oil, per 2,000 lb. charged, U. S. gal	42	47
Yield of completely dried oil per 2,000 lb. charged, U. S. gal	37.6	37.3
Specific gravity, completely dried oil	0.87	0.89
Yield of gas per 2,000 lb. charged, cu. ft	3,700	3,540
Composition of gas :		
Carbon dioxide	25.1	31.0
Illuminants	2.5	2.6
Oxygen	0.2	0.5
Carbon monoxide	19.8	5.2
Methane	24.6	23.2
Hydrogen	21.7	32.6
Nitrogen	6.1	5.1
Calorific value, B.t.u. per cu.ft	380.0	351.0
Yield of ammonium sulphate per 2,000 lb. charged, lb.	16.0	19.0
Nitrogen in residue, per cent	0.5	0.7
Distribution of nitrogen from charge:		
In ammonia, per cent	21.0	24.0
In residue, per cent	42.0	58.0
In gas and unaccounted for, per cent	37.0	18.0
SAMPLE OF SPENT SHALE FROM WALLACE RETORT		
Nitrogen, per cent	0.5	....

The results obtained with the Wallace retort check remarkably well with that obtained with the retort employed in the laboratories of the Fuel Testing Station, especially since the maximum quality of oil is extracted by the laboratory retort.

Enamel Investigations at the Bureau of Standards

THE jumping off of small particles of enamel which results in the defect known in shop practice as "fish scaling" is probably the most serious defect to which enamels for sheet steel are subjected. It occurs intermittently in practically all the plants manufacturing this class of material in this country and entails losses running into millions of dollars to the manufacturers. At the request of the Metalware Manufacturers Association of America, the Enameled Metal Division of the American Ceramic Society and a large number of individual manufacturers, the Bureau is carrying on a comprehensive research in an endeavor to discover the cause or causes of this defect and the methods of controlling and eliminating it. This investigation was begun in July, 1919, and has been conducted energetically ever since.

Causes of Fish Scaling

Up to the present time, the Bureau has made ninety melts of enamel composed of twenty-one different compositions. These have been subjected to various treatments in firing and melting and have been applied in various ways to several kinds of steel. In all, over 4,000 sample enameled plates have been made up to date. This work has demonstrated that one of the most important factors in the production of fish scaling is too severe heat treatment in the firing of the enamel. Excess heat treatment may consist of firing the enamel at too high a temperature or of holding the enamel in the furnace for too long a time at a given temperature. Other important factors are the composition of the enamel, the physical and chemical characteristics of the underlying metal, the method of melting the chemical mixtures used in making the enamels and the shape and weight of the metal pieces that are enameled. These various factors have been investigated to a certain extent in this work and will be studied more thoroughly as the investigation progresses.

The data obtained in this investigation up to the present time have enabled the Bureau to be of very material assistance to several manufacturers in eliminating this trouble. It seems very probable that the completion of the investigation as now planned will definitely eliminate fish scaling, and likewise settle the interesting question of what is the physical basis of the phenomenon.

Acid-Resisting Enamels

For several months the Bureau has had in progress an investigation of the relation of composition of enamel to solubility in strong mineral acids. The need for this investigation was clearly demonstrated during the war by the difficulty manufacturers of acid-resisting enameled wares experienced in meeting the requirements of chemical manufacturing plants. The manufacturers of enameled kitchen wares are also interested in this problem.

Up to the present time thirty-three enamel compositions have been melted and tested. While the problem is a large one and the investigational work will necessarily be continued for some time, results so far obtained indicate that some of the commonly accepted conceptions of the relation between composition and acid resistance of enamels are erroneous. The chief of these misconceptions seems to be that oxides which are similar in nature chemically will have similar effects when incorporated in enamel compositions. That this is not always true is shown by the fact that calcium oxide tends to produce enamels with very low resistance to attack of acids while barium oxide produces quite resistant enamels.

Expected Results From the Investigations

In connection with the gathering of data on the chief object of this investigation, information is being secured in regard to relations of composition to their fusibility and to the tendency to chip or to craze, or crack. It is expected that as a result of this investigation the Bureau will be able to advise manufacturers of acid-resisting wares as to the methods of compositions to be used in producing wares of this class superior to any now being made, and also that it will enable the Bureau to be of material assistance to manufacturers of enameled ware for culinary purposes. As a matter of interest, it may be stated that as a part of this investigation an enamel has been produced which appears to duplicate in composition and working properties the best grade of French acid-resisting enamel.

Synopsis of Recent Chemical & Metallurgical Literature

Manufacture of Methylethylketone From Normal Butyl Alcohol.—Early in 1917, British Acetones, Ltd., began to produce acetone and normal butyl alcohol in large quantities by the fermentation of carbohydrate material in the presence of certain micro-organisms. There was at that time an almost unlimited demand for acetone, but the disposal of the rapidly accumulating stocks of normal butyl alcohol was a different proposition. No commercial demand had been developed and an attempt to substitute it for ethyl alcohol as a solvent in the manufacture of smokeless powder had failed. How this problem was solved is told by T. C. NEWMAN in the *Canadian Chemical Journal*, February, 1920, p. 47.

Under the direction of D. A. Legge, a process was developed for the conversion of the alcohol into methylethylketone (methylacetone) or M.E.K., as it was called in the plant. This product was accepted by the British Government as a cordite solvent and was used under the name of "cordite ketone."

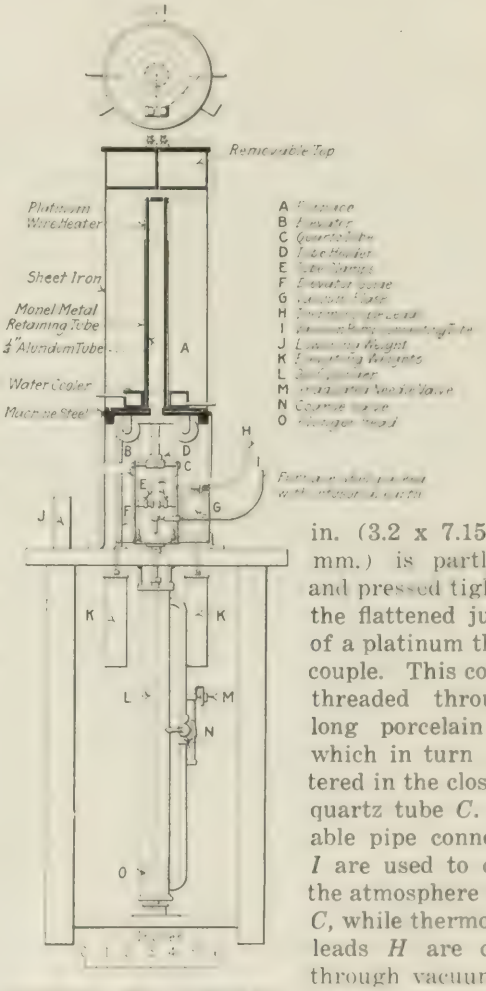
The theory of the process will be found in organic text books. The normal butyl alcohol is dehydrated, forming butylene, which treated with hydriodic acid yields β-iodo-normal-butane. This is converted into secondary butyl alcohol by heating with wet silver oxide. The secondary alcohol is then dehydrogenated, yielding methylethylketone. Of course, this is suited to the laboratory, but for a plant handling 25,000 lb. per day, substitutes for hydrogen iodide and silver oxide had to be found. In practice, sulphuric acid and water were used.

Butylene was prepared by passing the vapors of the normal butyl alcohol over heated kaolin. The temperatures required were markedly lower than those used in the preparation of ethylene from ethyl alcohol. The catalyzers were made up in batteries of three small units, each unit being held 40 deg. C. higher in temperature than the previous unit. The hot vapors from the catalyzers were passed through a gas cooler and gas separator. The butylene was then liquefied by an ordinary ammonia compressor and stored in high pressure storage tanks. The liquid butylene was pumped to a sulphating kettle, where it was treated with 60 per cent sulphuric acid. This reaction is extremely exothermic and is the most difficult step in the process. During the experimental stages there was a tendency for dibutylether to form, but this was overcome by details of plant operation.

The butylene hydrogen sulphate was diluted and distilled, forming secondary butyl alcohol with simultaneous regeneration of the sulphuric acid. The latter was reconcentrated in two 30-ton units. The secondary butyl alcohol was redistilled to free it from water and then passed through a second series of catalyzers similar in design to the first, in which it was dehydrogenated. Certain metallic oxides served as the catalyst. After condensation and separation from the hydrogen, the crude methylethylketone was distilled, yielding on a single distillation a very pure product containing as its only impurity slight traces of the pinacone.

Since the war the problem has been solved in a different manner through the production of butyl acetate, which is rapidly replacing amyl acetate as a nitrocellulose solvent. There are several reasons for this: The butyl alcohol is extremely pure, 90 to 95 per cent of it distilling within 0.5 deg. C. of the true boiling point; the odor of butyl acetate is not nearly so oppressive as that of amyl acetate; its technical effect is just as good; it is much cheaper in price.

Modified Rosenhain Furnace.—H. SCOTT and J. R. FREEMAN of the Bureau of Standards describe a perfected furnace for thermal analysis in Bulletin 152 of the American Institute of Mining and Metallurgical Engineers, and in Scientific Paper No. 348, Bureau of Standards. A sketch of the furnace is annexed and is practically self-explanatory. A small sample, ⅛ x ⅝ x ⅛



SKETCH OF MODIFIED ROSENHAIN FURNACE FOR THERMAL ANALYSIS

in. (3.2 x 7.15 x 3.2 mm.) is partly slit, and pressed tightly on the flattened junction of a platinum thermocouple. This couple is threaded through a long porcelain tube, which in turn is centered in the closed-end quartz tube *C*. Suitable pipe connections *I* are used to control the atmosphere within *C*, while thermocouple leads *H* are carried through vacuum flask *G* to a dial potentiometer. Steady current (5 amp. at 30 volts) passes through seventeen turns of 0.52-mm. platinum wire, wound around the top end of the ¼-in. walled alundum tube, and maintains the temperature of the top end continuously at something over 1,000 deg. C. The sample is gradually elevated to this heated region by means of gravity, weights *K* furnishing the motive power, regulated by oil by passing through needle valve *M*. Inverse-rate heating and cooling curves taken in this manner on transformationless steel (containing 28 per cent nickel) results in an almost geometric vertical between 250 and 1,000 deg. C.

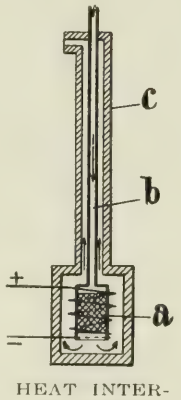
Recent Chemical & Metallurgical Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Benzoic Acid From Toluene.—A layer of toluene (100 lb.) is placed on the surface of about 250 lb. of 38 per cent HNO_3 in a suitable reaction vessel provided with a reflex condenser. After heating to about 90 deg. C., the reaction is started by adding 0.1 per cent paraformaldehyde. At the end of four or five days the reaction is complete and the upper layer of benzoic acid, benzaldehyde and toluene is removed and treated with alkali. The solution of sodium benzoate obtained may contain nitro compounds which may be removed by reduction to amino compounds. Benzoic acid is recovered by precipitation with an acid. It is claimed that the yield is nearly quantitative. The product is, of course, free from chloride. The process may also be applied to other oxidations of side-chains in aromatic compounds, such as the manufacture of orthonitrobenzoic acid from orthonitrotoluene. (1,332,028; VIRGIL COBLENTZ and HAROLD W. WALKER of New York, assignors to Commercial Research Co.; Feb. 24, 1920.)

Stopper.—WILLIAM M. GROSVENOR of New York has devised a stopper for use in connection with the distillation of inflammable volatile organic liquids. It is more permanent and efficient than the ordinary tinfoil-wrapped cork or rubber stopper. It consists of a short tube of block tin upon which a tapered rubber stopper is vulcanized. The rubber is protected with sheet tin about 0.015 in. thick, autogenously welded to the inner tube. (1,332,335; March 2, 1920.)

Heat Interchanger for Synthetic Ammonia Process.—The efficiency of the exchange of heat between incoming and outgoing gases in the Haber synthesis is increased by modifying the design of the interchanger in accordance with the principles set forth by Stanton and Pannel, *Philosophical Transactions*, A. 214, p 199; 1914. When the velocity of fluids exceeds a certain "critical velocity," turbulent motion (instead of stream line motion) is set up. The critical (mean linear) velocity is equal to a constant times the "kinematical viscosity" divided by the diameter of the tube. The "kinematical viscosity" is equal to the viscosity divided by the density. The constant is approximately equal to 2,500 for any fluid when dealing with smooth circular tubes and when using C. G. S. units. The "critical velocity" may be easily calculated provided that the density used corresponds to the pressure in the apparatus and that the value of the "kinematical viscosity" is taken for the temperature in question. In consequence of the turbulent motion of the fluid, the rate of transfer of heat across the separating partition between the two gases is very high, whereas with stream line motion of the fluid it is very low. The accompanying table gives data for an interchanger of the type illustrated, in which *a* is the electrically heated catalyst chamber, *b* the tube through which the incoming gases pass and *c* the tube for the outgoing gases.



HEAT INTERCHANGER

	Temp., Deg. C.	Pressure Atmospheres
Catalyst chamber	600	148
Inlet of *b*	20	150
Outlet of *b*	550	149
Inlet of *c*	600	148
Outlet of *c*	70	147

Diameter of tubes:
b—Internal, 2 in.; external, 2¼ in.
c—Internal, 3 in.
Volume of gas passing through the tubes 100,000 cu.ft. per hr., expressed as free hydrogen and nitrogen measured at 20 deg. C.

(1,329,397; HAROLD C. GREENWOOD of Putney, London, England; Feb. 3, 1920.)

Synthetic Production of Sodium Cyanide.—Molten metallic sodium and nitrogen gas are introduced simultaneously into an iron vessel filled with charcoal heated to about 800 deg. C. With 784 kg. of sodium and a slight excess over the theoretical equivalent of nitrogen, 96.7 kg. of NaCN drained from the charcoal while the balance of about 1,570 kg. was retained in the charcoal mass, the latter showing an average test of about 64 per cent NaCN. The NaCN can be leached out. (1,332,-439; HANS FOERSTERLING, HERBERT PHILIPP and RALPH N. SARGENT of Perth Amboy, N. J., assignors to Roessler & Hasslacher Chemical Co.; March 2, 1920.)

Synthesis of Ammonia.—The yields in the Haber process for the production of ammonia from mixtures of nitrogen and hydrogen are increased by the use of pressures from 400 to 2,000 atmospheres as compared with pressures of 100 to 200 atmospheres used by Haber. GEORGES CLAUDE of Paris, France, has perfected an apparatus whereby these enormous pressures may be achieved in practice. The gas mixture is compressed in stages to 100, 350 and 1,000 atmospheres and is then led through heat interchangers in series in which the catalyst is placed. Owing to the high pressure, the ammonia formed may be liquefied by cooling with water between interchangers. The liquid ammonia is removed while the uncombined gases pass on to the next interchanger. When operating at 1,000 atmospheres, three interchangers in series will give a coefficient of combination of 50 per cent, whereas the Haber process does not exceed 11 to 15 per cent. The reaction is started by an electrically-heated coil, after which the heat of reaction maintains the required temperature of 500 to 700 deg. C. The nature of the catalyst is not disclosed, but it is stated that catalysts of low efficiency, such as iron, may be employed. [1,332,460; assigned to L'Air Liquide (Societé Anonyme Pour L'Etude et L'Exploitation des Procédés Georges Claude); March 2, 1920.]

Alumina.—Aluminum hydroxide is precipitated from solutions of aluminum salts (obtained from the treatment of labradorite) by heating with ammonia in an autoclave for about 8 hr. at 10 to 15 atmospheres. Precipitate formed in this manner settles readily and may be filtered by suction. The wet precipitate is now heated to a temperature between 100 and 200 deg. C. This treatment changes the precipitate from colloidal to powder form, so that the mass may be washed and filtered with ease. The filtrate may be used for the treatment of further quantities of labradorite by heating under pressure. Ammonia is evolved and the residue of aluminum silicate may be converted into a soluble aluminum salt by treatment with acid. (1,333,020; BIRGER F. HALVORSEN of Christiania, Norway; March 9, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Industrial Conference Plan for Settling Labor Disputes

The Industrial Conference, appointed by the President last year to consider ways and means of preventing industrial disputes and settling differences between employers and employees, has made a final report. The machinery devised for the settlement of labor problems comprises a National Industrial Board, local Regional Conferences and Boards of Inquiry, functioning in the following manner:

1. The parties to the dispute may voluntarily submit their differences for settlement to a board, known as a Regional Adjustment Conference. This board consists of four representatives selected by the parties, and four others in their industry chosen by them and familiar with their problems. The board is presided over by a trained Government official, the regional chairman, who acts as a conciliator. If a unanimous agreement is reached, it results in a collective bargain having the same effect as if reached by joint organization in the shop.

2. If the Regional Conference fails to agree unanimously, the matter, with certain restrictions, goes, under the agreement of submission, to the National Industrial Board, unless the parties prefer the decision of an umpire selected by them.

No Interference With Production Pending Adjustment

3. The voluntary submission to a Regional Adjustment Conference carries with it an agreement by both parties that there shall be no interference with production pending the processes of adjustment.

4. If the parties, or either of them, refuse voluntarily to submit the dispute to the processes of the plan of adjustment, a Regional Board of Inquiry is formed by the regional chairman, of two employers and two employees from the industry, and not parties to the dispute. This board has the right, under proper safeguards, to subpœna witnesses and records, and the duty to publish its findings as a guide to public opinion. Either of the parties at conflict may join the Board of Inquiry on giving an undertaking that, so far as its side is concerned, it will agree to submit its contention to a Regional Adjustment Conference, and, if both join, a Regional Adjustment Conference is automatically created.

5. The National Industrial Board in Washington has general oversight of the working of the plan.

Plan Applicable to Public Utilities

6. The plan is applicable also to public utilities, but in such cases the Government agency having power to regulate the service has two representatives in the Adjustment Conference. Provision is made for prompt report of its findings to the rate regulating body.

The Conference makes no recommendation of a plan to cover steam railroads and other carriers, for which legislation has recently been enacted by Congress.

7. The plan provides machinery for prompt and fair adjustment of wages and working conditions of Government employees. It is especially necessary for this class of employees, who should not be permitted to strike.

Relies on Public Opinion

8. The plan involves no penalties other than those imposed by public opinion. It does not impose compulsory arbitration. It does not deny the right to strike.

It does not submit to arbitration the policy of the "closed" or "open" shop.

The plan is national in scope and operation, yet it is decentralized. It is different from anything in operation elsewhere. It is based upon American experience and is designed to meet American conditions. It employs no legal authority except the right of inquiry. Its basic idea is stimulation to settlement of differences by the parties in conflict, and the enlistment of public opinion toward enforcing that method of settlement.

American Association of Engineers' Convention

It has been decided that chapter representation at the sixth annual convention of the American Association of Engineers (St. Louis, May 10 and 11) will be in proportion to chapter membership. One chapter is entitled to one delegate or more, not to exceed one for each one hundred members. Each delegate is entitled to cast a number of votes equal to the number of certified and junior members in good standing in the chapter which he represents, but not to exceed 500 in all.

One of the subjects to be discussed is "The Reorganization of A. A. E. on a Business Basis." The suggestion has been made by W. W. K. Sparrow that the association employ a high-salaried paid president.

On the evening of the first day of the convention, Monday, May 10, there will be held seven group meetings for various groups of engineers. Among the subjects to be considered are:

"Getting Salary Schedules for Public Service Engineers Into Budgets," "What Part Shall A. A. E. Take in the Presidential Campaign?" "Making a Chapter a Force in the Community," "The Federal Department of A. A. E.," "Opportunities for the Engineer in Each of the Various Branches of the Profession," "Coordinating A. A. E. Activities in the State."

Senate Approves Sale of Sodium Nitrate

By accepting the House amendments to the bill providing for the distribution to fertilizer manufacturers and users of a portion of the Government's nitrate reserve the Senate eliminated all delay in the enactment of the legislation. The War Department opposed the House amendment until assured that it was the understanding of Congress that the funds derived from the sale of this nitrate would be available for the replacement of that portion of the nitrate reserve which might be used to meet the existing emergency.

War Department Defends Government Operation of Nitrate Plants

War Department officials appeared before the Senate Committee on Agriculture last week and presented arguments and data in reply to the contentions made by Frank S. Washburn of the American Cyanamid Co. The charges with which the War Department representatives took issue particularly were those to the effect that operation of the Muscle Shoals nitrate plant would be unfair to the Cyanamid company; that there would be no market for the products of the plant; that even if there were markets the products could be sold only at a loss; and that there would be no justification in reducing the stocks of sodium nitrate if the plant were operated. Issue also was taken with the recommendation by Mr. Washburn that construction work on the dam and power plant be stopped immediately; that the nitrate plant be put in standby condition ready for the production of ammonium nitrate in case of war; and that the Government hold itself in readiness to sell the plant to private interests should conditions justify.

Completion of Hydro-Electric Plant

The Secretary of War, who testified for the second time, expressed the opinion that work on the dam should be continued irrespective of whether the nitrate plant is operated or kept in standby. He based his statement on the general need of the country for additional electric power and the particular need of the section tributary to the Muscle Shoals water power. In addition he pointed out that $7,000,000 has already been expended on construction of the dam, all of which would be wasted if this project were to be abandoned. He emphasized the importance of operating the plant as a going concern in order to keep in touch with the developments in the fixation of nitrogen as well as to insure a trained organization which would form the nucleus for the expansion which would be necessary in case of an emergency.

Government Operation Does Not Violate Contract

Colonel Joyes in his testimony established that the proposal to operate this plant for the manufacture of nitrogen fertilizer materials was entirely in accordance with the present contracts in force between the Government and the American Cyanamid Co. and that there is no intention on the part of the Government of violating the contractual obligations with the company.

Replacement of Sodium Nitrate by Ammonium Sulphate

Major Gaillard testified again. He pointed out that sulphate of ammonia could replace, at least to the extent contemplated by this plant, nitrate of soda in fertilizers and instanced the fact that these two materials have sold and are selling on a competitive price basis. He brought out the relative prices of the two materials in mixed fertilizer in the past showing the steady increase in the use of sulphate as compared to nitrate.

Criticism of Production Costs

Major Gaillard also declared that Mr. Washburn's costs, which show no margin over and above operating expenses, were based on the use of steam power, which the Government did not contemplate using. He also claimed Mr. Washburn's figures contained other items not properly chargeable to operating costs. Even if Mr. Washburn's figures for the cost of production could be accepted, Major Gaillard declared, there still would be a margin of from $15 to $20 per ton of sulphate between the probable selling price and the cost of production.

Idleness Will Cause Deterioration

Colonel Burns, in an effort to disprove Mr. Washburn's contention that the plant would be just as available in case of a war emergency if kept in standby condition quoted from Mr. Washburn's testimony before the House Committee on Military Affairs in 1916 at which time Mr. Washburn stated that is was conceivable that plant of this sort could be maintained in idleness without such a degree of deterioration as to render it useless but that it was highly improbable that it would be so maintained and that a country which should rely for its powder supply upon the practically indefinite maintenance and working order of an idle plant would be taking a most extraordinary risk, which if it could be avoided, would be unwarranted and that a minor objection would be the cost of maintaing such a plant in readiness for operation, its upkeep and the interest on the idle capital. Colonel Burns reiterated that the operation of this plant would make it possible to redudce the reserve stock of Chilean nitrates by 150,000 long tons.

Availability of Ammonia Nitrogen

Dr. Milton Whitney, chief of the Bureau of Soils, testified as to the present urgent need in American agriculture of the products of this plant. He brought out the developments that must occur in the fertilizer industry in the use of inorganic nitrogen rather than of organic and of the more concentrated inorganic material. He stated that he entertained no doubt whatever that the products of this plant could be absorbed immediately in the agriculture of the country. He also called attention to the fact that while organic nitrogen, ammonia nitrogen, and nitrate nitrogen are somewhat different in their actions in the soil, that there is no such wide difference that would preclude the use of one material in the place of the other, in the absence of the other. He challanged Mr. Washburn's statement that ammonium sulphate cannot replace nitrate of soda in fertilizers.

Niagara District Industrial Association

There has recently been organized the Niagara District Industrial Association, embracing all the towns and cities of the Niagara Falls consular district and having for its object the promotion of industries in that section. With the rapid pushing forward of the hydro-electric canal and the completion of the Welland Ship Canal (on which work is soon to be resumed), an abundance of electric power and increased facilities for shipping will be made available here, and both points to a greater development of this already important industrial region. This district offers special opportunities to the following classes of industry: All manufactures of iron, steel, textiles, paper and pulp, electrochemicals, milling and refining.

It is in project to hold a three days' industrial congress in August next, for the purpose of bringing to the canal and power zone representatives of United States industries, in order to show them the advantages here in the way of power and of ocean-going transportation.

Canadian Institute of Chemistry

The Canadian Institute of Chemistry was organized last May at Montreal, and now has its headquarters at 314 Beaver Hall Hill in that city. The president is Prof. J. Watson Bain of the University of Toronto, and Harold J. Roast is secretary-treasurer. Among its objects are to develop the profession of chemistry so that trained chemists may become eligible for the growing needs of the country, to provide consultation for the requirements of the government, "to protect the public by gathering together a body of men who may be consulted with confidence," and to provide a registration bureau, social centers for chemists only and an employment bureau; also for the exchange of chemical knowledge by the organization of sections and sectional meetings.

Members are to be known as fellows and associate fellows, of whom the latter correspond to junior members, subject to approval by the council before their election to full fellowship. The requirements for fellowship are that the candidate

(*a*) be at least twenty-five years of age, a graduate of a recognized university having had a four years' course in pure or applied chemistry as his major subject, and who has been actively engaged in the pursuit of chemistry for two additional years in a responsible capacity.

(*b*) Under similar requirements in the main, if he has taken a three years' course he must show that he has had three years' additional experience in a responsible capacity in an approved laboratory.

(*c*) Lacking the requirements of (*a*) and (*b*), he must have held a position of responsibility in pure or applied chemistry for five years or more and will be examined as to his capacity by a committee of the Council. The examination may be waived in the discretion of the Council if the applicant has had eight years of such experience at the time of the inauguration of the Institute.

Associate fellowship provides for properly trained chemists under twenty-five years of age. At the last report the Institute had 113 fellows and three associate fellows, and it is announced by the secretary that "His Royal Highness, the Prince of Wales, has graciously consented to become an honorary fellow." In accordance with the British custom, fellows and associate fellows may add the letters F. C. I. C. or A. C. I. C. respectively after their names. Both men and women are eligible.

Bureau of Standards Appropriation

As finally agreed upon, the legislative, executive and judicial appropriation bill makes available to the Bureau of Standards $432,360 for salary accounts.

In addition, the bill provides $30,000 for testing varnish materials, soap materials, inks and chemicals. Another item of $10,000 is given the Bureau for work looking to the development of color standards and color measurement, with special reference to their industrial use in standardization and specification of colorants, such as dyestuffs, inks and pigments, and in paint, paper and textiles in which color is a pertinent property. The sum of $25,000 is provided for the continuation of the investigation of the problems involved in the production of optical glass. An additional $25,000 is allowed for metallurgical research. This work includes the development of metal substitutes, as for platinum.

Phthalic Anhydride May Again Be Used as Synthetic Indigo Intermediate

A new importance is being placed upon the development during the war by the Bureau of Chemistry of a method for producing phthalic anhydride. The scarcity of wood and other causes is adding materially to the cost of methyl alcohol and formaldehyde. Due to the cheapness with which phthalic anhydride is being manufactured by the Bureau of Chemistry's process, it seems probable that it will be employed in the near future in the manufacture of indigo. The wood situation is more clearly reflected in the paper market. That this scarcity is likely to continue for an extended period is indicated by the fact that English interests have just purchased, for a large sum, the English rights to the public service patent which was secured by the Bureau of Chemistry for its process.

The Bureau of Chemistry during the war developed the method of production on a laboratory scale. The process resulted in a purer product than had been made in Germany. Through co-operation with private manufacturers the process has been made a commercial success, with the result that phthalic anhydride is being produced at decreasing costs and is even being sold at the very gates of Germany. Switzerland has been a recent large buyer of the anhydride in this country. Important shipments also have been made to England, Japan and other countries.

Phthalic anhydride formerly was used as an intermediate in the manufacture of indigo, but was displaced by the use of the cheaper process, which in turn seems about to be displaced as a result of the cheapness of the new process combined with the rise in price of alcohol.

Potash From Green Sands

The Eastern Potash Corporation of New York is building a plant to make potash and fertilizer from the green sands of New Jersey. These sands contain from 7 to 8 per cent of potash, and occur in large deposits in the states of New Jersey, Delaware, Maryland and Virginia.

Their plant is located on the Raritan River Canal near New Brunswick, and is accessible by both water and rail. It covers about eighty acres, and is designed to handle 1,000 tons of green sands a day and produce 20,000 tons of K_2O and 600,000 tons of residue per year. Connected with this plant is the largest lime plant in the world, containing ten 8 x 125 ft. rotary kilns, producing 1,000 tons of lime a day.

Limestone for this plant will be quarried from the company's quarries located in the northern part of the state, where it will be crushed and then shipped by rail to New Brunswick. The company also owns the entire capital stock of the Raritan Refining Corporation, a near-by company, which has a favorable contract to refine Mexican petroleum. The Eastern Potash Corporation will use the fuel oil from this company to operate its power plants and kilns.

A contract has also been let to build a brick plant to utilize the residue, which makes a fine lime silica building brick. Capacity of this plant is to be 500,000 brick per day, and it is so designed that it can readily be increased to 1,000,000 brick per day.

The New Brunswick plant is now about 60 per cent completed and it is expected to be in operation early next fall. The cost of the plant is estimated to be about $250,000.

Society of Cotton Products Analysts to Hold Convention

The eleventh annual convention of the Society of Cotton Products Analysts will be held at the Grunewald Hotel, New Orleans, La., on Monday and Tuesday, May 10 and 11.

Besides the many matters of importance that will come up, and a number of reports and discussions, the program will include the following:

L. M. Tolman, chief chemist, Wilson & Co., "Oriental Oils."

Eugene E. Ayres, Sharples Specialty Co., "Centrifugal Recovery of Cottonseed Oil From Soap Stock."

George S. Jamieson, chemist in charge Fat, Oil and Wax Laboratory, Bureau of Chemistry, "The Composition of Cottonseed Oil."

Dr. David Wesson, chief chemist, Southern Cotton Oil Co., "The Eastman Colorimeter"; "A New Optical Method for Determining Oil in the Mill Product."

Harrison E. Howe, vice-chairman, Division of Industrial Relations, National Research Council, "The National Research Council and Its Relation to Our Society."

I. G. Priest, physicist, Bureau of Standards, "Rainbow Report on Color of Vegetable Oils."

Three sessions will be held, the first early Monday afternoon and two sessions Tuesday. Tuesday evening a real round-table gathering, in the form of a subscription dinner at the Grunewald, has been arranged.

Civil Service Examinations

The following examinations are announced by the United States Civil Service Commission:

Expert Driller. A vacancy exists in the Bureau of Mines at a salary of $3,000 to $3,600 a year. At least six years' experience in oil and gas well drilling is required. Apply on Form 2118 before May 11.

Supervising Metallurgist. The duties of this position will be to take charge of one of the mining experiment stations of the Bureau of Mines. Salary, $4,000 to $5,000 a year. Apply on Form 2118 before May 25.

Laboratorian Qualified in Photography. Applicants must have had at least three years' experience in general photographic work, two years of which must have been in photomicrographic work. They must understand rudiments of metallography and be able to etch metals and photograph their microstructure. Vacancies exist in the Navy Department at $4 to $7.20 per day. Apply on Form 1312 before May 25.

Sixth Member Society of Engineering Council

The American Railway Engineering Association has accepted an invitation from United Engineering Society to become a member society of Engineering Council. The Association has about 1,650 members and its headquarters are at 431 South Dearborn St., Chicago, Ill. Its president is Harry R. Safford, and its secretary E. H. Fritch. The excellent technical work done by the committees of this Association in many branches of railroad construction and maintenance is well known. The Association has named as its representative upon Engineering Council its president, Mr. Safford, who is a member of the American Society of Civil Engineers and Engineering Institute of Canada.

The societies now represented in Engineering Council have an aggregate membership of 45,000.

Relievin the Freight Car Shortage

The Material Handling Machinery Manufacturers Association has made the following calculation to show how co-operation will assist in relieving the existing car shortage.

In the United States there are about 2,452,000 freight cars now in use. These are rolling in trains loaded and empty only 9.03 per cent of the time. They average 11.29 per cent time loading and 11.29 per cent being unloaded, if every car is released before demurrage starts. The balance of 68.39 per cent is waste time, due to repairs, switching and unnecessary delays. One hour saved each day for each car would equal 2,452,000 car-hours per day. Dividing this figure by 24 (hours per day,) it is self-evident that the public would have over 102,000 additional cars to use through this simple saving of one hour per car per day.

This may be accomplished if every person or company loading or unloading cars will explain to the crews doing the work that every car released quickly helps each maker or manufacturer to increase his ability to get his goods quicker and at less expense. This ultimately reduces living costs for the crews and all.

Offer to Lease Muscle Shoals Nitrate Plant

A new angle in the matter of whether Muscle Shoals plant should operate was introduced by the proposals of L. T. Layton, representing the Fisheries Products Co., a $10,000,000 corporation, when he appeared before the House of Representatives committee investigating expenditures in the War Department. Mr. Layton's company is considering negotiation of a lease of part or all of the Muscle Shoals plant, with the idea of adding these operations to the company's existing fertilizer manufacturing activities. At present its principal activity is in the field of fish scrap, which it has developed as a fertilizer material, most extensively through North Carolina, South Carolina and Georgia.

This definite proposal that one company is willing to make arrangements with the Government to lease or perhaps purchase this plant seems in conflict with the claims which have been made recently that there is no available market for it or its products.

Stumpage for Tannin Extract for Sale

Plans are being made by the District Forester in Washington for the sale of approximately 150,000 cords of chestnut tannin extract wood stumpage in the Nantahala National Forest, in western North Carolina. The timber lies in Macon county along the Nantahala River and about fifteen miles distant from Andrews. Franklin is about the same distance to the east.

On privately owned land adjacent to this body of Government timber there is estimated to be approximately 200,000 cords of chestnut. This, in connection with the timber to be sold by the Forest Service, would be sufficient to maintain a moderate-sized tannic-acid plant for twenty-five years. Approximately 15,000 acres of Government lands are involved, of which 10,500 are heavily timbered.

The topography is favorable for all lumbering operations and work may be carried on practically throughout the year. A privately owned standard-gage railroad parallels the tract for some distance. Sufficient labor to operate a moderate-sized plant is said to be available from local sources.

A Few Uses of Zinc and Zinc Compounds

The inter-departmental committee of the Bureau of Standards at Washington has adopted new specifications for paint to be purchased by the Government that provide for not less than 30 per cent of zinc oxide in the pigment mixture. This material prevents chalking, insures color constancy and gives longer wear to paint. Zinc oxide has been used by the British Navy for half a century in battleship paint.

The rotating cylinders of many leading washing machines, now rapidly becoming a necessary adjunct to the American home, are made of rolled zinc. This material does not rust and therefore permits clothes being cleaned without discoloration.

Almost one-half of the compound of the best automobile tires on the market today is lead-free zinc oxide. This filler gives the tire its white color and resiliency and increases its tensile strength and durability.

Lithopone, a zinc product, is used in all flat wall finishes, wall paper and other interior decorations of the home. This material is also found in linoleum and table oilcloth, as well as being an important ingredient in surgical rubber goods and in certain hospital supplies.

According to wood-preserving experts, the railroads of the country could save 4c. each year on all ties they buy if these were treated before being placed in use. On one division of the Illinois Central in Kentucky ties treated with zinc chloride in 1903 are apparently still in almost perfect condition.

Zinc roofs have been in vogue in Europe for centuries. Their durability and the fact that zinc is a non-rusting material are qualities responsible for Europeans adhering to this type of covering for both their homes and for public buildings.

Book Reviews

THE PETROLEUM HANDBOOK. By *Stephen O. Andros, E. M.* 206 pp. 48 figs. 17 tables. Chicago: The Shaw Publishing Co. Price, $2.

While this book contains only a small proportion of original matter, it represents a careful and intelligent selection of fundamental data in regard to the petroleum industry. Facts and figures from twenty-seven standard works of reference have been brought together in the form of a connected, coherent résumé of this great industry.

The book is divided into eight chapters. The first discusses the origin, accumulation and occurrence of petroleum, the second the methods of exploration and drilling for oil and gas. Chapter III reviews briefly the methods of refining, giving flow sheets to illustrate the principal processes. Chapter IV describes the compression, refrigeration and absorption methods for the recovery of gasoline from natural gas. The shale oil industry is touched upon in Chapter V. Chapters VI and VII take up: The marketing of petroleum products in barrels, trucks and tank cars; gasoline specifications, inspection laws and marketing practices. A summary of the different state inspection laws relating to gasoline and kesosene is given in tabular form. The final chapter, "The Economic Utilization of Petroleum," illustrates the interrelation of the several factors previously discussed, in the working of a typical large progressive oil company.

Engineers, students and others interested in a brief yet accurate summary of the petroleum industry will welcome the appearance of this condensed reference book.

ALAN G. WIKOFF.

Personal

ADAM G. ADAMS, JR., who was until recently consulting engineer with the Nitrate Division of the Army Ordnance at Washington, has become affiliated with the Ashcraft-Wilkinson Co., of Atlanta, Ga., manufacturer and distributor of fertilizing materials.

A. V. BLEININGER, chief of the Ceramic Research Laboratory of the Bureau of Standards at Pittsburgh, has gone to Washington with his entire staff. A dinner and a large purse was given for Mr. Bleininger by his friends in Pittsburgh. The Ceramic Research Laboratory will be located in the new Engineering Building at the Bureau of Standards, Washington, D. C.

ELLERY K. FILES has become assistant superintendent of the pyroxylin department of the Duratex Co., Newark, N. J.

Dr. ZAY JEFFRIES will give fifteen lectures on non-ferrous metallography at the Graduate School, Harvard University, May 10 to June 1.

C. BRACE KELLY, formerly district manager of the American Sintering Co., Youngstown, Ohio, is now engineer for the American Ore Reclamation Co., with offices in New York.

E. G. REPPEL, general sales manager of the Buffalo Foundry & Machine Co., has spent a month touring the West. He left San Francisco April 24 by way of the Northwest for the East.

F. ROHDE has resigned as vice-president and general manager of the Palo Co., New York, to become president of the Rohde Laboratory Supply Co., recently incorporated.

FREDERICK J. RYAN has been elected president of the American Metallurgical Corporation, Philadelphia, Pa.

S. R. SCHOLES has severed his connection with the H. C. Fry Glass Co., Rochester, Pa., to become general manager of the Utility Glass Works, Lonaconing, Md.

Prof. ROBERT E. SWAIN of Leland Stanford University has been appointed by Federal Judge T. D. Johnson, commissioner to observe the operation of the smelters at Murray and Midvale, Utah, and investigate all complaints made as to smoke damage, reporting to the court on Feb. 1, 1921.

CLARENCE T. TODD, formerly with the Timber Butte Milling Co., is now with the engineering department of the Ray Consolidated Copper Co.

MAX ALBERT WHITING addressed the New York Electrical Society on Wednesday, April 21, on "Electricity in the Production of Iron and Steel."

ORVILLE WRIGHT is to be the recipient of the John Fritz Medal this year, at a meeting to be held in the auditorium of the Engineering Societies Building, New York City, May 7.

F. W. YOST, formerly engineer of the American Ore Reclamation Co., succeeds Mr. Kelly, resigned, as district manager of the American Sintering Co., Youngstown, Ohio.

Obituary

Dr. JOHN A. BRASHEAR, past president of the American Institute of Mechanical Engineers, died at his home in Pittsburgh, April 8, following a lingering illness.

O. J. D. THOMAS, late chief chemist of the E. B. Eddy Co., Hull, Canada, is dead of pneumonia. Mr. Thomas came from England some years ago, and, after spending some time in metallurgical work, engaged with the Eddy Co. in 1917.

Current Market Reports

The Non-Ferrous Metal Market

New York, April 26, 1920.—The domestic copper market remains quiet at 19¼c. for shipment up to August, with the outside market shading quotations to 18½c., with a very little metal to offer. The quietude is probably very largely due to the railroad tie-up. It must also be taken into account that the Butte strike has greatly lowered the production of the refineries. Lead and zinc strengthened slightly, while silver continues to fall off in price. Another break in tin dropped the price to 61½c.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	11.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	61.50
Lead, New York, spot	9.00
Lead, E. St. Louis, spot	9.25
Zinc, spot, New York	8.75@9.00
Zinc, spot, E. St. Louis	8.45

OTHER METALS

Silver	oz.	$1.17⅞
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f. o. b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	103.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	26.75
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless bronze tubing	34.50
Seamless high brass tubing	30.50

SCRAP METALS

	Cents per Lb. Buying Price
Aluminum, cast scrap	22.50 @24.50
Aluminum, sheet scrap	23.50 @24.50
Copper, heavy machinery comp	15.50 @16.00
Copper, heavy and wire	15.75 @16.00
Copper, light and bottoms	14.25 @14.75
Copper, heavy cut and crucible	16.25 @17.25
Brass, heavy	10.00 @10.25
Brass, light	8.50 @ 9.00
No. 1 clean brass turnings	10.00 @10.25
No. 1 comp. turnings	13.75 @14.25
Lead, tea	5.75 @ 6.00
Lead, heavy	7.50 @ 7.75
Zinc, scrap	5.00 @ 5.25

The Iron and Steel Market

Pittsburgh, Pa., April 23, 1920.

The course of the pig iron and steel markets has been uninteresting, the markets being extremely dull. Interest centers largely upon the curtailment in steel production and shipments caused by the rail strike and the possible effect such curtailment may have.

While the general accounts of the rail strike are very favorable as to the resumption of rail movement, it chances that the iron and steel industry has had but little relief thus far. While conditions East and West have improved materially, there is little improvement in the immediate Pittsburgh district and none in the valleys. There has been considerable improvement in the Chicago district, including Gary. The Pittsburgh gateway remains practically closed. The railroads are moving some perishables and foodstuffs, but not much even of such commodities. When it comes to commodities in which the iron and steel industry is interested, the railroads offer but little outside of suggestions that solid trainloads be made up, and there is question whether much of that sort of thing would prove successful.

Production Curtailed Less Than Expected

Production in the iron and steel industry, however, has not been curtailed to as great an extent as was expected or as was estimated early in the rail strike that began about a fortnight ago. While many blast furnaces are banked and not a few works are closed or are merely "limping along," there has been operation of many furnaces and plants by unexpected or devious means. Much Connellsville coke has been moved by water. Several lines of communication have been established over public roads, closed by the strike as to normal operation, but correspondingly open if shippers or consignees had locomotives and crews they could send out to use rails that would otherwise be idle. A few furnaces have been found with stocks of coke, accumulated during the several months of restricted transportation, when everyone took all the coke obtainable irrespective of requirements.

Even should the rail strike end entirely within a few days the curtailment in production would last for some time, as return of empties will undoubtedly be slow, and the total loss of production, in pig iron and steel, may amount to nearly if not quite a week's normal production by the whole industry.

Shipments Reduced More Than Production

Shipments of steel are reduced very much more than production. While the Youngstown mills are nearly all closed, the immediate Pittsburgh district is producing a fairly large tonnage, but has been shipping scarcely any. The largest local independent managed to gather a total of about 1,500 cars, which were loaded and have gone to railroad sidings or remain on company sidings, it becoming necessary then to pile steel on the ground. The Carnegie Steel Co. has been greatly aided in keeping its mills from being choked by having its own interplant line, the Union Railroad, as well as the Bessemer road, both of which have been in regular operation except for the moving of freight off their rails.

Consumers Are Indifferent

Curtailment in shipment has not brought the consumers into the prompt market to any extent. The indifference of consumers may be due to their being likewise restricted, in their operations, to a realization that prompt steel could hardly be secured by bidding for it, or to their having greater stocks that has been assumed. This last point raises an interesting question, for widely divergent views have been expressed of late as to the interpretation of the large output the industry has had in the past three months. One view was that the large output being absorbed so readily showed that the country had unexpectedly great absorbing power, the opposed view being that all the steel shipped was not consumed, but was to a considerable degree absorbed in stocks. Time may soon tell which was the correct analysis.

Whatever may be the state of order books or the position of the market at the moment as to the level of prices or the stiffness with which they are maintained, one cannot possibly contend that the position of the money and security markets disclosed by developments of the past few days is not an important factor in making or indicating the steel market's future. In the long run the steel industry, particularly when it is 40 or 45 per cent larger than just before the war, cannot have full employment for its capacity unless a large percentage of the output passes into works of permanent construction, into what may be called long term investments. Such investments certainly are not made when financial conditions are as at present. When the underwriters of 10-yr. 7 per cent gold bonds of the Pennsylvania R.R. can offer the bonds to the public at face, it is evident that investment construction generally cannot proceed on a high level of activity.

Steel Corporation Booked Far Ahead

Light on this general subject may be thrown by consideration of the state of steel mill order books. Several of the

large independent producers state that they have not formally opened their order books for third quarter shipments, though undoubtedly they have booked considerable tonnages, with large customers, for that period, while they will probably carry over some second quarter tonnages. The smaller independents, which are quoting much higher prices than the larger independents, are of course booked still less distances ahead. The Steel Corporation alone is booked far ahead, its average date being about Jan. 15, 1921, though of course this is merely an average, the various products being sold for widely different distances ahead. That the Steel Corporation is booked far ahead is merely a reflection of the fact that its prices are lower than those of the independents, and the further fact that its customers know that, in accordance with established practice in the steel trade, they would not be expected to take deliveries such as would work a distinct hardship to the buyer. The short distance ahead to which the independents are sold is significant. It might be thought that sales farther ahead could be effected by reducing prices, but such reductions would probably discourage buyers, and the policy of independents generally seems to be that, since they have attained certain price levels, it is better to adhere to them and let the trade buy for whatever distance ahead it chooses. It seems far from improbable that a general readjustment to a safer and saner condition in business generally is about to occur, and in any such adjustment the iron and steel industry will naturally have a part. Not a few bankers have predicted a crisis for next August, hence it is reasonably certain that no such thing will occur, for an expected crisis or panic is practically impossible. Either the event will not occur at all or it will be precipitated, for an earner time, by the expectation.

Chemical and Allied Industrial Markets

New York, April 26, 1920.

General conditions throughout the list have not improved during the week; if anything the situation has become more serious than it has ever been before in the memory of those engaged in the trade. Spot material of the alkali group is being consumed faster than it arrives, producers are behind in their contracts on the heavy chemicals and all coal-tar products are practically nominal both on spot and contract. Shipments made just prior to the railroad strike are still en route and whatever material is on hand for the producer to ship is lying idle because of the lack of cars. Both foreign and domestic demand is very strong, as it has been for some time back, but owing to the above-mentioned conditions the volume of business has fallen off considerably.

PRINCIPAL PRICE CHANGES

	Today	Last Week	Last Month	Last Year
Aqua ammonia, 26 deg., lb.	$0.08½–$0.12	$0.08½–$0.12	$0.08½–$0.12	$0.06½–$0.09
Bleaching powder, cwt.	4.00 – 5.00	4.00 – 5.00	3.50 – 4.50	1.40– 2.00
Calcium chloride, fused lump, ton	22.00 –40.00	22.00 –40.00	20.00 –30.00	19.00 –20.00
Glauber's salt, cwt.	1.65 – 2.00	1.50 – 2.00	1.45 – 1.65	1.35 – 1.50
Salt cake, ton	21.00 –32.00	22.00 –26.00	21.00 –22.00	12.00 –14.00

General Chemicals

No new developments have occurred in this list, prices in general being sustained by the tightness of supplies. It is reported that producers are pretty well sold out on *calcium chloride* for future and the spot market is in a very poor way. The fused lump grade is firm at $22@$25 for car lots and $30@$40 per ton for less, while granulated came up slightly at 1½@2½c. per lb. Heavy demand on *carbon bisulphide* has tightened up. The spot market is short of supplies, and quotations vary from 9@10c. for spot, with the latter figure prevailing. Continued heavy demand both foreign and domestic has left producers in a bad way, being sold up for months ahead and unable to keep pace with contracts. The spot market is practically bare of material and as high as $32 per ton has been heard, but the average seems to be between $28@$30 per ton. With the arrival of shipments of *sodium nitrite* from Norway the situation is easier. Spot material is 22@24c. per lb. *Nickel salts* has been under heavy inquiry during the week and former quotations of 14@15c. for double and 16@17c. per lb. for single are well maintained. *Soda ash* remains in the same nominal position, with quotations varying from $3.50@$4.50 for either grade, while export demand continues brisk and grasping at all available supplies. *Bleaching powder* is practically off the market, and figures as high as $5 per cwt. have been heard during the week, but this cannot be considered the market, as there is so little material available that whatever does change hands is at a premium. The *acid* group is extremely short and business is being done on a small scale. *Hydrochloric* is wholly nominal, as there is very little material on hand. *Hydrofluoric* is in almost the same position and producers are reported sold ahead as far as three months. The 52 per cent grade is listed at 12@14c. per lb. *Oxalic* crystals under heavy demand has come up and is quoted at 55@57c. per lb.

Coal-Tar Products

Practically the same conditions prevailing throughout the chemical list exist also in tar products market. The spot shortages and transportation difficulties are possibly felt more acutely here than in any other market. There is practically no spot market on any of the items and producers are so much handicapped by the extremely heavy demand and the large decrease in production as not to be able even to conjecture when and how the situation may be made easier. *Beta napthol benzoate* remained firm, with difficulty in obtaining material. The previous listing of 50@65c. per lb. still holds. *Phthalic anhydride* is under the usual demand with one factor practically controlling the market price on this item. *Aniline oil*, under usual demand, held firm at 34@45c. with some difficulty in locating material at these figures. The *salts* are scarce on spot and 42@48c. per lb. is being asked.

Naval Stores

In naval stores the tight situation of extremely high prices, no material and heavy demand has not become any easier during the week. *Turpentine* still remains nominally quoted at $2.50 per gal., but there is no material obtainable even at this level. *Rosins* are nominal also, as there is nothing to be had in either the New York or Savannah market. These conditions will remain until the arrival of the crudes at the primary market and until such time as the transportation problem can be made easier.

Vegetable Oils

Very little activity on the part of buyers of vegetable oils has been shown during the period and on the whole the market has been very weak. *Soya bean*, in barrels, slumped and is listed at 18@18½c., against 19@23c. per lb. of last week, and tanks at 13¾c. *Cottonseed* has been weak and dropped 1½c. to 16@17c. per lb.

Miscellaneous Materials

Barytes remains in the same nominal position as was previously reported. All quotations by producers are subject to conditions at the time of shipment. There is no spot material available. Quotations of $38@$40 for white floated and $20@$25 for off color per ton still hold.

The *feldspar* situation remains unchanged, with prices of $13@$18 for ground grade, f.o.b. New York State, well maintained.

Fluorspar, gravel, f.o.b. Tunuco, Mexico, is listed at $25, while nominal prices of $30@$45 for acid grade lump, and $52@$57 per ton, for acid grade ground, f.o.b. Tunuco, still hold.

Ores and Semi-Finished Products

The Government price having been removed from coke, the price jumped from $6 to $11@$12 for furnace and from $7 to $12@$14 per ton on foundry. Due to the recent railroad strike, very little material has been moving from the Connellsville district, which makes listings practically nominal.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.60 – $0.65
Acetone	lb.	$0.13 – $0.15	.16 – .18
Acid, acetic, 28 per cent	cwt.	3.50 – 4.00	4.25 – 4.50
Acetic, 56 per cent	cwt.	8.00 – 8.50	8.75 – 9.00
Acetic, glacial, 99½ per cent, carboy	cwt.	15.50 – 16.00	16.50 – 17.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 – .86	1.17 – 1.18
Hydrochloric (nominal)	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 – .....
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.05 – .05½	.06 – .07
Molybdic, C. P	lb.	.....	4.25 – 5.00
Nitric, 40 deg	lb.	.07 – .07¼	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09¼
Oxalic, crystals	lb.	.55 – .57	.....
Phosphoric, Ortho, 50 per cent solution	lb.	.24 –	.....
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	16.00 – 18.00	.....
Sulphuric, 60 deg., drums	ton	.....	.....
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	.....
Sulphuric, 66 deg., drums	ton	32.00 – 33.00	.....
Sulphuric, 66 deg., carboys	ton	34.00 – 35.00	.....
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 – .....
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	34.00 – .....
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 – .....
Tannic, U. S. P	lb.	.....	1.35 – 1.45
Tannic (tech.)	lb.	.....	.60 – .80
Tartaric, crystals	lb.	.....	.69 – .74
Tungstic, per lb. of WO	lb.	.....	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.50 – 3.50	.....
Alcohol, denatured, 188 proof (nominal)	gal.	.....	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	.....	.98 – 1.02
Alum, ammonia lump	lb.	.04 – .05	.05½ – .06
Alum, potash lump	lb.	.08 – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15 – .16	.18 – .20
Aluminum sulphate, commercial	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03¼ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.08½ – .12	.....
Ammonium sulphate	lb.	.07 – .08	.08½ – .....
Amylacetate	gal.	.....	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	.....	.13½ – .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	.....
Barium chloride (nominal)	ton	.....	165.00 – 175.00
Barium dioxide (peroxide)	lb.	.23 – .27	.28 – .30
Barium nitrate	lb.	.17 – .19	.20 – .22
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		.....	.....
Blue vitriol (see copper sulphate)		.....	.....
Borax (see sodium borate)		.....	.....
Brimstone (see sulphur, roll)		.....	.....
Bromine	lb.	.85 – .90	.....
Calcium acetate	cwt.	2.00 – 2.05	2.10 – .....
Calcium carbide	lb.	.06 – .06½	.07 – .07½
Calcium chloride, fused, lump	ton	22.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.35 – 5.00
Calcium peroxide	lb.	.....	1.50 – 1.70
Calcium phosphate, monobasic	lb.	.....	.75 – .80
Calcium sulphate, pure	lb.	.....	.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	.....	.80 – 1.05
Caustic potash (see potassium hydroxide)		.....	.....
Caustic soda (see sodium hydroxide)		.....	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.07½ – .08	.08½ – .09
Chloroform	lb.	.29 – .30	.31 – .32
Cobalt oxide	lb.	.....	2.00 – 2.05
Copperas (see iron sulphate)		.....	.....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	.....	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		.....	.....
Epsom salt (see magnesium sulphate)		.....	.....
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)		.....	.....
Glycerine	lb.	.....	.24½ – .26
Iodine, resublimed	lb.	.....	4.10 – 4.30
Iron oxide, red	lb.	.....	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	.14 – .14½	.15 – .18
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	.....	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	.....	1.50 – .....
Magnesium carbonate, technical	lb.	.....	.13 – .14½
Magnesium sulphate, U. S. P	100 lb.	3.40 – 3.55	3.60 – 4.25
Magnesium sulphate, commercial	100 lb.	3.00 – 3.10	3.10 – 3.25
Nickel salt, double	lb.	.14 –	.15 – .....
Nickel salt, single	lb.	.16 – .17	.17½ – .....
Phosgene (see carbonyl chloride)		.....	.....
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	.....	.35 – .37
Potassium bichromate	lb.	.36 – .37	38 – .42
Potassium bitartrate (cream of Tartar)	lb.	.56 – .58	.59 – .61
Potassium bromide, granular	lb.	.....	.50 – .65
Potassium carbonate, U. S. P	lb.	.60 –	.65 – .70
Potassium carbonate, crude	lb.	.26 – .27	.28 – .30
Potassium chlorate, crystals	lb	.15 – .16	.21 – .....
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	.....	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 – .....
Potassium permanganate	lb.	.....	$0.65 – $0 95
Potassium prussiate, red	lb.	.90 – 1.00	1.05 – .....
Potassium prussiate, yellow	lb.	.34 – .36	.38 – .41
Potassium sulphate	ton	$225.00 – 240.00	.....
Rochelle salts (see sodium potas. tartrate)		.....	.....
Salammoniac (see ammonium chloride)		.....	.....
Sal soda (see sodium carbonate)		.....	.....
Salt cake	ton	28.00 – 32.00	.....
Silver cyanide (nominal)	oz.	.....	1.25 – .....
Silver nitrate (nominal)	oz.	.....	.77 – 82¾
Soda ash, light	100 lb.	.....	3.50 – 3 60
Soda ash, dense	100 lb.	.....	3.55 – 3 65
Sodium acetate	lb.	.08½ – .09	.09½ – .10
Sodium bicarbonate	100 lb.	2.45 – 2.60	2.75 – 3 00
Sodium bichromate	lb.	.40 – .41	.42 – 43
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10 00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – 07½
Sodium borate (borax)	lb.	.08½ – .08¾	.09 – 09½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 –	.12 – 14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.50 – 5.50	7.00 – 7 50
Sodium hyposulphite	lb.	.....	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25¾ – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.22 – .24	.24 – .25
Sodium peroxide, powdered	lb.	.....	.30 – .32
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .z	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.65 – 1.70	1.75 – 2 00
Sodium sulphide, crystal, 60–62 per cent (cone)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.25 –	.28 – .....
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	.....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 – .....
Zinc carbonate, precipitate	lb.	.....	.19 – .20
Zinc chloride, gran	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12¼ – .12½	.13 – .15
Zinc oxide, U. S. P	lb.	.....	.19 – .21
Zinc sulphate	lb.	.03¼ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.60
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.42 —	.48
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.25 —	1.35
Benzidine, sulphate	lb.	1.20 —	1.25
Benzoic acid, U.S.P	lb.	.90 —	1.10
Benzoate of soda, U.S.P	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	25 —	.35
Beta naphthol benzoate	lb.	50 —	.65
Beta naphthol, sublimed	lb.	.70 —	.90
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.16 —	.18
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.95 —	1.10
Cresylic acid, 95-97%, dark, in drums	gal.	.85 —	1.00
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.70
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	1.40 —	1.50
Dimethylaniline (nominal)	lb.	..... —	.....
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb.	.25 —	.30
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.34 —	.36
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.55 —	.65
H-acid (nominal)	lb.	1.90 —	2.00
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.10 —	.12
Monoethylaniline	lb.	1.70 —	1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	.08 —	.09
Naphthaline, flake	lb.	.09 —	.10
Naphthaline, balls	lb.	.10½ —	.11
Naphthionic acid, crude	lb.	.70 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.75 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.25 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	1.00 —	1.35
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.60 —	3.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.50 —	.52
Salicylic acid, U. S. P	lb.	.55 —	.60
Salol	lb.	90 —	1 00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.25 —	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.38 —	$0.39
Beeswax, refined, light	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal) †	lb.	.45 —	.46
Japan	lb.	.20 —	.21
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	—	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	—	.11
Paraffine waxes, refined, 118-120 m.p.	lb.	—	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.12 —	.12½
Paraffine waxes, refined, 133-135 m.p.	lb.	.14 —	.14½
Paraffine waxes, refined, 135-137 m.p.	lb.	.16 —	.16½
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$18.50	—$19.50
Rosin E-I	280 lb	19.75	— 20.00
Rosin K-N	280 lb.	20.25	— 21.95
Rosin W. G.-W. W.	280 lb.	22.00	— 24.00
Wood rosin, bbl.	280 lb.	15.50	— 18.50
Spirits of turpentine	gal.	....	— 2.50
Wood turpentine, steam dist.	gal.	2.35	— 2.40
Wood turpentine, dest. dist.	gal.	....	— 2.00
Pine tar pitch, bbl.	200 lb.	8.40	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 15.00
Retort tar, bbl.	500 lb.	15.00	— 15.50
Rosin oil, first run	gal.	.92	— .95
Rosin oil, second run	gal.	.94	— .97
Rosin oil, third run	gal.	1.10	— 1.15
Rosin oil, fourth run	gal.	1.17	— 1.18

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb	$0.40½ —	$0.42
Upriver coarse	lb.	.30½ —	.32
Upriver caucho ball	lb.	.32½ —	.33
Plantation—First latex crepe	lb.	.43 —	.44
Ribbed smoked sheets	lb.	.42¼ —	.42½
Brown crepe, thin, clean	lb.	.42 —	....
Amber crepe No. 1	lb.	.40½ —	.41½

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.19 —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.23
China wood oil, in bbls.	lb.	.24 —	.24½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½ —	.19
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.19 —	.20
Corn oil, crude, in bbls.	lb.	.17¾ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.16 —	.17
Cottonseed oil, summer yellow	lb.	.18½ —	.19
Cottonseed oil, winter yellow	lb.	.21 —	.23
Linseed oil, raw, car lots	gal.	1.84 —	....
Linseed oil, raw, tank cars	gal.	1.79 —	....
Linseed oil, boiled, car lots	gal.	1.87 —	....
Olive oil, commercial	gal.	2.75 —	3.00
Palm, Lagos	lb.	.15½ —	.16½
Palm, bright red	lb.	.14½ —	.17½
Palm, Niger	lb.	.14 —	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.20½ —	.22
Peanut oil, refined, in bbls.	lb.	.25 —	.26
Rapeseed oil, refined in bbls.	gal.	1.65 —	1.66
Rapeseed oil, blown, in bbls.	gal.	1.78 —	1.80
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	18 —	18½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.13¾ —	.14¾

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal.	1.34 —	1.36

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$38.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Blanc fixe, dry	lb.	.04½ —	.05½
Blanc fixe, pulp	ton	30.00 —	50.00
Casein	lb.	—	
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50 —	18.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, Mex	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00 —	65.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	—	07½
Graphite, crucible, 86% carbon content	lb.	—	.08
Graphite, crucible, 87% carbon content	lb.	—	.08
Graphite, crucible, 88% carbon content	lb.	—	.09
Graphite, crucible, 89% carbon content	lb.	—	.09½
Graphite, crucible, 90% carbon content	lb.	—	.10
Graphite, crucible, 91% carbon content	lb.	—	.10½
Graphite, crucible, 92% carbon content	lb.	—	.11
Graphite, crucible, plus 92%	lb.	—	12½
Pumice stone, imported	lb.	.03 —	06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine nominal	lb.	1.45 —	....
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	30.00
Talc, imported	ton	60.00 —	70.00

Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	75-80 at Chester, Penn
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn
Magnesite, dead burned	net ton	50-55 at Chester, Penn
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	180.00 —	250.00
Spiegeleisen, 16-20% Mn.	gross ton	60.00 —	65.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50% of U	lb.	7.00 —	....
Ferro-vanadium, 30-40% per lb. of contained V.	lb	6.50 —	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70 —	$0.85
Chrome ore, 48% and over	unit	1.00 —	1.25
Coke, foundry, f.o.b. ovens	net ton	12.00 —	14.00
Coke, furnace, f.o.b. ovens	net ton	11.00 —	12.00
Petroleum coke, refinery, Atlantic seaboard	net ton	.... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
Manganese ore, 45% Mn and over	unit	.75 —	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	5.00 —	7.00
Pyrites, foreign, lump	unit	.17 —	....
Pyrites, foreign, fine	unit	.17 —	....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	....
Rutile, 95% TiO_2	lb.	.11 —	....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	....
Monazite, per unit of ThO_2	unit	42.00 —	....

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

EL MONTE—The city rejected all bids for the installation of a septic tank in connection with the proposed sewer system, here. Olmsted & Gillilen, Hollingsworth Bldg., Los Angeles, Engrs. Work will be readvertised.

Connecticut

MIDDLETOWN—W. S. Miller, 37 Washington St., has awarded the contract for the construction of a 1-story, 40 x 70-ft. manufacturing plant addition on Washington St., to D. McKenzie, 17 Allison St. Estimated cost, $18,000.

NORWALK—Arnold & Co., Hoyt St., has awarded the contract for the construction of a 1-story, 50 x 100-ft. foundry, to M. J. Riordan, Hoyt St. Estimated cost, $30,000.

SHELTON—The city had plans prepared for the construction of a high school, here. A separate contract for installing a chemical laboratory in same will be sublet. Brown & Von Beren, 185 Church St., New Haven, Archts.

District of Columbia

WASHINGTON—The General Purchasing Officer of the Panama Canal will receive bids until May 5 for furnishing materials, including muriatic acid, oxalic acid, ethyl alcohol, aluminum sulphate, ammonia, barium sulphate, calcium chloride, chrome yellow, lampblack, white lead, mercuric oxide, yellow ocher, creosote oil, japan oil, linseed oil, putty, drop-black, paint, gum shellac, zinc dust, zinc oxide, etc.

Illinois

DANVILLE—The Interstate Water Co. plans to build an addition to its filtration plant here.

Indiana

INDIANAPOLIS—The Chapman Price Steel Co., 1970 Madison Ave., plans to rebuild the plant recently destroyed by fire. The plant will be converted into a rolling mill, which will be constructed on a 46 acre site south of Troy Ave. between Pennsylvania R.R. and Shelby St. Estimated cost, $1,000,000. Niles Chapman, Pres. and Treas.

INDIANAPOLIS—The Ft. Dodge Serum Co., Fort Dodge, plans to build a large hog and cholera serum plant, including 2-story buildings on West and McCarty Sts. Estimated cost, $150,000.

Iowa

WASHTA—The city has awarded the contract for the construction of a sewage disposal plant, to Frank Humphrey, Cherokee, at $13,400.

Kansas

OSAWATOMIE — The Missouri Pacific R.R. plans to construct a water treating plant, here. Estimated cost, $61,700. E. A. Hadley, 6061 Pershing Ave., St. Louis, Mo., Chief Engr.

PROTECTION — The city has awarded the contract for the construction of sewers and a sewage disposal plant, to Amerman & Snyder, Wichita, at $48,500. Noted April 7.

VALLEY FALLS—The Bd. Educ. will soon award the contract for the construction of a 2-story, 29 x 115-ft. and 38 x 54-ft. high school, here. A physical and chemical laboratory will be installed in same. Estimated cost, $62,000. E. E. Simpson, secy. W. E. Glover, 609 Kansas Ave., Topeka, Archt.

Kentucky

LOUISVILLE—The Mengel Box Co. is constructing a furniture panel factory on 16th St. and Ormsby Ave. Twelve large dry kilns will be built and a large 1-story warehouse will be converted into the factory proper. Estimated cost, $100,000. C. C. Mengel, pres.

Massachusetts

BOSTON — The Graphic Arts Printing Corp., 516 Atlantic Ave., plans to construct a 10-story, 150 x 268-ft. office building on Stuart St. Estimated cost, $300,000. Lockwood Greene Co., State St., Engrs. Derby & Robinson, 20 Beacon St., Archts.

HOLYOKE—The Hampden Glazed Paper & Card Co. plans to construct an addition to its present plant and raise one of its buildings one story in height. Estimated cost, from $100,000 to $125,000.

MITTENERGUE—The Strathmore Paper Co. has awarded the contract for the construction of a 5 story, 32 x 50-ft manufacturing plant addition, to D. O'Connell's Sons, 480 Hampden St., Holyoke. Estimated cost, $30,000.

Michigan

DETROIT — The Clayton-Lambert Co., 1380 Beaubien St., has awarded the contract for the construction of a 1-story, 210 x 300-ft. factory press building on Knodell Ave. and Detroit Terminal Ry., to the Wisconsin Bridge & Iron Co., 1362 Penobscot Bldg. Plans include a 1-story, 60 x 120 ft. foundry. Estimated cost, $322,000.

DETROIT—The Detroit Belt Lacer Co., 27 A St., is having plans prepared for the construction of a 1-story, 80 x 100-ft. heat-treating building on A St. Heat-treating furnaces will be installed in same. Estimated cost, $35,000. Louis Scisorek, 225 Farwell Bldg., Archt.

DETROIT—Albert Kahn, Archt., Marquette Bldg., will soon award the contract for the construction of a 1-story, 51 x 88-ft. foundry on Lafayette and Hastings Sts., for A. J. Detlaff, East Lafayette St. Estimated cost, $10,000.

HAMTRAMCK (Detroit P. O.) — The Swedish Crucible Steel Co., Butler St., is having plans revised for the construction of a 4-story, 100 x 200-ft. factory on Butler St., near the Grand Trunk Ry. Estimated cost, $200,000. Raseman & Freier, 1302 Penobscot Bldg., Detroit, archts.

MARYSVILLE—The Detroit Edison Co., David Whitney Bldg., Detroit, plans to build a gas plant on Bunce Creek Rd. Estimated cost, $200,000.

Minnesota

BERMIDJI—The Stellar Co., 922 2nd Ave. S., Minneapolis, plans to build a wood distillation plant, here, for the manufacture of turpentine. Estimated cost, $100,000.

Missouri

EXCELSIOR SPRINGS—The city is having plans prepared for the construction of a sewage disposal plant.

ST. JOSEPH—The St. Joseph Structural Steel Co. has awarded the contract for the construction of a 1-story, 100 x 180-ft. steel plant to the Lawlion Constr. Co. Estimated cost, $125,000.

ST. LOUIS, The Eureka Brass Co., 615-19 Red Bud St., has awarded the contract for the construction of a 1-story, 50 x 148-ft. foundry addition to the Fruin Colnon Contg. Co., Merchant Laclede Bldg. Estimated cost, $10,000.

WILLIAMSVILLE—The Midco Iron Co., Midco Carter Co., have leased several acres here and plan to construct an ore-washing plant on same. Estimated cost, $100,000.

New Jersey

KEARNY (Arlington P. O.) — The Bd. Educ. plans to construct a 3-story high school, here. A chemical laboratory will be installed in same. Estmated cost, $400,000. Guilbert & Betelle, 665 Broad St., Newark, Archts.

NEW BRUNSWICK—The State plans to construct a building, for making ceramics. Estimated cost, $100,000. F. H. Bent, 142 West State St., archt.

TRENTON — The Mutual Potteries Co. plans to construct a new sanitary pottery building here. John A. Campbell, 379 West State St., pres.

New York

GLENFIELD—The Dexter Sulphite Pulp & Paper Co., Dexter, plans to build a large sawmill, here. Estimated cost, $100,000. Address, H. A. Long.

MIDDLETOWN—The Middletown Rubber Co., 5 Columbus Circle, New York City, plans to construct a 3-story rubber factory. Estimated cost, $500,000. Waldron & Van Winkler, 37 Wall St., New York City, Engrs.

NEW YORK—The Majestic Mills Paper Co., 464 Broome St., will alter a 6-story factory. Estimated cost, $25,000. Work will be done by day labor.

OSSINING—Charles F. Rattigan, supt. of prisons, Capitol, Albany, will receive bids until May 18 for the installation of duplicate solution type liquid chlorinating apparatus, etc., for the water supply system, at the Sing Sing Prison, here.

Ohio

CINCINNATI—The M. B. Farrin Lumber Co., Wenton Pl. Station, has awarded the contract for the construction of 1-story, 80 x 125-ft. dry kiln plant, to the Hazen Jones Co., 407 Johnson Bldg. Estimated cost, $30,000.

CLEVELAND—The Superior Fdry. Co., East 71st St. and the Wheeling and Lake Erie R.R., has awarded the contract for the construction of a 2-story, 60 x 200-ft. foundry, to the Sam W. Emerson Co., 1900 Euclid Ave. Estimated cost, $100,000.

CLEVELAND — The Virdon Mfg. Co., Ashland Rd., manufacturer of brass spinners, is having plans prepared for the construction of a 1-story, 40 x 92-ft. factory addition on Ashland Rd. and Longfellow Ave. Estimated cost, $60,000. J. E. Virdon, pres. Ernest McGeorge, 1900 Euclid Ave., archt. and engr.

CUYAHOGA FALLS—The Falls Rubber Co. is having plans prepared for the construction of a 3-story, 61 x 84-ft. factory addition. Estimated cost, $100,000. Ernest McGeorge, 1900 Euclid Ave., Cleveland, archt.

DAYTON—The A.-C. Electrical Mfg. Co., U. B. Bldg., plans to build a 2-story, 100 x 250-ft. factory for the manufacture of electrical appliances on East 4th St. Estimated cost, $150,000.

NORWOOD—The G. A. Gray Co., Gest and Depot Sts., Cincinnati, plans to build a factory for the manufacture of metal planers, on Edwards and Edmondson Aves. Estimated cost, $1,500,000.

RAVENNA—The McElrath Tire & Rubber Co., 1836 Euclid Ave., will receive bids until May 1 for the construction of a 1 and 2-story, 100 x 300-ft. factory and 30 x 50-ft. boiler house. Estimated cost, $125,000. P. J. McElrath, pres. Donald C. Smith, Lennox Bldg., Cleveland, architect and engineer.

RAVENNA—The Oak Rubber Co. has awarded the contract for the construction of a 2-story, 60 x 180-ft. rubber factory, to the P. S. Frank Co. Estimated cost, $60,000.

TOLEDO — The Grasselli Chemical Co., c/o S. Gronemeyer, Guardian Bldg., Cleveland, is having preliminary plans prepared for the construction of a 1-story chemical plant. Estimated cost, $300,000.

Oklahoma

CLINTON — The State Bd. of Affairs, Oklahoma City, is receiving bids for the construction of a water supply line, electric pole line and a sewage disposal plant. E. J. Peters and A. M. Jenkins, Shawnee, archts.

GRANDFIELD — The Bd. Educ. has awarded the contract for the construction of a 2-story high school, here, to W. E. Corlett, Vinita. A chemical laboratory will be installed in same.

Pennsylvania

DICKSON CITY—The Early Foundry Co. plans to construct a 38 x 90 x 200-ft. foundry on the Main Rd. Foundry equipment will be installed in same. Total estimated cost, $200,000.

ERIE—The city plans to vote on $1,300,000 bond issue for various city improvements, including sewers and a sewage disposal plant, etc., to cost $333,000. F. Hanlon, city clk.

HARRISBURG—The Bd. Educ. is having plans prepared for the construction of a senior high school on 6th and Division Sts. A chemical laboratory will be installed in same. Plans also include a foundry, machine shop, physics laboratory, etc.

LOCK HAVEN—The city has awarded the contract for the construction of a 2-story, 300 x 500-ft. paper mill, to the Turner Construction Company. Estimated cost, $2,000,000.

Rhode Island

CENTRAL FALLS (Pawtucket P. O)—The United Nets Corp., 229 4th Ave., New York City, is having plans prepared for the construction of a 2-story dyehouse and bleachery on High St. Estimated cost, $20,000. Clark, McMullen & Riley, 101 Park Ave., New York City, Archts. and Engrs.

Tennessee

ALTON PARK—J. F. Hager, mayor, and the city comrs. will receive bids until May 8 for the construction of a system of sanitary sewers, consisting of septic tank, flushing tanks, etc.

MEMPHIS—The Maury-Cole Co., 462 South Wagner St., plans to install new machinery in the existing plant for the preparation of peanut products.

Texas

HOUSTON—The Macks Mfg. Co., Ltd., Mack St., is building extensions to its present extensive factory, here, including a 74x200-ft. steel foundry equipped with a 3-ton electric furnace, core ovens and other equipment. Charles R. Edwards, supt.

WHITESBORO—The Whitesboro Oil & Refining Co. has awarded the contract for the construction of a 2,000-bbl. daily capacity oil refinery, to Earl & Beck, St. Louis, Mo. Estimated cost, $150,000.

West Virginia

PARSONS—The O. A. Miller's Chemical Co. is in the market for bottle filling, labeling and corking machines, filters, mixing tanks, etc.

Wisconsin

CUDAHY—The Federal Rubber Co., Packard Ave., has awarded the contract for the construction of a 6-story, 100x120-ft. rubber mill, to the Leonard Constr. Co., 332 South Michigan Ave., Chicago.

MILWAUKEE—The Bernert Mfg. Co., 489-91 12th St., has purchased an 8-acre site on Atkinson Ave., North Milwaukee, and plans to build a 120x260-ft. building and a 60x100-ft. foundry on same. Joseph Glaser, archt.

MILWAUKEE — The Lindemann & Hoverson Co., 1st and Cleveland Aves., is having plans prepared for the construction of a 1-story, 60x80-ft. annealing plant on 1st Ave. Estimated cost, $25,000. Klug & Smith, Mack Bldg., engrs.

MARINETTE—The Hoskins-Morainville Paper Co. has awarded the contract for the construction of a mill, here, to the H. J. Selmer Constr. Co., Green Bay. The mill will include a 2-story, 63x80-ft. main building, a turbine house, power house and stack. Estimated cost, $350,000.

SHEBOYGAN—The Badger State Tanning Co., South Water St. and Maryland Ave., has awarded the contract for the construction of a 4-story, 105x342-ft. tannery, to the Westinghouse, Church, Kerr Co., Inc., 37 Wall St., New York City. Estimated cost, $750,000. Noted Jan. 21.

SHEBOYGAN—The Rexire Co., South River St., plans to build a 4-story, 60x200-ft. factory and an addition to present factory for the manufacture of soaps and oils. Estimated cost, from $45,000 to $50,000.

Ontario

ESSEX—The Essex Traction Co. plans to construct a 1- and 2-story addition to its factory for the manufacture of traction engines. Estimated cost, $50,000.

LONDON—The Bd. Educ. plans to build a school building, here. A chemical and physical laboratory with complete equipment will be installed in same. Estimated cost, $175,000. L. E. Carrothers, archt.

OTTAWA—The Dept. of Pub. Wks. will soon receive bids for the construction of a 4-story research institute for the Dominion Government. Scientific instruments will be installed in same. Estimated cost, $500,000. R. C. Knight, archt.

OTTAWA—The Nukol Fuel Co., Ltd., 198 Sparks St., will soon have plans prepared for the construction of a factory for the manufacture of nukol. Estimated cost, $250,000.

SARNIA—S. B. Coon & Son, archts., 36 Toronto St., Toronto, will receive bids until May 5, for the construction of a 3-story high school, here, for the Bd. Educ. Chemical and physical laboratory equipment will be installed in same. Estimated cost, $325,000. Melvern F. Thomas, 229 College St., Toronto, engr.

TORONTO—The Canadian Tygard Engine Co., Kingston Rd., has awarded the general contract for the construction of a 2-story, 50x160-ft. factory for the manufacture of carburetors and engines, to Walter Snelling. Estimated cost, $40,000.

TORONTO—The Dominion Oxygen Co., 120 Elm St., has awarded the contract for the construction of a 3-story, 60x80-ft. liquid oxygen plant on Elm St., to Wells & Gray, Confederation Life Bldg. Chemical equipment for oxygen generation will be installed in same. Estimated cost, $75,000.

TORONTO—The Photo Engravers Ltd., 70 Bond St., has awarded the general contract for the construction of a 3-story, 60x80-ft. photo engraving building, to T. E. Essery, Confederation Life Bldg., at $80,000.

WOODSTOCK—The city has awarded the contract for the installation of filtros plate, in connection with the proposed sludge plant, here, to the General Filtration Co., Cutler Bldg., Rochester, N. Y., at $4,551.

Quebec

MURRAY BAY—The Murray Bay Power and Pulp Co. plans to construct a plant here. Estimated cost, $500,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its sixth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold regular meetings on May 7 and June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18, inclusive.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK announces the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Modern Coke and Gas Manufacture" (Koppers process), Thursday, April 29, at 4 p.m., E. L. Crowe (*Lantern and cinema*); "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA plans to hold its annual convention in the Auditorium Theater, Chicago, Ill., May 19, 20 and 21.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E., will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect. The autumn meeting of the Iron and Steel Institute (British) will be held at Cardiff, by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13, 14 and 15.

THE MINING SOCIETY OF NOVA SCOTIA has planned a meeting for May 4 and 5, which will be held in Glace Bay.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 and 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NEW JERSEY CHEMICAL SOCIETY plans the following: Monday evening, May 10, regular meeting; Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J., regular meeting and ladies' day.

THE SOCIÉTÉ CHIMIE INDUSTRIELLE will hold a meeting at the Chemist's Club, May 14.

THE SOCIETY OF COTTON PRODUCTS ANALYSTS will hold its eleventh annual convention at the Grunewald Hotel, New Orleans, La., May 10 and 11.

THE SOCIETY OF CHEMICAL INDUSTRY, American Section, will hold a meeting, May 21, at the Chemists' Club.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

Industrial Notes

C. C. MCDERMOTT has succeeded J. W. Lazear as district manager of the Chicago office of the Brown Instrument Co. of Philadelphia. Mr. McDermott has been transferred from the Philadelphia office, where he was district manager for some time.

THE CHICAGO PNEUMATIC TOOL CO. transferred its general office from Chicago to New York City on March 31. The new quarters of the company are in a 10-story structure erected for its exclusive use at 6 East 44th St. At the same time the Chicago district sales branch, formerly in the Fisher Bldg., was moved to 300 North Michigan Boulevard. The Chicago service branch, formerly at 521 South Dearborn St., has been consolidated with the sales branch at the new address, where both are under the direction of J. S. Canby, district manager.

THE YARNALL-WARING CO., Philadelphia, announces that D. T. Newman, formerly connected with the Philadelphia sales office, has been placed in charge of its Atlanta, Ga., office, recently opened in the Candler Annex.

THE COOPER UNION FOR THE ADVANCEMENT OF SCIENCE AND ART, New York City, announces a new day course in industrial chemistry opening Oct. 4, 1920. The course will cover a period of four years. It is intended that the instruction provided shall be eminently practical and thoroughly scientific and that it will furnish adequate equipment for young men and women who desire employment as analysts, production foremen, research chemists, engineers, factory superintendents, purchasing agents, and in other phases of industry which call for persons with chemical training.

THE TABER PUMP CO., Buffalo, N. Y., maintains a resident representative in Chicago in the person of G. T. Schushan, with office at 410 Cunard Bldg.

THE PLAN FOR THE MERGER of Westinghouse, Church, Kerr & Co., Inc., and Dwight P. Robinson & Co., Inc., recently submitted for the approval of the stockholders of these companies, has been declared operative by the committee appointed in accordance with plan. At a meeting of the board of directors of Westinghouse, Church, Kerr & Co., Inc., Dwight P. Robinson was elected president of that company, pending final completion of the merger and organization of the new company. General Guy E. Tripp, now chairman of the board of Westinghouse, Church, Kerr & Co., Inc., retains this position pending completion of the merger. The Westinghouse Electric & Manufacturing Co. is one of the largest stockholders of Westinghouse, Church, Kerr & Co., and the two companies have been closely identified for many years. To avoid what has seemed a handicap in procuring business by the latter company, on account of the belief by prospective clients that if they employed it as their construction engineer, they might be expected to purchase Westinghouse electric equipment, and also to permit the Westinghouse Electric & Manufacturing Co. to withdraw from any

interest in the engineering and construction business, it was deemed in the interest of both companies that the association should be terminated. To accomplish this without embarrassment to other stockholders, and to their advantage, negotiations were initiated with Dwight P. Robinson, president of Dwight P. Robinson & Co., Inc., looking to a merger of Westinghouse, Church, Kerr & Co. with Dwight P. Robinson & Co., Inc. These negotiations resulted in the plan of merger now declared operative, under which depositing stockholders will receive for their present holdings either cash or stock in the new company.

THE RESEARCH CORPORATION announces the removal of its offices to 31 West 43rd Street, New York.

THE ELECTRO-ALLOYS Co., Elyria, Ohio, has been formed to take over and manufacture certain alloys developed by F. A. Fahrenwald. The initial product will be chiefly a high-temperature alloy in the form of heat-treating and other apparatus requiring resistance to oxidation at high temperatures. These high-temperature products will be marketed under the trade name—"Thermalloy." The electric foundry will be in operation about May 1.

THE BARBER-GREEN Co., Aurora, Ill., has found it necessary to make certain additions and changes in its selling organization due to the rapid growth of the company and the demand for B-G self-feeding bucket loaders and standardized belt conveyors. It is represented in St. Louis by R. E. Foulke, 404 Third National Bank Bldg.; in Pittsburgh by J. A. Gurney, 605-606 Arrott Bldg.; in Philadelphia by F. S. Sawyer, 1010 Penn Square Bldg.; in Indianapolis by W. T. MacDonald, 305 Merchants Bank Bldg.

THE ROVEY INSTRUMENT & CHEMICAL Co. has been incorporated in Buffalo, N. Y., by George G. Stuart, of Cleveland, Ohio, district salesmanager for the Youngstown Sheet & Tube Co., John S. Rovey, former purchasing agent for the Buffalo Apparatus Co., and Mrs. James M. Gisel, with a capital stock of $25,000. The concern is located at 75 Niagara Sq., Buffalo, N. Y. For the present it will act as sales agent, although Mr. Rovey announces that it is the idea of the incorporators to engage in the manufacture of industrial and commercial and laboratory instruments.

THE PHILADELPHIA TEXTILE MACHINERY Co., Philadelphia, Pa., announces its change of name to Proctor & Schwartz, Inc. The change is in name only, as the management, finances, policies, etc., remain as before.

WHEELER & WOODRUFF, chemical engineers, 280 Madison Ave., New York, announce the opening of a research and chemical engineering laboratory at 236 East 151st St., New York. The following chemical engineers and chemists have recently joined the organization: James F. Walsh, chemical engineer, lately Lieutenant in the Chemical Warfare Service, in charge of the charcoal development at the Astoria plant of the Gas Defense Division. Before entering the service Mr. Walsh was employed as chemist by the Goldschmidt Co., the Bosch Magneto Co., Borden's Condensed Milk Co. and the Otis Elevator Co. George Urquhart, chemical engineer, lately Captain in the Chemical Warfare Service, assigned to the chemical manufacture and development section of the Gas Defense Division. Before entering the service Mr. Urquhart was employed by the Solvay Process and Semet-Solvay companies at Syracuse, N. Y. William A. Jarrett, chemist, lately Lieutenant in Infantry, U. S. Army. Before entering the service Mr. Jarrett was employed as chemist by the Horton Ice Cream Co., New York. Walter C. Spiess, chemist, lately in the Gas Defense Division of the Chemical Warfare Service. Before entering the service Mr. Spiess was employed as chemist by Baker & Co., Inc., Newark, N. J.

THE METAL & THERMIT CORPORATION, New York City, N. Y., in order to more adequately take care of its rapidly increasing business in the New England States and in Canada, has appointed James G. McCarty manager of its Canadian branch, with headquarters in Toronto, and has transferred Robert L. Browne from its New York office to Boston, where he will have charge of all sales in the New England States.

THE STEPHENS-ADAMSON MFG. Co., Aurora, Ill., announces the opening of a new branch store, assembling shops and sales office at 412 East Third St., Los Angeles, Cal. This office will be under the direction of R. C. Pierce.

JOSEPH T. RYERSON & SON of Chicago and New York, and the Camden Iron Works, Camden, N. J., announce a new selling arrangement whereby Joseph T. Ryerson & Son become representatives of the Camden Iron Works in the sale of its hydraulic machinery products. Joseph T. Ryerson & Son have been in business for the past seventy-eight years, with their main warehouse plant and general office at Chicago, branch plants at New York, Buffalo, Detroit and St. Louis, and sales offices in the larger cities in the United States. They also have a foreign selling organization, with representatives in Europe and the Orient. The Camden Iron Works is also an old-established manufacturing concern, and in addition to a complete line of hydraulic tools, is a builder of centrifugal pumps, cast-iron pipe and fittings, gas holders and kindred products.

THE NITRATE AGENCIES Co., a subsidiary of W. R. Grace & Co. of New York, is building a $250,000 plant at Bergen Point, Bayonne, N. J., for the manufacture of dyes, disinfectants, intermediate and spraying materials. The four-story building will be of hollow tile, reinforced-concrete construction, with 36,000 sq.ft. capacity. An additional warehouse of 20,000 sq.ft. floor space is also planned. The Elliott C. Brown Co. of New York has the contract for erecting the plant. Production and sales department will be in charge of Mr. Goulard. Dr. Joseph L. Turner is the technologist. The plant is expected to be in operation next September.

H. H. HARRIS, formerly general sales manager for the Swedish Crucible Steel Co., has been appointed manager for the department of heat-treating equipment of the Quigley Furnace Specialties Co., 26 Cortlandt St., New York City.

THE SOUTHERN LABORATORY SUPPLY Co., which has opened offices and warehouse in Birmingham, Ala., is the first laboratory supply house to locate in the South. For years the need of such an institution has been apparent and the establishment of this pioneer enterprise in Southern territory has met with the approval of the business and industrial interests of this section. The executive heads of the compay are Charles W. Hogg, president, and George B. Meanor, Jr., vice-president, both formerly of Pittsburgh, Pa.

THE THERMAL SYNDICATE, LTD., New York City, announces that W. Earle Strevig, formerly of the New York office, is now its Pittsburgh-Cleveland representative. He can be reached at 71 Crafton Ave., Crafton, Pa.

THE GUARANTEE BATTERY CORPORATION, of 1830 Blake St., Denver, Col., has recently been organized for the manufacture of automobile storage batteries. A part of the plant is already operating in the capacity of thirty-six batteries per day. This will be increased to eighty-five about May 1. George W. Brayfield is president, and Harry C. Brayfield secretary-treasurer. Earl B. Gandy is general manager and director of sales.

WILLIAM M. TAYLOR announces the formation of the HAMMOND INDUSTRIAL LABORATORIES, with offices at 80 Maple St., Hammond, Ind. These laboratories will specialize in the purification of water for industrial purposes and in the analysis of tanning materials. Mr. Taylor has been chemical engineer for the Kenicott Co., chemist for Montgomery, Ward & Co., chief chemist for the Refinite Co. of Omaha, and of Paige & Jones Chemical Co. of New York and Hammond, Ind.

THE NATIONAL LUMBER MANUFACTURERS ASSOCIATION has removed its general offices to the McCormick Bldg., 332 South Michigan Ave., Chicago, Ill.

WALLACE & TIERNAN Co., INC., manufacturer of chlorine control apparatus for water and sewage purification and industrial uses, announces that Harold S. Hutton has been appointed district sales representative with headquarters in the Commonwealth Bldg., Pittsburgh, Pa. Mr. Hutton succeeds P. O. Collins, who has been given indefinite leave of absence on account of illness.

D. R. SPERRY & Co., manufacturers of filter presses at Batavia, Ill., have added a department to the factory, which is turning out filter cloth and fabric, and are now prepared to ship either sewed cloth or rolls. This company also has added to the foundry equipment, which is now double its former capacity.

THE CHICAGO ASSOCIATION OF COMMERCE has organized a convention bureau, with headquarters at 10 So. LaSalle St., which will function to procure hotel accommodations for business men visiting the city as well as those desiring to stay over long periods. Crowded conditions during convention periods will be obviated.

THE MORSE CHAIN Co., Ithaca, N. Y., has moved its offices from Greensboro, N. C., to 404 Commercial Bank Bldg., Charlotte, N. C. George W. Pritchett, Southeastern manager, has found this change advisable owing to the increase in use of Morse silent chains in the textile industry.

Manufacturers' Catalogs

THE AUTOMATIC PRIMER Co., 420 Conway Bldg., Chicago, Ill., has just issued a leaflet describing a new automatic primer for centrifugal pumps.

THE CALORIZING CORPORATION OF AMERICA, Detroit, Mich., has issued a handsomely illustrated booklet, "The Protection of Metals from Oxidation at High Temperatures," which deals with protective coatings, the development and application of calorizing, and contains an appendix of useful tables. The de luxe edition is bound in flexible leather and shows a colored scale for heat measurement.

THE ELECTROLABS Co., Pittsburgh, Pa., is issuing a pamphlet on Levin Oxy-Hydrogen cells. It also announces that it offers complete plants for the production, distribution, compression and utilization of oxygen and hydrogen gases, and can, through its own manufacture supply all the necessary accessory equipment. Actual photographs of plants in operation and letters from manufacturers are included.

THE NORTON Co., Worcester, Mass., has issued three booklets, entitled "How to Order Grinding Wheels," "Grinding Wheel Stands in the Machine Shop," and "The Norton Razor Hone."

THE H. S. B. W. COCHRANE CORP., Philadelphia, Pa., formerly the Harrison Safety Boiler Works, has issued a book describing the hot process water softener. The hot process softener is a modern development of the well-known lime-soda process, the difference being that the chemicals are added to the water only after it has been heated to 205 deg. F. or higher, which results in practically instantaneous and complete chemical reactions and in more rapid settlement of the precipitate. The result is a considerable reduction in the time required for the sedimentation so that the apparatus can usually be installed within power plant buildings and without requiring special foundations or housing. The fact that a feed water heater is combined as part of the apparatus also reduces the complication and the expense of piping, etc. It is also claimed that the maximum reduction of scale- and sludge-forming matter is obtained with a minimum excess of reagents and that there is no after-precipitation or troublesome deposits of scale and sludge in pumps, piping, feed-water heaters and boilers, while, due to the reduced solubility of the products in hot alkaline water, the minimum amount of sludge-forming solids enter the boiler and the tendency to priming and foaming is minimized. In the present publication these statements are supported by scientific data and by the results of practical operation. An improved type of a chemical feeder designed to force the water into the softener against back pressure, and a system of pressure filters, are also described. The closing chapter enumerates the impurities found in boiler-feed water and describes the kinds and amounts of chemicals necessary for their removal. The book will be of value to all who are concerned with the operation of steam boilers.

THE CELITE PRODUCTS Co., 11 Broadway, N. Y., is issuing an interesting bulletin known as B-6a, describing the insulation construction of different types of boilers. The bulletin is illustrated with diagrams and views of various installations.

THE DEISTER CONCENTRATOR Co., Fort Wayne, Ind., calls attention to its latest catalog, No. 5, illustrating and describing the Deister-Overstrom diagonal deck tables.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., is distributing a catalog entitled "The American Trolley Carrier," which is an economical one-man method of handling coal ashes and like material. The equipment consists of an overhead trolley, operated on either a monorail track or suspension cable. A hoist is used to lower and move a 7-ton, self-dumping bucket, in which the material is carried. One man handles the carrier in all its operations—loading, hoisting, conveying, dumping and returning the bucket. He is not obliged to leave his station at the hoist at any time. An average of 30 tons of coal can be handled an hour. Five or six cars can be emptied during the day. The cost per ton of coal handled is extremely small, 3c. or 4c. as contrasted with the usual 18c. or 20c. entailed. Copies will be sent to interested readers on request.

THE BARNSTEAD STILL & STERILIZER Co., Boston, Mass., and Chicago, Ill., has issued a catalog on Barnstead patent water purifier and still.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, May 5, 1920 *Number* 18

The Report of the Industrial Conference

THE report of the Industrial Conference called by the President, issued a few weeks ago, apparently has received little public comment despite the fact that it offers a definite plan for the prevention of disputes and adjustment of differences now so prevalent in industry. This Conference was more successful than its predecessor, which was disrupted when Mr. GOMPERS withdrew with the representatives of Labor. The failure of that first Conference was inevitable because the groups composing it were directly interested in securing official recognition and adoption of partisan policies which were already bones of contention in industrial relations. Further, the proceedings were public. There was too much incentive to play to the galleries, and unyielding partisanship finally wrecked a hopeless attempt to formulate a constructive program.

The second Conference seems to have been more rational in its organization and procedure, and its report gives evidence of calm study, sober second thought and freedom from partisan hysteria. An effort has been made to gather facts, to learn from practical successful experience, and to formulate general policies, leaving the details to be worked out in accordance with the peculiar conditions surrounding individual industries.

For preventing industrial strife the plan which the Conference indorses is to secure co-operative effort through a "joint organization of management and employees." The Conference would prefer to "diminish the field of arbitration and enlarge the scope of voluntary settlement by agreement." And since the form of employee representation may vary in every plant, the subject "is not a field for legislation," but for local adoption and individual administration. "The strategic place to begin battle with misunderstanding is within the industrial plant itself."

The Conference is led to support the general proposition of a joint organization of management and employees because it finds that wherever such organization has been "undertaken with sincerity and good will" it has a record of success. This successful experience, the Conference believes, "is more useful than the views of extremists on either side." In case co-operative effort is not successful in reaching a collective agreement in any particular case, the Conference proposes a system of settlement through three bodies: A National Industrial Board, Regional Conferences and Boards of Inquiry, all under "governmental encouragement." "The entrance of the Government into these problems should be to stimulate further co-operation."

Opposition to the idea of employee representation is found by the Conference in two sources. On the one hand is the unprogressive and unenlightened employer, whose tribe fortunately is decreasing, who still regards labor as a commodity and who balks at any form of co-operation with his employees. On the other, there is the narrow trade-union leader who looks upon shop representation as something inimical to the union and likely to supplant its authority. As the Conference points out, however, the distorted view of the employer is rapidly disappearing, and the fear of the labor leader is based on a misconception of the relations between shop committees and unions, which are in fact complementary. "Local problems fall naturally within the province of shop committees. No organization covering the whole trade and unfamiliar with special local conditions and the questions that come up from day to day is by itself in a position to deal with these questions adequately."

The Conference recognizes fully that "employee representation offers no royal road to industrial peace. . . . It is only a means whereby sincerity of purpose, frank dealing and the establishment of common interests may bring mutual advantage." Too much stress cannot be laid on the prerequisite of sincerity of purpose in putting such a plan into effect. It is the cornerstone of all institutions involving human relations, for suspicion will defeat the ends of ideal plans. In view of the fact that the Conference discovered enthusiastic approval among employers and employees who have had experience with co-operative effort, we may accept its recommendations as representative of both parties in industrial relations. And as for the proposed system of settling disputes not agreeably disposed of through collective effort, it seems worth a trial, since "its basic idea is stimulation to settlement of differences by the parties in conflict, and the enlistment of public opinion toward enforcing that method of settlement."

A "Carnival of Greed and Imposition"

ELBERT H. GARY has been chairman of the United States Steel Corporation since its formation nineteen years ago, and has had occasion to make many public utterances, which have obviously been delivered only after careful consideration. In no such utterance has Judge GARY ever used intemperate language, and rarely has he used what might be denominated "strong" language. He has a way of having the thought expressed stronger than the language used in its expression. When, therefore, in his formal address at the recent annual meeting of the stockholders of the corporation Judge GARY referred to there being a "carnival of greed and imposition," the expression must be taken as representing a very strong conviction upon an extremely undesirable state of affairs. Judge GARY felt it to be everyone's duty, even at some personal

sacrifice, to help check the carnival. The United States Steel Corporation has been doing what it could, by continuing to sell its steel products at the March 21, 1919, prices, set by the medium of an agreement between Secretary REDFIELD'S Industrial Board and representatives of the iron and steel industry. For months past consumers of steel have been bidding higher prices and the independent producers have been asking and accepting higher prices, sometimes very much higher prices.

There are several reasons why sellers should endeavor to hold prices down in a time like this. One reason is that great injustice is worked by advancing prices, as Judge GARY clearly pointed out, to those with more or less fixed incomes, like salaries, for in essence such people are paid in a depreciated dollar.

Another reason, more or less selfish, is one that does not concern the United States Steel Corporation, since it is self-contained. That is that when a manufacturer advances his selling prices those who sell his raw materials to him are likely to advance their prices, and the manufacturer cannot "get away" with all the extra profits his own price advance seemed to assure him. It is recent history how the merchant blast furnaces greatly advanced their pig-iron market, whereupon the Lake Superior iron-ore producers advanced their ore prices and the Connellsville coke producers advanced their coke prices. The merchant furnaceman has no assurance that his advanced pig-iron market will last as long as the advanced ore and coke markets.

A third reason for holding prices to a safe and sane basis is that "whatever goes up must come down." When prices come down, usually somebody gets hurt. The proper course of business is certainly disturbed. We want to make progress, and efficiency in making progress requires that there be steady markets and uniform conditions, so that men can plan ahead and build ahead.

When there has been a great disturbance unpreventable by business interests, such as the late war, business should protect itself from the after effects. When the Great War closed there was a disposition to look at the course of industry and markets after our Civil War to see if some light might not be secured. It was unsafe then to conclude that conditions had much in common, but at this time, nearly a year and a half after the Armistice, evidence has accumulated that there is no small degree of similarity. The similarity is not a synchronism, but one should not ask for time similarity, since a month nowadays does not mean the same compass of business experience as it did over a half century ago, in the post-Civil War times. The history of that time was that after LEE'S surrender, April 9, 1865, ending the Civil War, pig iron declined for a few months, approximately from $48 to $35, then advanced to $51, a higher price than obtained at the end of the war, and then declined again. The second low point fell thirteen months after LEE'S surrender. We are slower in these days, or our business is more ponderous. There were five clearly marked round-trip swings in the pig-iron market before the continued decline set in during the great industrial depression of 1873 to 1878. It seems reasonable to assume that the fluctuations were disadvantageous to business, just as wide fluctuations are today.

If anyone assumes that prices can be pushed up and held up long enough to prove profitable, as compared with conditions under a stable and reasonable market, he is probably wrong. The worm will turn. If he assumes that there is only one advance possible and that on the basis of enlightened selfishness as much as possible ought to be made out of the advance, he is probably wrong again. Prices pushed too high eventually decline too far, and then they advance again. The present is not the last chance that is going to be afforded this generation to make money.

Either on the basis of reasonable regard for the general good or on the basis of enlightened selfishness the course dictated is that of moderation in the naming of prices for commodities or charges for service. The "carnival of greed and imposition" is probably a psychological reaction from the war-time sacrifice and co-operation. Instead of continuing the good work, we have had a reaction.

Testing High-Speed Steels In the Small Shop

A CASUAL reader may wonder just how "metallurgical engineering" can be stretched to cover the subject of lathe tools. But the metallurgist in the progressive manufacturing establishments of today realizes as keenly as does any confirmed efficiency expert the need of dependable, uniform quality of tools, and it is ordinarily he who puts the most thought and care upon them. As long as a fairly good tool is available in quantity, the men in the shop do not have much to say, but the metallurgist or heat treater is the first man to hear about any serious breakdown on account of tools. On the other hand, he is the man most actively interested in —one might almost say the only man continually seeking—a method whereby really superior tools may be secured for each class of work passing through the shop in large volume.

He has a continual problem, however, to determine to his own satisfaction whether a change in his practice will actually improve the efficiency of his product. Certain it is that relief may not infallibly follow a change in tool steels, for Major BELLIS quotes the Springfield armory as one shining example where attention to infinite detail regularly produces the most extraordinary rifle-barrel drills from mushet steel, which any salesman will tell you is obsolete, a relic of the dark ages, and even bolshevik to think about. Yet the same salesman would be hard put to make a drill from his pet brand which is half as good; perhaps BELLIS could do it, given time, but the salesman certainly not.

Inquiry among the mechanics, tool room men and shop foremen as to what they "think" of a certain brand of steel or kind of tool is admittedly a very insecure method of judging their real quality. Yet the metallurgist who has read FREDERICK W. TAYLOR'S monograph "On the Art of Cutting Metals" (and who has not?) will be so impressed with the almost overwhelming resources needed to test the efficiency of a particular tool in TAYLOR'S exhaustive manner that he will realize its impossibility of widespread application. Yet some accurate, experimental basis is essential for progress.

Mr. LANGHAMMER'S articles commencing on page 829 of this issue have within them the potentiality of enormous advance in tool steel practice, simply because they point out how the metallurgist, tool man and heat treater in the thousands of progressive but small shops may continually improve their methods with a corresponding reflection in the total costs. Of course, a large volume of ideally uniform material to be cut is seldom available

sufficient to compare so large a number of tools as did the Packard company. But the problem before the smaller shop is not so much whether they should change their brand. In fact if they are securing their stock from one of the American tool-steel makers whose every effort is for a quality product, they had far better turn a deaf ear to the persuasive salesman and attempt to develop the inherent possibilities of their regular tools. So their problem is much simplified. It is merely this: Will this small change in one detail of hardening-room practice, or tool-grinding practice, or any one of the dozens of factors responsible for a good steel, *actually improve the tool?*

It is only necessary to make up carefully two sets of, say, six tools each; one set by the standard method and the other set by the revised method, reference them by complex code markings, lay them aside and forget the code. Then watch the work going through the shop, and some day when a long job appears, carefully inspect the rough metal to be worked and select enough of it for its uniformity to cause failure in the dozen prepared tools in both first run and after regrinding. Put this work on a first class machine, work out correct conditions of operation as explained by Mr. LANGHAMMER, do the work with most careful, conscientious workmen, and make a correct log of the run.

At the end you will have something more than "opinion" to tell you whether it is better to draw from 1,100 or from 1,050.

Research Among The Bakers

THE American Institute of Baking, the first child of the National Research Council, if we are not mistaken, has duly appeared in Minneapolis, and, to judge by its first bulletin, it seems to be of requisite weight, to have lusty respiration, to possess the right number of fingers and toes—in short, to be a promising infant. Dr. H. E. BARNARD is the director, and his name gives confidence in the wisdom and scholarship of its management. It has found asylum with the Dunwoody Institute, a continuation school in Minneapolis, and here the American Institute of Baking will maintain scholarships and provide for six months' courses for bakers against the payment of fees, as well as conduct research and give consultation to its members. The president is GORDON SMITH of Mobile, Ala., and the secretary is DR. P. CHISHOLM, of Chicago.

Here is a chemical industry that has not known itself as such. It is ancient of days, replete with traditions, and complete knowledge and understanding of the art was supposed to be well-nigh universal. In fact, some of us who can hark back a generation or more recall the sage advice not to marry a lass unless she can bake a loaf of bread—and bake it well. If there was any place where the chemist was not wanted it was in the bakery—and save in rare exceptions he stayed away. The Research Department therefore finds itself confronted with chemical, physical and biological problems in remarkable number. They are complex as well as numerous, and, in the words of the bulletin, "The selection of any one of them will lead to many unknown investigations, the nature and value of which cannot be predicted. Some of these subsidiary problems may be of practical value and others may have for the present but the interest of a problem in pure science." Among the immediate projects are: The determination of moisture retention in bread and the prevention of staleness, the study of sweetening agents, shortening agents and their effects on fermentation, the activation of ferments to expedite rising, development of control tests for bakeries without laboratories, and, in co-operation with other laboratories, the study of standard and uniform methods of analysis of flour and other baking materials. In addition to these are questions of flavor, yeasts and yeast-foods to be determined—and all this is merely a beginning.

The technical and service department will offer to bakers the rapid solution of momentary difficulties and supply information on technical or chemical questions. The baking laboratory is prepared to make bread by almost any method of procedure, and an engineering bureau will give attention to questions of building construction, power, heating, ventilation, wrapping, etc. It is planned to make chemical surveys of stocks of raw materials and to keep a watchful eye for fraud and upon nostrums that are offered to the trade.

A questionnaire is included in the bulletins to which members are invited to reply. We venture to predict that the answers to question No. 8 will be an index of the scientific measure of the minds of the bakers who compose the organization. It reads: "What is your formula for the bread which is your best seller?" We wonder how many bakers there are who have enough scientific understanding to know that it will do them no harm to tell? Or that thousands of others know as much of the technique of baking as they do? Or that, scientifically considered, they are still outside the portals of knowledge? Or of the delectable gardens of profit that are available to the *cognoscenti*?

Availability of Nitrate And Ammonia Nitrogen

IN ACCORDANCE with a policy outlined in these pages some time ago, a thorough survey is being made of the fixed inorganic nitrogen industry. During the controversy over the proposed Government operation of the Muscle Shoals plants, a question has been raised which seems to be of fundamental importance in a consideration of the fixed inorganic nitrogen situation. This concerns the relative availability of nitrate and ammonia nitrogen.

This is, of course, a problem in plant metabolism, and we must turn to the agricultural chemist for reply. The commonly accepted view is that nitrate nitrogen is immediately available for plant use, while ammonia nitrogen becomes available only after it has been oxidized to nitrate by the action of certain micro-organisms in the soil.

No classical study has been concluded giving the soil and temperature conditions under which the nitrifying bacteria function. Before the days of Chilean saltpeter, almost every farm in Europe had its niter leaching bed, but the temperatures were high in these due to the heat of fermentation. Such favorable thermal conditions are seldom encountered in the present-day application of inorganic ammonium salts. This is especially true in the more northern localities. Here exists an opportunity for the bacteriological and agricultural chemists to co-operate in the isolation and study of these important bugs. The development of a more hardy type having a thermal range of activity coincident with that of plant life is not beyond the bounds of possibility.

British Chemical Industry

(From Our London Correspondent)

London, April 7, 1920.

THE past month has not been distinguished by any outstanding feature of interest, but the flood of new capital issues has practically ceased, probably because the uncertainty of the international and financial situation has made it more difficult to make underwriting arrangements. The chemical industry, which in the past has been singularly immune from difficulties arising out of strikes and labor unrest, is now passing through a transition period in which successive demands for increased wages and better conditions are being made by the workpeople. It is difficult, if not impossible, in some cases to improve the somewhat unpleasant conditions of labor obtaining in chemical factories, and on the whole grievances of this kind are being successfully met. The question of wages is proving a more difficult proposition, chiefly because the workmen's delegates are adopting the policy of making fresh demands as soon as possible after agreement has been reached on a previous claim. In the result much time and effort on the part of the executives are being wasted which could be more profitably utilized.

In the chemical trade demand still exceeds supply, especially for export account, and prices therefore remain steady and firm. Bleaching powder is practically unobtainable, and there is evidence that attempts are being made to create a temporary monopoly in cream of tartar, which is talked up to £400 per ton, as against the present price of about £300. It remains to be seen whether the increasing use of substitutes, such as acid phosphate of calcium, will have a deterrent effect, but until fresh supplies become available after the summer the outlook in this and kindred commodities is somewhat obscure.

Colloidal Fuel Development—Sugar Industry—Prospects for Synthetic Indigo

An interesting new issue is the Liquid & Solid Fuels Co., Ltd., with which, it is understood, the Duckham and Anglo-Persian interests are to some extent identified. It is rumored that this company is to exploit the patents of Lindon W. Bates and his associates, who, it will be remembered, did such valuable work for the Submarine Defense Association of America during the war. It is thought that there will be a vigorous development in the colloidal fuel field, possibly in conjunction with the provision of bunkering stations on the trade routes supplying colloidal fuel to ocean-going steamships instead of fuel oil. The position is somewhat obscure at present, as the patents have not yet been published, but it is known that there are other workers in the field in regard to suitable "fixateurs," so that in a few months' time the position should become extremely interesting. As the British Government has a large interest in the Anglo-Persian Oil Co., the problem is likely to become a national one, while at the same time industrial users are not overlooking the possibilities of this new fuel.

Another industry which is attracting increasing attention is that exemplified by Home Grown Sugar, Ltd., which, under government auspices, is to establish the beet sugar industry in Norfolk. The production of sugar within the British Empire was the subject of a report to the Society of Chemical Industry published in its *Journal* of Aug. 15, 1919, and while some years must elapse before definite results are available, it is hoped that this move will have a stabilizing effect upon the upward trend of sugar prices in this country.

The Indian indigo industry is again attracting attention as a possible competitor of synthetic indigo, a curious reversal of the situation at the time when the synthetic manufacture was perfected in Germany. The prospects of the industry are stated to be increasingly favorable since scientific investigation and methods have been applied and it was found that the use of phosphate fertilizers greatly increased production, while the alkaline action of the cement-lined tanks had an adverse effect on yields. Natural indigo is a more effective dye than the synthetic product, probably because it contains ingredients other than the indigotin which is its main constituent and is the pure material made by the synthetic process.

Trade and University Activities

The projected association of merchants, in which the lead is being taken by the larger and old-established firms, is expected to take definite shape very soon, but it is still a moot point whether an entirely new organization is to be created or whether an amicable arrangement can be arrived at with the existing British Chemical Trade Association. In this case it is interesting to note that the honorary secretary of the latter body, S. J. C. Mason, who represents an American firm, has resigned, and the assistant secretary, O. F. C. Bromfield, has been appointed to succeed him. The position is somewhat similar to that of a trade union for any particular industry, as only one such trade union can be registered. Similarly, the British Chemical Trade Association has been recognized officially by the government authorities, and an interesting situation may therefore arise if it is decided to form a new body instead of going to amalgamation.

The appeal for funds of Manchester University has taken a form akin to a company prospectus, applications being invited for shares carrying no dividends, and it would seem that "conservative" Manchester is taking a leaf out of the American book as regards its method of publicity and giving a not unwelcome lead to others.

It is understood that Brunner-Mond are not acting alone in their purchase of the Billingham nitrate factory and the acquisition of a nitrogen monopoly, but that other heavy chemical interests such as Explosives Trades, British Cellulose, etc., are concerned.

Research Work Encouraged

Colonel A. W. Crossley, who did valuable work during the war at the poison gas experimental station near Salisbury, has left his professorship at King's College to take up the position of director of the British Cotton Industry Research Association of Manchester and about $1,000,000 is to be spent upon a research institute under his guidance.

Of more than passing interest is the transfer of the director of the British Photographic Research Association to one of the largest chemical firms, the change it is understood, having been made on condition that a transfer fee was paid to the funds of the Association. This arrangement seems to be without precedent—always a fetish in British national life—and, together with the incipient absorption of academic men in industry owing to its superior financial attractions, may be regarded as a sign of the times.

A Comparative Test Upon High-Speed Steels—I

Notes on a Competition of Modern High-Speed Steels Conducted for an Automotive Manufacturer—Preliminary Observations on Current Sales Practices and a General Review of Various Classes, and the Effect of Chemical Compositions and Heat Treatment

By A. J. LANGHAMMER, M.E.*

IN THE last sixteen years the use of high-speed steel has grown from practically a metallurgical and manufacturing experiment to what is today one of our most important economic and industrial factors. The principal reason for its wide application is the rapid growth of quantity production methods as applied particularly to the automobile, machine tool and allied industries, and the introduction of scientific management in these works.

Today there are dozens of brands of American-made high-speed steel on the market, and in the last eight months some of the famous English brands have again made their appearance. British-American brands too are very much in evidence, particularly in the crucible mills. Both electric-furnace and crucible steels are well represented, though the latter is still very much in preponderance.

Salesmen's Methods

High-speed steel selling methods of today leave very much to be desired. In general, the steel is sold by voluble salesmen who know nothing of their wares, have never been in a steel mill, and have never graced the floor of a machine shop. Fortunately, there are always some saving exceptions. It is indeed astonishing how little the average steel salesman knows of his product. If an interview is granted him, he begins by nonchalantly announcing that his brand is the best in the market, and that he can increase your production anywhere from 50 to 100 per cent, or more. When pressed for supporting data, he refers you to a local machine shop or some large manufacturer out of the city. During the war, Government plants and arsenals were quoted elaborately as using solely their steel. If you took the trouble to investigate, it would invariably develop that the particular brand in question had never been used, or that a small sample had been left gratis by the salesman for test purposes. Usually the test disclosed a mediocre or even a poor steel. The damage done to the steel company by such misrepresentation is almost immeasurable, for though it may later improve its product or even bring forth a superior brand, you still retain that bad taste from the interview and are suspicious, if not antagonistic.

Sometimes you meet in steel salesmen a canny old-time mechanic who has forced his way into the selling business and who is wiliness personified. If such a man is permitted to have a hand in directing the test, and the man in charge of the test is not himself an expert, then the result is never in doubt. The steel that the "old-timer" represents will win out.

High-speed steel salesmen often have access to a supply of specially-prepared steel for test purposes. At the mills a heat may be prepared which has the best possible composition and subsequent workings and heat treatments are very carefully performed. When this practice is not followed, a batch of "regular run" steel that has shown exceptional performance under test is retained for test purposes only. Obviously, when the steel company begins to fill orders, it will ship from the regular run of stock, which is inferior in quality to the "special" bar submitted for test purposes. In justice to the steel manufacturers it must be said that such practices seldom or never reflect the true policy of the companies represented (or misrepresented).

Most steel companies, too, manufacture several grades of high-speed steel. One of the grades is usually superior to all of the others and is the best steel that experience and careful manufacture can produce. This steel is then used for test purposes and should it win a place when the final selection is made, great care must be exercised to see that the "best grade" is received on subsequent shipments and not specimens of the poorer grades.

High Cost of Cheap Tool Steel

Much is found wanting in the average buyer or specifier. In most plants the purchasing agent decides on the brands, and he is naturally gullible on this subject. His decision is usually based on price, which to him is all important, while in reality it constitutes practically a negligible item. Then, too, if market conditions seem to warrant, as they do in recurring stress periods, he will buy as much high-speed steel as he can and of every available brand. In this way his errors are multiplied, for not only does he get steel which is primarily poor, but also such rejected stock as has been accumulated by the steel salesmen.

Under modern manufacturing conditions it is of utmost importance to know the comparative capabilities of the various brands of high-speed steel on the market. This applies to the small machine shop as well as the giant works. As stated above, the first cost of the raw material in a high-speed tool is practically negligible. This is true because the labor cost for the machining of such a tool is usually several times that of the raw material. Also, when a tool is made up of an inferior grade of steel, it may be scrapped after an attempt at hardening before it ever gets into the shop, thus producing an immediate combined loss of indirect material, labor and overhead. If the tool should successfully pass through the hardening room and subsequent inspection into the machine shop, trouble at once begins. Production is decreased, more work is incurred for the machine operator and tool grinder due to the increased tool changes, and costs increase accordingly. Spoilage or scrap also takes a jump and the costs increase again.

When the capabilities of certain brands of high-speed

*Industrial engineer, Thompson & Black, engineers and accountants, New York and Detroit.
Formerly mechanical engineer, Packard Motor Car Co.

steel are to be determined, it is imperative that the test be conducted under the constant supervision of a competent observer. This man need not be a technical graduate, but he should be a good mechanic and in addition he must possess the mental and moral qualities that permit him to follow instructions explicitly. The man in charge of the test, however, must be familiar with all the variables that affect the life of a cutting tool. He can then correctly plan the complete details of the test which will be executed by his subordinates. Too much stress cannot be laid on the fact that the man in charge of the test must know all the variables that are factors in the life of a cutting tool. One of the reasons that large quantities of relatively poor high-speed steel are used annually is that such tests are conducted by incompetent men.

In addition to the objection to the use of a large number of miscellaneous brands of high-speed steel noted two or three paragraphs back, there is that of difficulty in heat treatment. A standard method of heat treatment is all-essential for uniformly good results. Mediocre or poor grades of steel do not in general permit high heats and must be treated accordingly. If the next tool is made of a good steel which must be subjected to a high heat for best results, the chances are very much against its proper hardening, and the result is confusion, increased difficulties, more work, and finally a general run of poor tools. When quantity production methods are employed, as for example in a cutter or twist drill plant, these bad conditions are considerably augmented.

With a selection of brands that permit a uniform heat treatment, the tool hardener has an ideal condition and his work will show results.

Tool Steels in General

Carbon Steels

Carbon tool steel, which was the earliest form of cutting steel used in machine shops by manufacturers, is now used only in relatively small quantities for its once popular purposes except in cutting non-ferrous metals and non-metallic materials. It has a wide and universal application, however, for hand tools such as chisels, punches, dies, shearing blades, cutlery, broaches, hand taps and reamers, etc. Large quantities of plain carbon steels are also used for forging dies, hammer dies and machinery parts, though in these instances elements that promote toughening, resistance to wear and shrinkage are usually added to the alloy. As a cutting tool it fails because of the low duty that can only be exacted and the premature dulling of the cutting edges.

Self-Hardening Steels

Mushet, or self-hardening, tool steel (so called from the name of its inventor) was the immediate successor of carbon tool steel. This steel usually contained from 6 to 9 per cent of tungsten, 2 per cent of manganese, and a high percentage (about 2) of carbon. With the introduction of mushet steel, cutting speeds were increased about 60 per cent, and this record stands out as one of the most notable achievements of that time, though not fully exploited. Today this steel is obsolete, but it was of extreme usefulness in that it formed an indispensable link in the development of modern high-speed tool steel. It is an obsolescent product because practice today demands a cutting speed far in excess of its capabilities.

High-Speed Steel

Self-hardening tool steel was the immediate predecessor of high-speed tool steel. The composition of the average high-speed tool steel (by actual analysis of sixteen different brands) is as follows: carbon, 0.60 to 0.70 per cent; tungsten, 16 to 18 per cent (although one or two brands go as high as 22 per cent); vanadium, 0.75 to 1.05 per cent; chromium, 3 to 4 per cent. In addition to these "standard" elements, some brands contain also uranium, cobalt, manganese and molybdenum. Sulphur and phosphorus average from 0.02 to 0.04 per cent and the same minimum amount of silicon is generally present.

High-speed steel enabled an increase of about 400 per cent in cutting speed over mushet or self-hardening steel. The feature wherein the tools made from this steel differ from and exceed in performance the tools from the preceding steels is their ability to maintain a sharp, strong cutting edge while heated to a temperature far above that which would cause "failure" or "breaking down" of the cutting edges on tools made of the simple steels. As a matter of fact, the sharp cutting edge is maintained until just a short time before failure occurs. Carbon steel tools, on the other hand, show wear or dullness of the cutting edge as soon as they are put to work. The heat generated by the friction of the chips on the tool when cutting steel, plus the pressure, is great enough to weld small bits of the chip to the tool at some distance (depending principally on the depth of cut) back of the cutting edge proper and to wear a groove into the lip surface. The property of being able to retain hardness and cutting ability at a red heat is termed "red hardness." In the early days, the principal objection to high-speed steel was the apparent inability to produce a good finish. This handicap was largely imaginary and not well founded, for in the general run of work no such difficulty is experienced.

Stellite

As self-hardening tool steel was supplanted by high-speed tool steel, so the latter will in some cases give way to stellite when this alloy is applicable. Stellite is made up of approximately 65 per cent cobalt, 25 per cent chromium and 10 per cent molybdenum. It is extremely hard, quite brittle and possesses the quality of red hardness to a very marked degree. On cast iron, stellite has a cutting speed of 100 per cent above high-speed steel, while on bronze it may run as high as 700 per cent faster. On soft steel, honors are about even, depending on conditions. Stellite, however, is not adaptable even to cast iron or bronze when the tool is subjected to sudden shocks, on account of its brittleness.

Much work is being done in developing both stellite and similar alloys, but to date none of the rival products tested by the writer have equalled stellite in performance or adaptability. The range of utility of stellite is greatly increased, due to the fact that small rectangular or square sections can be readily welded in an electrical welder to large steel shanks, which arrangement gives a high-duty tool of low cost. The same procedure, of course, is applicable to high-speed steel.

Cast Tool Steels

Within the last two years several very promising brands of "cast high-speed steel," both air- and oil-

hardening, have been produced in this country. In some cases the alloy has a composition very similar to that of a good brand of high-speed steel, while in others no tungsten is used. Distinct advantages are claimed which greatly reduce factory costs. Thus it can be cast readily into almost any intricate shape such as dies for presses, milling cutters, core drills, form cutters and other special high-duty working and cutting tools. These castings, which usually anneal readily and machine easily, require but a small percentage of machining as compared with the tool made from a solid bar, whereby the labor cost is reduced very appreciably.

When placed in actual operation, some of these tools have produced as high as ten and twenty times as many parts as a regular high-speed tool on the same task, with the consequent saving in costs. Milling cutters made of such cast high-speed steel have been seen by the writer in use, and their performance appeared to be excellent. In this case, however, the duty was not very heavy, though the cutting speed was high, so that too much importance could not be attached to the one demonstration. Cutters of such material and of intricate design were at once ordered by the author's firm, but to date they have not been tested. In view of the recorded successes of "cast" steel and the large amount of experimental work that is being done with them, developments of extreme importance can be expected in the near future. This is the more interesting because the idea of casting high-speed steel is diametrically opposed to one of the fundamental requisites of a good high-speed steel, which is that the ingots must be of sufficient size that the proper reduction in area occurs in the working with the subsequent refined structure and hardy constitution.

English Brands

English steel makers are doing a great deal of work on high-speed steel, supposedly in an effort to produce a superior grade. As their efforts are chiefly confined to securing a substitute for tungsten, their object is probably to produce a cheaper steel. Molybdenum (already exploited by American metallurgists and discarded) is understood to be the principal element that is receiving their attention. Cobalt, too, is being thoroughly investigated, although both these elements are at the present time more expensive than tungsten. One English manufacturer has actually brought out a so-called "tungsten-less" high-speed steel that is being offered at an unusually attractive figure. In an actual cutting test, when run against a good brand of high-speed steel, it proved a failure. There may be quite a market for such a product, however, where a cheap cutting steel is desired for limited performance, or even for general work on aluminum, brass, or such easily machined metals. Again, this steel may be vastly improved, thereby increasing its usefulness.

Influence of Chemical Composition

It has been the writer's experience that the analysis of a particular brand of tool steel is but an indicator as to its ultimate capabilities. By this is meant that just because a high-speed steel has 18 per cent tungsten and other elements in proportion, it cannot be classed as a good steel on this basis alone. If, on the other hand, the analysis shows the presence of but 10 to 12 per cent tungsten, and no other substituting element, then one can readily assume that it would be a waste of time and money to investigate further such a steel. Since, broadly speaking, analysis does not in any way guarantee the performance of a tool, it is a grave mistake to order or purchase high-speed steel on the basis of specified composition only, which unfortunately is practiced by some large manufacturing industries. During an efficiency test, one of which is later described, it was always our policy to impress carefully upon the steel men that to us, chemical analysis as such meant nothing except as an indicator; the final requisite was that subsequent shipments of high-speed steel duplicated or closely approximated the performance of the test specimen. This usually served a good purpose, for not only would the salesman instruct the mill to inspect rigidly the first large shipment that was sent, but he would emphasize this point from time to time, because he knew that the steel would be subjected to a "check" test and the performance would have to be good.

The qualities ascribed to the various elements contained in high-speed steel are as follows, it being understood when discussing one that the other requisite elements are present in proper proportion:

Tungsten

Tungsten has long been credited as being the most valuable element in high-speed steel. The principal characteristic is that with a moderately rapid rate of cooling from high temperatures tungsten steels are exceptionally hard, and this hardness is retained even when the steel is again heated to a high temperature, because it offers a strong obstruction to the various changes from austenite to pearlite. This element, too, is very heavy, its specific gravity being about 19.3, it apparently diffuses very slowly, and in addition it is the most infusible element in steel with the exception of carbon. It is these three factors that may cause considerable trouble, especially in the crucible process, if in charging the tungsten is not placed at the top of the mixture so as to counteract in a measure its tendency to settle. If this tendency were not counteracted, an ingot of irregular composition would result. Tungsten raises the strength of the steel and also the temperature of fusion.

Vanadium

The effect of vanadium is to increase the hardness or red-hardness of cutting tools and also the resistance to wear. It has a strong affinity for oxygen and therefore probably acts to good advantage as a purifier. Vanadium greatly increases the strength of steel up to a certain percentage, though this limit is usually exceeded considerably in high-speed steel to get the effect of red-hardness.

Chromium

The effect of chromium in high-speed steel is to increase the hardness or red-hardness and also the life of the cutting edge. It also adds strength and especially toughness, thereby increasing the ability of the tool to withstand shocks and sudden strains. European steels, due presumably to their relative cheapness, use as high as 10 per cent of chromium.

Molybdenum

The use of molybdenum as a major constituent has in general been discontinued. High-speed steel with a goodly proportion of molybdenum is generally characterized by irregular performance, which is said to be due

to the ease with which it is volatilized. Such tools too often exhibit a tendency to crack in quenching. In general, molybdenum possesses the same quality of producing red-hardness as tungsten, though in a greater magnitude—possibly two or three times as great. This advantage is apparently lost almost entirely by reason of its instability, especially after re-hardening. However, European makers are now advocating the use of a relatively high percentage of molybdenum as a substitute for tungsten.

Uranium

To uranium is generally attributed the quality of increasing the red-hardness, ability to withstand shock and resistance to wear. It is also a powerful agent for removing gases, principally oxygen, nitrogen and their compounds. This element, however, apparently exhibits characteristics which call for careful mixing and expert handling at the steel mill. It appears, too, that the electric furnace is most adaptable for the manufacture of this steel.

Cobalt

To cobalt is usually attributed the quality of being able to cut extremely hard steel. It is generally conceded that an excess of cobalt produces a premature deadening or softening of the cutting edge. American manufacturers are apparently using little or no cobalt at present, probably due somewhat to its high cost.

Manganese

The effect of manganese in high-speed steel is to strengthen or toughen the body, at the same time allowing it to be worked readily. Apparently the effective range is very close, and when this is exceeded, excessive breakage results. It is believed that chromium is in general substituted for manganese.

TABLE I. MAKER'S RECOMMENDATIONS FOR TREATING LATHE AND PLANER TOOLS

Brands	Pre-Heating Temperature, Deg. F.	Hardening Temperature, Deg. F.	Quenching Medium	Drawing Temperature, Deg. F.
1	1600–1650	2250–2300	Oil until black, then cool in air.....	800–1000
2	No mention	Heat nose until it sweats, then quench quickly.....	No mention.....	No mention
3	No mention	About 2300	Cool in air blast until nose is cold.....	No mention
4	Bright red..	2250	Tempering oil.....	1000–1100
5	1700.....	2300.....	Lard-linseed or fish oil	400–600
6	1500–1700..	2150–2400.	Oil or air blast.....	No mention
7	No mention	About 2200	Air blast or oil.....	Draw when necessary
8	Red heat....	2200–2250.	Air blast or oil.....	500-600; 100–1100 for toughness
9	1400.....	2200–2300.	Air blast or thin oil.....	700 750
10	Red heat....	About 2300	Air blast or oil.....	No mention
11	1400	2200–2300.	Thin oil or air blast...	700–750
12	1375–1450..	2250.....	Oil or air blast.....	500–750
13	1400.....	2300.....	Oil.....	1065
14	1500.....	2200–2300.	Cottonseed oil.....	No mention
15	1400–1500..	2250–2300.	Oil or lead.....	1050
16	1400.....	2200–2250.	Oil or air blast.....	No mention
17	1450–1550..	2150–2250.	Oil or lead.....	When necessary
18	No mention.	About 2300	Fish or tempering oil..	650 1130
19	Cherry red..	White heat	Oil.....	No mention
20	Bright red..	Melting or running point....	Air blast.....	No mention
21	1750–1850..	2250–2300.	No mention.....	No mention
22	Cherry red..	White sweating heat.....	Oil.....	No mention
23	About 1400	2200–2300.	Air blast or thin oil...	700–750 in lead
24	No mention.	Slowly to 2100	Air blast.....	No mention
25	No mention.	2300 ..	Air blast or oil.....	None required

Carbon

Carbon is the element which forms the basis for all steel hardening and is a requisite constituent. In high-speed steel it is usually present in smaller amounts than would produce satisfactory results in the hardening of simple steels. This element in high-speed steel acts in a somewhat different way from what it does in the simple steels. In high-speed steel some of the carbon unites with the tungsten and chromium to form carbides of these two elements. The carbides in high-speed steel, especially tungsten carbide, are more insoluble than the cementite of the carbon steels and therefore, for hardening, a much higher temperature must be resorted to. The effect of carbon in connection with the various elements discussed above is beyond the scope of this work and will therefore be omitted.[1]

Inconsistency of Recommended Heat Treatments

The uncertainty of heat treatments recommended by steel makers is responsible for a great amount of cutting tool troubles and very much more accurate data should be forthcoming at an early date. This is especially true of the better steels. Precise information as to the proper time-temperature factor required for forging, pre-heating, heating and hardening, and drawing, at least, should be given. Variations for tools of different duties should be provided. Quenching mediums, "drawing mediums" and the time required for these operations should be given careful consideration.

To illustrate this point, the specifications of about twenty leading makers of steel (the majority of whom were represented in the test to be described later) are listed in Table I, and attention is invited to the apparent uncertainty in a large number of directions. For the sake of simplicity only the pre-heating, hardening and drawing temperatures plus the quenching mediums specified for "lathe and plane." tools are given.

(Part II will be published in our next issue.)

[1] For more detailed information concerning the influence of the various chemical elements in high-speed steel, the reader is referred to the works of Messrs. Arnold, E. T. Edwards, Carpenter, C. A. Edwards, Read, etc., in the *Journal* of the Iron and Steel Institute.

Automatic Gas-Analysis Apparatus for Government Helium Plants

S. F. Pickering, one of the members of the Bureau of Standards gas chemistry section, is to install additional automatic gas-analysis equipment which has been designed by the Bureau of Standards gas laboratories for use in the Government helium plants located in Petrolia, Tex.

The new equipment will record automatically the composition of the gas at twelve points in the plant, giving a written record every six minutes by equipment operating upon the principle of the differences in heat conductivity of the gases. At different points the relative amount of gas from two fields of the supply station, the relative percentages of methane and ethane, the relative percentages of methane and nitrogen, and relative percentages of nitrogen and helium, will be recorded.

This is the second and by far the larger installation which has been developed by this organization for the Government helium plants under the direction of E. R. Weaver, chief of the gas laboratories, Bureau of Standards.

FIG. 1. GOVERNMENT CASTOR OIL PLANT, GAINESVILLE, FLA.

Operation of the Gainesville Castor Oil Plant

A Description With Many Details of the Expeller and Solvent Extraction Process of Obtaining a High Recovery of Oil From Castor Beans—Cleaning and Tempering Beans—Drying and Bleaching Oil—Cake Extraction and Operating Difficulties

BY J. H. SHRADER* AND A. C. GOETZ†

WHEN the War Department decided that castor oil was absolutely essential for the lubrication of a certain class of airplane motors (rotary, air-cooled motors, notably the Gnome engine), it was found that the Government would have to secure about 5,000,000 gal. of castor oil. Even the industrial demands were in excess of this supply, on account of the difficulty of importing the beans. Hence, to assure to the army an ample supply of oil, it was necessary to arrange for a corresponding supply of beans. Since the heretofore greatest producer and exporter of this commodity was India, and since also the British Government needed a large supply of oil, the American officials not only sought far and wide for beans, but also contracted extensively through the Southern states for home grown beans. To crush this crop, save hauling at a time of great railroad congestion, and at the same time leave the meal and hulls in the localities where they could be utilized readily, the Government decided to erect a mill in the castor bean belt. At Gainesville, Fla., a large turpentine extraction plant, temporarily shut down on account of conditions attendant on the war, was leased. With this as a nucleus, the oil-expressing mill, warehouses and tanks were soon added. This equipment was purchased outright and held as Government property. Thus the expressing mill and equipment was owned by the Government, but the extraction plant was leased under a contract to return it to its owners. The whole plant was operated by the Gillett Oil Co., which was under contract to crush the crop and produce oil of specified quality. The Government was to pay for the cost of operation and allow the company a fixed rate according to the tonnage of the crush.

The plant consisted of a large seed storehouse, an expeller and refining room, an extraction house, a pomace storage house, together with sheds, tanks and engine room. A panoramic view of the plant is presented in Fig. 1.

CRUSHING THE BEANS

The procedure in castor bean crushing may be briefly outlined as follows: After weighing and cleaning, the beans are conducted to the heaters. These raise the temperature of the beans to about 100 deg. F. and discharge them direct into the expellers. These machines are continuous in operation and press out the oil and meal in uninterrupted separate streams. The oil is conducted to tanks, weighed and refined. The meal is conveyed to the extraction house, where it is placed in large retorts and treated with benzol to extract out the residual oil. The two grades of oil thus produced, namely, the No. 1 oil by expelling, and the so-called No. 3 oil by extraction, are tanked and constitute the ordinary commercial grades.

The Gainesville plant was designed to crush 100 tons of beans per day of 24 hr., and it was fully capable of handling this tonnage if the crops had produced. Their failure resulted in a tonnage of only about one-fourth of the beans required for capacity running. As an experiment and demonstration the mill was run to capacity several times by accumulating ahead enough beans for the runs. The railroad sidings could accommodate sixty cars. There were the usual track scales and scale house.

After the cars of beans were weighed on the track scale, they were moved to the seed storage house, the flat building to the right in the picture. This was a frame building 150 x 300 ft., with cement floor holding 300,000 bushels, calculating 2 cu.ft. per bushel, with brick fire walls dividing it into three parts. The beans were unloaded from the cars and placed on trucks, ten bags to the truck. An occasional bag or truck load was weighed by another scale provided in the bean storage house; if this weight was found to check with the re-

*Cocoanut Products Corp. Formerly Chemical Technologist, U. S. Dept. Agriculture.
†Formerly First Lieutenant in charge of Inspection of Chemical Supplies and Materials, Air Service.

ported weight on the bag, the weight of the car was accepted as reported. If the weight of one bag or truck did not check with the reported weight, then the entire lot of bags was weighed in the bean storage house. The beans were then trucked in by hand, but a stacking machine was used for piling. This machine was made by the Brown Portable Conveyor Machinery Co., Chicago.

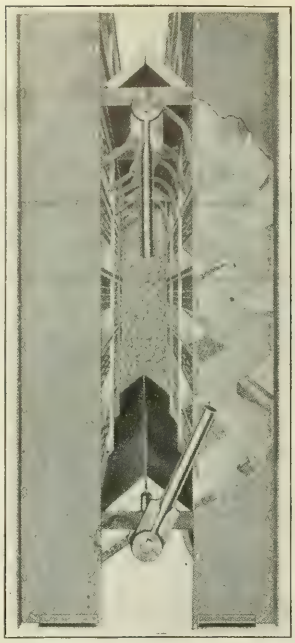


FIG. 2. HESS HEATER

Cleaning the Beans

Just below the surface of the floor in the middle of each half of the house were two belt conveyors each 300 ft. long covered with removable traps. Through wooden portable spouts, each holding the contents of a bag and large enough to set over a trap and deliver its charge clean, the beans were dumped onto the two conveyors and carried to an elevator, which raised them to a storage bin over the cleaner. The beans then dropped to a No. 4 Invincible Bean Cleaner, which had a capacity of handling 150 tons daily. This machine is made by the Invincible Grain Cleaning Co., Silver Creek, N. Y.

After passing through the cleaning machine, the beans were elevated to a storage bin, whence they passed to an Automatic Richardson Scale dumping 350 lb. at a charge. This scale is manufactured by the Richardson Scale Co., Passaic, N. J.

Tempering the Beans

From the scales the beans passed by a belt conveyor to a bucket elevator, which raised them to the heater. This heater was manufactured by the Hess Warming & Ventilating Co., Chicago, Ill., and had a capacity of approximately 150 tons per 24 hr. The Hess heater, Fig. 2, consisted of a galvanized iron hopper under which were columns of trays with pitched bottoms. The beans flowed downward by a zigzag course into another hopper, from which they discharged automatically through chutes to the expellers. The purpose of the heater was to raise the temperature of the beans in order to expedite the expression of the oil. The Hess heater was so arranged that in addition to the heating coils, there were open steam pipes. If the beans were found to be too dry, the moisture content and the temperature of the beans could be quickly increased by opening the live steam pipes, thus increasing the humidity of the heating room.

The heater was enclosed in a concrete room over the expeller room. (See Fig. 3.) The temperature of this room should be kept at 180 deg. F. In the construction of the chutes for the beans from the Hess heater, care was taken that the angle of slope was not less than 45 deg., to insure ready flow. In shutting down, the lower hopper of the Hess heater was left entirely empty so as to prevent the passage of cold beans from the heater when starting up again.

The expeller room, Fig. 4, was equipped with fifteen No. 1 Anderson expellers made by the V. D. Anderson Co., Cleveland, Ohio. The optimum temperature for the beans on entering the expellers was 120 deg. F. Good practice showed the temperature of the oil just as expelled to be about 80 deg. C. (176 deg. F.). The cake was about 120 deg. F. Actual tests of the temperature of the oil from the expeller taken just beneath the barrel as the oil was expelled were as follows:

	Temperature of Oil, December, 1919	Temperature of Oil, January 13, 1919
	79	74
	77	78
	79	84
	79½	87
	87	..
Average,	80	80¾

The cake was about $\frac{7}{16}$ in. thick and ran 12 to 13 per cent oil and about 6 per cent moisture. The capacity of an expeller was 800 to 900 lb. of beans per hour with a 13 per cent cake.

A small jet of steam was allowed to play into the stream of beans in the chute just immediately before they entered the expellers.

Screens were placed under the barrels of the expellers to remove surplus foots or meal. In the earlier runs, the amount of meal per 24 hr. per expeller was probably not over four quarts, but this increased as the machines operated longer until it required auxiliary equipment to handle it. This was not provided; the result was a curtailment of capacity due to loss of oil in the meal. All such meal, when it became excessive, was sent to the extraction house, yielding its oil as No. 3 grade. From the expeller the oil was conducted by closed screw conveyors to a sump tank. The cake was delivered by screw conveyors to the extraction house, where it was loaded directly into the retort or stored on the charging floor. The operation of the extractors will be discussed later.

FIG. 3. EXPELLER HOUSE

The sump tank had a capacity of 750 gal. It was cleaned from two to three times a week, the foots from the cleaning being placed in the No. 3 mixing tank. From the sump tank the oil was pumped to the weighing tank, which had a capacity of 32,000 lb., or about 6-hr. run at full capacity. The oil was carefully screened before passing into the weighing tank to remove any particles of seed coats or hulls which might later give trouble in the bleaching of the oil. It was found that the presence of such particles materially darkened the oil in the heating prior to bleaching.

Vacuum Pans

From the weighing tank the oil was pumped to the vacuum pan, 8 ft. diameter x 15 ft. depth over all, with a 4-in. vacuum pipe, made by the F. J. Stokes Machine

Co., Philadelphia, Pa. This pan had a capacity of 30,000 lb. of oil, but it was usually operated with 26,000 to 28,000 lb. Six to eight hours were required to dry the oil in the vacuum pan at a temperature of 230 deg. F., using 28 in. of vacuum. One of the three mixing tanks or bleaching tanks was also fitted up as a vacuum tank and could be used as such when necessary.

In order to secure the best possible agitation and to secure a thorough dehydration, the oil was pumped out from the bottom and into the top of the tank and thus circulated in one complete cycle two or three times within the period that the oil was being dehydrated.

Bleaching

The oil in batches of about 18,000 lb. then passed from the vacuum pan to the mixing or bleaching tanks, of which there were three—two for No. 1 oil and one for No. 3 oil. If the mixing tanks were all in use, the oil could be passed to the storage tank. In the mixing tanks the oil was agitated and brought to a temperature of 210 deg. F., held there for a short time and then dropped to 190 deg. F., when 2 per cent Florida fullers earth and 0.85 per cent decolorizing carbon bought from Salomon Bros., New York City, were added. When the temperature of the tank was over 190 deg. F. it was always under a vacuum. The oil in the bleaching tanks was circulated when the fullers earth and carbon were added and during the whole period of bleaching.

After agitation the oil was passed through the usual type of plate and frame filter presses containing thirty-six 30 x 30 plates. Each plate was covered by a sheet of Bachman filter paper and one duck cloth, the oil passing first through the paper and then through the duck. The filter paper for the plates enabled the cloths on the first press to be used for three batches of oil, whereas when the paper was not used the cloths had to be changed for each batch.

After passing through the first press, the oil was run back to the mixing tank until it flowed clear, whereupon it was pumped through the second press, which was of the same description as the first press, but provided with one cloth and two papers. The pressure on the first press varied from 50 to 125 lb. per sq.in., the maximum pressure on the second press being about 40 lb. The finished oil passed from the second filter press to a small preliminary storage tank, thence to the large storage tank.

There were in all four filter presses. One filter press

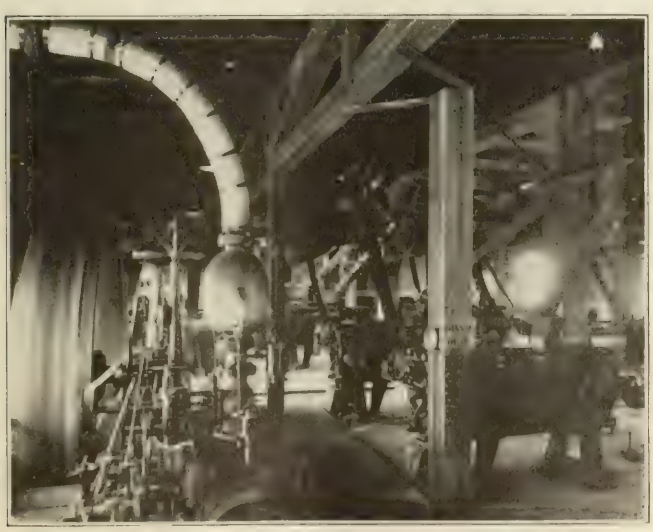


FIG. 4. EXPELLER ROOM

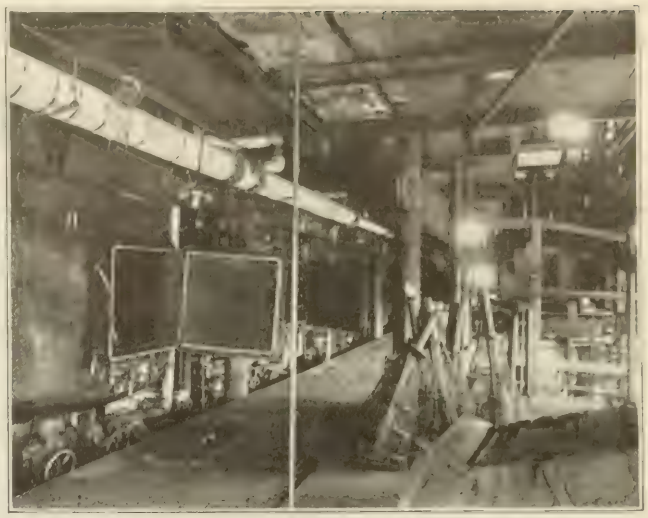


FIG. 5. RETORT BUILDING

was used for filtering No. 3 oil exclusively. Under ordinary conditions when the filter presses worked well, a 2,200-gal. batch of oil could be filtered in about 3 hr. Compressed air was blown through the filter presses after filtering to remove as much of the oil as possible. The filter cloths were cleaned by first soaking and washing in caustic soda water, then rinsing in hot water, wringing and drying. The residues from the cloths were sent to the extraction house to recover the last traces of oil.

In pumping the oil in the refinery, there were used two 2½-in. belt-driven rotary oil pumps, standard No. 6, each equipped with a 2½-in. suction and a 2½-in. discharge, manufactured by the Gould Manufacturing Co., Seneca Falls, N. Y. These pumps gave entire satisfaction.

The capacity for storing No. 1 oil consisted of one 250,000-gal. tank and three 30,000-gal. tanks. In addition there were two 5,200-gal. filling tanks and one 30,000-gal. storage tank for No. 3 oil.

Extraction Plant

Difficulties Experienced. The extraction plant was formerly used by the Florida Industrial Corporation for extracting pine tree stumps for turpentine, rosin, etc., and was erected by the Ernest Scott Co., Fall River, Mass. (Fig. 5.) The extraction apparatus worked very well for the extraction of the above products, but was unsatisfactory without remodelling for the extraction of the castor pomace. The principal changes in the plant were in piping and the addition of a system for agitating the charge and breaking up channelling.

There were eight extractors, each 9 ft. in diameter x 12 ft. tall, arranged in groups of four. It was estimated that the extractors would hold 3,000 lb. of pomace to the vertical foot. Considerable difficulty was experienced at first in operating the extraction plant, largely because stirrers or sweeps were readily broken from the shaft during the process of agitation. At first they were placed so as to clear the floor of the extractor; they were then raised to about 2 ft. above the floor and provided above and below with teeth 2 ft. long and 6 in. apart. This arrangement, however, did not work satisfactorily, for the sweeps still broke. Another difficulty experienced was in drying the castor pomace after extraction, due to it packing so tightly during extraction and steaming off of solvent that the moisture could not

be removed. Instead of loading 10 tons in one charge into the extractor, only 2½ to 5 tons could be loaded. If the pomace was not dried to within a moisture content of 12 to 13 per cent or, better, 10 per cent, it decomposed with a loss of ammonia, resulting in a consequent decrease in the value of the pomace.

At the top a manhole admitted the pomace during charging; on the side near the bottom, a large door permitted the removal of the charge. An agitator of the single-arm, sweep type rotated on the vertical axis of the retort. The floors were constructed with false bottoms supported on girders. These bottoms consisted of first a circular iron plate (in sections) about ½ in. thick and perforated with ½-in. holes. Over this was placed another plate about ⅛ in. thick with ⅛-in. holes. This second plate worked very well for chips, but did not work for castor pomace. There was substituted for this upper plate a covering made by burlap over ¼-in. mesh chicken wire. Over this burlap was spread a layer of castor bean hulls about 6 in. deep. Much time and effort were devoted to this problem before a satisfactory solution was found.

Overcoming Packing of the Charge

In order to effect the removal of the last trace of the solvent and in order to dry the pomace, it was necessary to pass live superheated steam through it. Considerable difficulty was experienced in pumping the solvent and driving off the last traces of moisture and solvent on account of the persistent packing of the charge. It was found necessary to change the practice of pumping the solvent in at the top and down through the pomace to the bottom by reversing it, pumping in at the bottom and forcing the solvent upward. The height of the solvent in the extractor was regulated by an adjustable arm in the extractor added by the Gillett Oil Co. It was found that pumping from the bottom to the top gave very good results and overcame the difficulty due to the formation of an impervious layer. However, packing of the charge was still troublesome. This manifested itself by difficulty in drying the pomace; even the aid of a vacuum did not solve the problem. After trying many methods, the following was finally adopted in January, 1919, and found to give satisfactory results:

Placed proportionately around the inside of the extractors and near the walls were nine upright 1-in. capped pipes perforated with ⅛-in. holes about every 8 to 10 in. The height of these pipes was regulated by the depth of the charge. After extracting the oil from the pomace, it was found that if steam was blown through it by means of these upright pipes, the pomace could be made dry enough not to decompose. This method was tried out in one extractor and found to give such excellent results that the remaining extractors were adapted to this method of drying. Under this arrangement the extractors could be worked to handle ten tons of material to be extracted per charge, extracting to about 1 per cent of remaining oil. From loading to loading about 20 hr. was required, but this time was often reduced to about 15 hr. Even at 20 hr. per extraction the extractors could handle the expeller cake from a 100-ton daily expeller run.

Operation of the Extractor

The castor pomace was charged in at the top of the extractor and all openings on the extractors tightly sealed. Solvent was then pumped through the mass a sufficient number of times to extract all the oil economically. The first and usually the second washings were pumped direct to the storage tank, which led to the purifiers (solvent stills). The third and fourth washings were used for the first and second washings on the next extractor in the same unit. Sometimes heat was used when the solvent was to be pumped through the extractor and sometimes not, depending upon conditions. After the solvent had been pumped off from the extractor, the heat was applied by a closed coil to distill off the solvent.

The last traces of solvent were driven off by means of live steam blown through the mass of pomace in the retort. During the "blowing off" with steam, a vacuum of about 10 in. was used. This vacuum assisted greatly in driving off the last traces of solvent vapor and moisture. These were pumped to the separating tank, which consisted of one large tank with a partition almost dividing the tank in two, the moisture and solvent entering one side of the tank. The water settled to the bottom and the solvent overflowed the partition to the other side. The vents from this tank and the vacuum pumps were sealed by a barrel of oil. This oil absorbed the last traces of solvent, later recovered in a third purifier.

Purification of No. 3 Oil

After reaching the storage tank (about 5 ft. in diameter and 20 ft. long), the solvent and oil were conducted by gravity to the purifiers, made by Ernest Scott, Fall River, Mass. In the purifiers most of the solvent was driven off by steam, leaving the No. 3 oil behind, while the condensed solvent was pumped to the separating tanks. The oil was then conducted to a tank, where it was treated with live steam to remove all traces of solvent and to clarify the oil. The exhaust from this tank was also conducted to the separators. The No. 3 oil was then pumped to the mixing tank in the refinery, where it was treated with fullers earth in the proportion of 250 lb. of fullers earth to 2,200 gal. of oil, merely for clarifying purposes. The oil was then passed through a filter press to the storage tank. The capacity for storing No. 3 oil was one tank of 33,000-gal. capacity.

Extraction Operation Reports

An idea of the time and procedure in operating the extractors can best be obtained by study of the accompanying retort reports, Tables I and II:

TABLE I. GILLETT OIL CO. RETORT REPORT
Retort No. 3. Charge No. 16. Date Feb. 13, 1919

	Start	Stop	Remarks
Filling	4:25	4:35	
Pumping in solvent	4:35	5:00	
Circulating (boil)	5:00	5:55	
To storage	5:55	6:15	
Pumping in solvent	6:15	6:25	
Circulating (boil)	6:25	6:45	
Advance to storage	6:45	6:55	
Pumping in solvent	6:55	7:25	
Circulating (boil)	7:25	7:45	
Advance to No. 4	7:45	8:30	
Pumping in solvent	8:30	8:45	
Circulating (boil)	8:45	9:45	
Advance to No. 4	9:45	10:20	25 min. lost in draining line.
Pumping in solvent	....	....	
Circulating	....	....	
Advance to:			
Steaming	10:45	1:45	
Steaming	....	....	
Steaming	....	....	
Vacuum	1:45	2:45	4 hr., 5 min. lost by orders to wait until next shift.
Unloading	7:50	9:15	

TABLE II. GILLETT OIL CO. RETORT REPORT

Retort No. 4. Charge No. 15. Date Feb. 12, 1919

	Start	Stop	Remarks
Filling	12:25	12:35	
Pumping in solvent	3:55	5:30	3 hr., 20 min. lost on account not ready to work.
Circulating (boil)	5:30	5:45	
To storage	5:45	8:15	
Pumping in solvent	8:15	8:30	
Circulating (boil)	8:30	9:00	
Advance to storage	9:00	9:50	
Pumping in solvent	9:50	10:00	
Circulating (boil)	10:00	10:30	
Advance to storage	10:30	11:30	
Pumping in solvent	....	....	
Circulating	....	....	
Advance to	....	....	
Pumping in solvent	....	....	
Circulating	....	....	
Advance to			
Steaming	11:30	2:00 a.m.	
Steaming	....	....	
Steaming	....	....	
Vacuum	2:00	3:00	
Unloading	3:40	4:30	

Pomace House

From the extractors the pomace was dumped directly onto a conveyor and sent to the pomace house, a peaked building about 100 x 50 ft. and 50 ft. high, divided into two parts. The pomace passed from the conveyor to a No. 8 Bauer Bros. grinding mill, and thence by an elevator to a conveyor traveling the length of the house just under the roof. From this it was dumped in any part of the house desired. Mechanical conveyors loaded the pomace directly into cars.

The power plant consisted of one 200-hp. water tube boiler operating at 150-lb. pressure, and two return tubular boilers of the Casey-Hedges make, Memphis, Tenn., 200 hp. operating at 150-lb. pressure, giving a total of 400 hp. Wood was used as fuel on account of the plentiful supply and the scarcity of coal, but the latter was later used. Superheated steam was used throughout the plant. In the expeller room there was a Hamilton Corliss engine, 250-hp. girder frame type. In the powerhouse furnishing the electric power was a 260-hp. condensing Ames Uniflow engine directly connected with a 180-kw. generator.

There were also two 7¾-in. barrel type well pumps made by the Keystone Drill Co., Beaver Falls, Pa. These pumps gave more than an ample supply of water for boiler and fire purposes from two wells on the premises. There were also two sets of fountain sprays, for cooling the extractor and condenser.

Laboratory

The mill was equipped with a chemical laboratory to control all factory operations. This consisted of examining all incoming beans and finished pomace for moisture and oil. Such tests as bleaching, oil in expeller meal, and other matters of routine character, were carried out from time to time. Determination of the acidity of the finished oil was always necessary, as this and color were the only specifications under the control of the manufacturing procedure.

Capacity and Yields

At a time that all the fifteen expellers were operating they crushed in 8 hr. 82,800 lb. of beans, yielding 40,260 lb. of oil (about 5,000 gal.) with its attendant moisture. Another test run was as follows: 41,400 lb. of beans produced 15,962 lb. of oil (38.05 per cent). From Nov. 8, 1918, the date the plant commenced operation, to Dec. 31, 1918, there was produced 257,456 lb. (32,182 gal.) of No. 1 oil. To produce this, 715,000 lb. or 15,540 bushels, of beans were crushed. This corresponds to 36 per cent of No. 1 oil, or 15.56 lb. of oil to a 46-lb. bushel. The production of No. 3 castor oil was 4,300 gal., with about 2,000 gal. still in process of manufacture.

Analytical Data

Table III gives the analyses of the oil produced at this plant.

TABLE III. ANALYSIS OF CASTOR OIL RECEIVED FROM THE GILLETT OIL CO.

G. A. Kirchmaier, Chemist, Toledo, Ohio

No. 3500-A.

	Specification Tests	No. I	4th Run II	Batch 6 III	Batch 7 IV	Batch 8 V
5	Specific gravity, 15 deg.	0.962	0.961	0.961	0.9612	0.9611
4	Color	Yellowish	Same	Same	Same	Same
6	Solubility	Soluble	Same	Same	Same	Same
7	Acidity, acid number	1.7	2.91	2.1	2.4	2.3
9	Iodine number	85.1%	80.8%	83.7%	85.4%	86.1%
10	Saponification number	179	180	180	178	182
12	Unsaponifiable number	0.3%	0.21%	0.28%	0.26%	0.3%
13	Rosin	Negative	Same	Same	Same	Same
14	Cottonseed oil	Negative	Same	Same	Same	Same
16	Viscosity (Engler)	2019	2020	2020	2018	2019
17	Flash point	526° F.	525° F.	525° F.	526° F.	527° F.
18	Cold test (Zero F.)	O. K.	O. K.	O. K.	O. K.	O. K.

All of the above samples comply with U. S. specification, the oil is good, a trifling yellowish cast or color, could be removed with bone black and clay to satisfy requirement in drug trade, but not necessary for mechanical use.

The beans crushed were almost entirely the first crop of those raised in this country from imported seed. The analyses extend over the whole period of operation from November, 1918, to June, 1919, inclusive.

BEANS	Per Cent	POMACE	Per Cent
Moisture	5.31	Moisture	13.04
Oil	45.15	Oil	2.40
Highest value	57.50	Lowest value	0.20
Lowest value	38.00	Highest	25.95

These values are not selected, but include all batches, notably those produced early in the operation before the extractors were made to perform satisfactorily. The average for the last few weeks of the operation was: Oil, 1.03 per cent; moisture, 10.13 per cent.

Oil No. 1		Oil No. 3	
Specific gravity	0.9620	Specific gravity	0.9614
Acidity, per cent	0.98	Acidity, per cent	4.80

A sample of hulls analyzed:

	Per Cent		Per Cent
Moisture	10.35	NH_3	1.27
Oil	1.88	K_2O	1.99

A sample of pomace analyzed:

	No. 1 Per Cent	No. 2 Per Cent
Moisture	15.05	11.28
NH_3	4.49	5.81
K_2O	0.89	0.99

Quality of Products

No. 1 oil: The No. 1 produced when operations first began had a higher color and higher acid (about 1.25 to 1.50 per cent) than the usual c.p. castor oil of commerce. The acidity of No. 1 oil later on ran about 1 per cent acid. The color of this oil was as light as most of the No. 1 oil produced by the regular trade, but was slightly muddy or dull or not quite so snappy in appearance as some No. 1 oil. The slightly dull appearance was not noticeable to the layman and could be noticed only when compared directly beside the very best No. 1 oil of the regular trade.

The production of No. 1 oil improved in quality steadily, and earlier poor batches were better as regards color and acidity than some No. 1 oil old process previously produced and now produced by the old established firms.

No. 3 oil: The No. 3 oil at first was very dark in

color, but improved very markedly until that later produced was equally as good as the regular No. 3 oil on the market.

Pomace: Due to the high moisture content of the pomace caused by the earlier poor operation of the extractors, the pomace produced at first heated and decomposed. With the later methods of operating the extractors, a low or normal moisture content was secured. The pomace also was uniform in fineness, which was a quality not possessed by some of the old-established brands.

General Statement

The Government castor oil mill was the first castor oil mill, expeller process, on a large scale ever erected. Some years ago castor oil was made by this method with success, but no large mills were ever erected using exclusively this process. Heretofore the old-type hydraulic process was used. Really the only difficulty experienced at the Government castor oil mill was in the operation of the extractors. These difficulties have been previously described. At the time of closing down, the plant was doing all and more than it was expected to do. It produced a castor oil which conformed to the specifications of the Air Service and further conformed to the U. S. Pharmacopœia castor oil. The production of the plant was earlier limited by the capacity of the extractors, but these were so improved that the mill met the original expectation, which was a capacity of 100 tons per day of 24 hr.

If the war had continued, the production of castor oil at this mill for airplane lubrication would not have been retarded. The capacity of the expellers could be pushed to 150 tons per day. Under stress of war times, no doubt, the extractors could have been put in satisfactory operation sooner. As it was, however, they were finally working successfully and producing a satisfactory pomace, extracting the pomace down to 1 per cent of oil, much better practice than obtained in some of the oldest and largest mills in this country.

Thus in about eight months the Government built and operated the largest castor oil mill in the world and produced high-grade oil from beans of local production, whereas the American castor bean crushing industry was built up on crushing beans mostly of East Indian variety. In the above short period this mill produced a grade of oil fully up to the specifications of the Air Service and ahead of expectations in a commercial sense. Objection has been made that the oil deposits a slight amount of foots on standing. Some of this oil does so react, but since ordinary commercially produced oil does likewise, it can hardly be charged with justice against the operation of the above plant. Another objection encountered was with respect to the excessive wear on the expellers. It was found, however, that they do not wear any more than with operating on peanuts. Excessive meal is discharged during long operating, but auxiliary equipment can handle this trouble. One of the best commentaries on a process is the attitude of the operators to it. In this case, they would unquestionably use expellers for crushing castor beans. With regard to the operation of the extractors, the staff made them applicable to extracting castor beans, one of the most difficult oil-seeds to handle due to the mushy, non-fibrous character of the kernel. Only the cessation of hostilities and partial failure of the home-grown bean crop prevented the mill from functioning fully up to its estimated capacity.

A Plea for the Scientific Study of Cellulose Chemistry

By Harold Hibbert

IN A previous communication on "The Future of Industrial Organic Chemistry"[1], it was pointed out by the writer that the study of aliphatic compounds has been subordinated both here and in Europe to that of the aromatic, and this in spite of the fact that the actual cash value of the latter is an insignificant sum in comparison with that of the former. Attention was directed to the value of the United States cotton crop for 1918, which according to the report of the Department of Commerce amounted to the huge sum of $1,616,207,000.

Importance of Cellulose Industry

If we consider the total amount involved in the production and utilization of cellulose in the manufacture of such products as textiles, paper pulp, vulcanized fiber, artificial silk, cellulose nitrate and acetate, viscose (artificial silk) and celluloid, the total amount involved is probably greater than in any other single industry, with the possible exception of steel and coal.

In view of the fact that by far the greater portion of the world's supply of cotton is grown in America and that all of the industries mentioned above are now established here on a firm footing, it is difficult to understand why the scientific study of the chemistry of this so fundamentally important raw material should have been almost entirely neglected. The results of such neglect are apparent in every field where the application of cellulose plays an important role, for all of these industries have been built up essentially on empirical data rather than based on deep-seated knowledge of the nature of the constitution of the cellulose molecule.

Few American Contributions to Chemistry of Cellulose

During a discussion on cellulose at a recent meeting of the New York Section of the American Chemical Society[2] it was pointed out by the writer that the scientific study of cellulose chemistry has been neglected to such an extent that it is not only necessary for the American student to study abroad (since few facilities are available in any American university or college), but that he has also to depend on foreign literature for the fundamental and scientific facts covering this field.

It may possibly be of interest to record the fact that a review of the contents of the *Journal* of the American Chemical Society for the period 1893-1918 shows that during this interval of twenty-five years only three papers were published under the heading of Cellulose or Cellulose derivatives. Of these three papers one represents a contribution from the Sheffield Scientific School, Yale University, in 1907 on the "Estimation of Cellulose in Wood," by Dean and Tower. The second is entitled "Notes on Cellulose Esters," by R. G. Woodbridge, and was published in 1909 as a contribution from the Massachusetts Institute of Technology, while the third is a paper on "New Solvents for Cellulose," by H. G. Deming, published in 1911 from the University of Wisconsin. It is of interest in this connection that the second research was carried out with funds provided by Dr. Arthur D. Little for the purpose of carrying out

[1] Chem. & Met. Eng., vol. 21, pp. 335-341 (1919). This article was reproduced in *Chemiker Zeitung*, vol. 43, pp. 573-576 (1919), under the title "Die Ueberschaetzung der aromatischen und Unterschaetzung der aliphatischen organischen Chemie."

[2] Chemists' Club, New York, Nov. 7, 1919.

"scientific" (as distinct from "technical") research. This total contribution of three short papers to the advancement of the science of cellulose chemistry from a nation claiming a chemical society with a membership of about 13,000 chemists and controlling the world's supply of the raw material is not, it must be admitted, one which the American Chemical Society as a body, or the chemical industry, can view with any great degree of complacence. The surprising feature is that the industries themselves should not have contributed anything, and this in spite of the enormous wealth accumulated by them. This point is even more accentuated by the fact that during the same period several thousand contributions have been made by the chemists of other nations. This is plainly seen if we analyze the authorship of important articles referred to, for example, in the well-known text book on Cellulose by Schwalbe. An investigation of the references quoted in the footnotes shows that the total number of such amounts to about 2,500, of which 23, or less than 1 per cent, refer to American authors

Publication of Scientific Data Urged

On the occasion of the sectional meeting referred to above an earnest appeal was made by the writer to the large industrial companies to take an interest in the subject and, by publishing their scientific (as distinct from their technical) results, to assist the universities, colleges and chemical students generally in obtaining a more accurate and comprehensive knowledge of the subject, since it is only through publication that the progress of the science can be secured.

The industry has hitherto adopted an altogether too parochial attitude on such matters, but with the new spirit now in evidence a much better outlook is in prospect. Thus tribute must be paid to the scientific contributions on tungsten and other metals as well as to remarkable theoretical papers from the laboratories of the General Electric Co.; to the fine spirit shown by the du Pont company in financing and publishing scientific data on nitroglycerine, and to the contributions by The Barrett Co. and other large concerns, while the admirable series of library synopses planned by the Arthur D. Little Co. represent a praiseworthy public-spirited contribution to chemical progress.

In view of what has already been said, it is not in the least surprising that the information necessary for the development of new cellulose industries such as that of artificial silk, etc., should have had to be procured abroad.

The researches of Abel, Cross and Bevan, Green, Knecht, Fenton, Vieille, Grandmougin, Vignon, Chardonnet, Girard, Nastjukoff, Georgievics, Saposhnikow, Witt, Baeyer, Schwalbe, Ost, Will, and many others are well known to chemists, both scientific and industrial, and only make the absence of American contributions the more conspicuous. While tribute is gladly paid to the valuable compilations of Worden on cellulose derivatives, there is still lacking a comprehensive *scientific* textbook in English on the subject, comparable for instance to the well known textbook of Schwalbe.

The subject of cellulose chemistry, on account of the colloidal nature of cellulose, is closely related to, and interwoven with, that of colloid chemistry, and the enthusiasm and interest awakened in this latter subject through the efforts of Bancroft and others might well be utilized for the purpose of increasing our scientific knowledge in this field.

If we consider such subjects as the question of the best type of cellulose suitable for the manufacture of photographic paper, writing paper, celluloid, nitrocellulose, etc., we find each industry subjecting the raw material to a special treatment founded on data which are in the last analysis entirely empirical and which must remain so until the research chemist is able to provide some more definite data regarding the chemical nature of the cellulose molecule. How can the active interest of the chemist in the subject be best awakened and stimulated? The answer would seem to be first of all by the publication of the scientific data already in possession of the industries, and secondly by the endowment of several university professorships for the encouragement of scientific research in this field, together with provision for a considerable number of research scholarships.

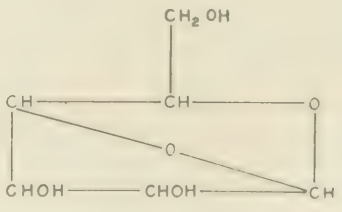
The country and the public generally are now both accustomed to the idea of special industries being concentrated in the hands of a limited number of companies, since it is only through the combined wealth associated with such organizations that sufficient funds are available to meet the large expense involved in carrying on more or less unproductive research for long periods of time. Granting this, they have at the same time the right to demand, in view of their benevolent attitude toward such trade combinations, that these latter shall repay such considerations by contributing their share to the progress of the science, progress which can be assisted in no better way, in the writer's opinion, than along the lines just indicated.

The time has long since passed when the country's knowledge of cellulose chemistry should be confined to the ranks of a few technical experts and it is to be hoped that the coming decennium will witness the publication in American journals of a vastly increased number of valuable scientific and technical communications on cellulose chemistry.

Constitution of the Cellulose Molecule

It must not be forgotten that the problem of the constitution of the cellulose molecule is one requiring the intimate co-operation of the botanist, the organic chemist and the physical chemist. Sooner or later America will presumably have its National Research Institute and the study of the chemistry of cellulose and wood products would seem to be one peculiarly adaptable to such an environment. In the meantime the universities, if liberally endowed and financed, can contribute much of value, as the forthcoming publication of the brilliant researches carried out recently at Yale by Prof. T. B. Johnson and his pupils on the constitution of silk will clearly demonstrate.

In connection with a forthcoming paper dealing with a new formula for cellulose proposed by the writer, namely,



it is hoped that opportunity may be found for a discussion of certain promising lines of scientific research in this field.

Yale University,
New Haven, Conn.

Electrochemical Industries in Sweden

By J. W. Beckman

A VERY extensive investigation on the utilization of water power for electrochemical purposes in Sweden has recently been published by Prof. Wilh. Palmaer, professor of chemistry at the Royal Technical University of Stockholm, and the growth of the industry, as indicated by him in this publication, is of such a kind that it should stimulate countries situated in a similar way to further efforts.

Sweden is a sparsely-settled territory which is about as long as the Pacific coast between the Mexican line and the Canadian line. Its total width is not over 300 miles, which naturally affects the transportation question very materially.

It has been customary all over the world to look to Sweden and Norway as pioneers in the electrochemical developments and this is primarily due to the fact that the people of Sweden have at an early date been impressed, through the means of the daily papers, of what hidden wealth was stored away in the flowing rivers of that country.

Prof. Palmaer's pamphlet covers the field completely up to 1918. When the Swedish production figures are compared with similar figures of the United States, they are pygmies, but in spite of that, Swedish electrochemical products are found all over the world.

Electrochemical Sodium and Potassium Salts Industries

The total power used in the manufacture of caustic soda and bleach products in Sweden up to 1918 was 2,140 kw., which was divided among four factories. The reason for the comparatively small production of these products is due to the fact that salt, essential as raw material in this industry, has to be imported from Germany or the southern countries of Europe. The cost of this material is therefore considerable and has held back the industry, though there is a large demand both for caustic and bleach. In all the paper mills bleach is needed badly, and large quantities of this material have been imported from as distant countries as the United States.

Potassium chlorate and perchlorate have been produced in considerable quantities and 750 kw. is consumed by this industry alone. The chlorate manufacture is one of the oldest electrochemical industries in Sweden and has an enviable position on this account.

Other Electrochemical Industries

The calcium carbide manufacture has been carried out with a total power consumption of 24,000 kw., with an increase during the war of about 25 per cent.

The fixation of atmospheric nitrogen has gone forward considerably, and the latest information indicated that 16,375 tons of cyanide was produced and 12,000 kw. was consumed in the synthetic manufacture of nitric acid.

The shortage of sulphuric acid in Sweden during the war and the demand for increased food-product yields stimulated the possibility of developing electrochemical phosphate processes for the production of a soluble phosphate suitable for fertilizing purposes. Prof. Palmaer has developed such a process, which has shown itself efficacious under special conditions.

At the present time there is being used 2,000 kw. for the manufacture of potash salt and potassium cyanide in electric furnaces. The process has proved itself successful, and should open the field for the synthetic manufacture of potassium cyanide in parts of the United States where potash silicates and cheap electric power are available.

There is being utilized at the present time 700 kw. in the manufacture of carborundum, and the manufacture of alundum has been under serious consideration. For the manufacture of artificial graphite 1,650 kw. is being utilized.

About 1,000 kw. is being utilized, in two different plants, in the manufacture of phosphorus. In addition to the industries mentioned above, a number of small plants taking close to 1,000 kw. are operating, producing hydrogen, oxygen, hydrogen peroxide and other products, which find a ready market in the country.

Electric Iron, Steel and Ferro-Alloys

The Swedish pig-iron industry is gradually being changed over to an electric pig-iron industry, and the impulses have been strong along these lines during the war years. The total power consumption for the manufacture of pig iron in electric furnaces up to 1918 was about 70,000 kw., an increase of three and a half times that in 1915.

Along with the electric smelting of pig iron the electric steel furnaces have grown and there are at present installed forty-two electric steel furnaces consuming 7,975 kw.

The ferro-alloys, such as ferromanganese, ferrochrome, ferrosilicon, silico-aluminum, manganese-silico-aluminum and manganese-copper, have grown parallel with the steel industries, and the total consumption for these industries amounts to approximately 45,000 kw.

Electrolytic Copper Refining

Other metallurgical processes have been contemplated, but the most interesting is the electrolytic refining of copper, a matter which is of great importance to Sweden, since the country's electrical industries are highly developed and the need for refined copper for these is very essential. Small amounts of copper are produced in the country, and these will be refined there. The war, of course, has indicated the danger of complete dependence on outside sources for refined copper.

Summary

The following table shows the growth of electrochemical industries in Sweden during the years 1904-1917:

Year	No. of Electrochemical Plants	No. of Kw. Consumed	Value of Products in Swedish Crowns*
1904	8	9,000	4,500,000
1908	10	13,500	7,500,000
1911	14	25,000	11,000,000
1913	22	60,000	20,000,000
1915	36	78,000	31,000,000
1917	75	126,000	55,000,000

* $1 = 3.75 crowns at normal exchange.

San Francisco, Cal.

Photo-Sensitizing Dyes in Demand

Extensive commercial use is being made of the sensitizing dyes produced by the Bureau of Chemistry as a part of its war work. The recent successful development of color photography is resulting in a brisk demand for isocyanines, pinaverdol, pinacyanines, krytocyanines, and other sensitizing dyes. They were developed originally for aircraft photography.

Supply of Inorganic Nitrogen in the United States

The Inadequate Domestic Supply of Nitrogen in the United States Is Supplemented by Importations From Chile—Summary of Figures on Consumption and Supply Showing Deficiency Even if Government Plants Are Operated

By Major D. P. GAILLARD
Nitrate Division, Ordnance Department, U. S. A.

A PREVIOUS paper on the consumption of inorganic nitrogen in the United States outlined the conditions during the last twenty years and considered the factors that would probably affect our consumption of nitrogen in the future.* It is important to investigate the source of supply of nitrogen from which this demand can be met. The United States has been very largely dependent upon importation for its supply of nitrogen, as only a small part of the total nitrogen consumed has been produced here. This domestic production has come from the recovery of nitrogen contained in all bituminous coal in connection with coking for the manufacture of coal gas and byproduct coke. The principal source of imported nitrogen has been the nitrate fields of Chile. There have also been imports, comparatively small in amount, from Europe of byproduct nitrogen and from Canada of nitrogen fixed from the atmosphere. The supply of nitrogen, therefore, comes from imports and domestic production.

Nitrogen Recovered From Coal

Byproduct Coke Production

Byproduct coke ovens were first introduced in this country about 1893, but by 1902 the total coke production from this source was only 5 per cent of the total. There was a more or less constant growth to 1912, in which year about 25 per cent of the total coke was produced in byproduct ovens. The consequence of this very rapid increase was a tendency toward an oversupply of byproducts, and consequently the building of additional byproduct ovens was checked somewhat until stimulated by the war. Since 1914 the increase has been abnormal, owing to the demand for the byproducts in the manufacture of munitions. In 1917 and 1918, in order to secure an adequate supply of toluol, the basis of TNT, the Ordnance Department stimulated by special contracts the construction of many additional byproduct ovens. The last of the ovens so constructed will not be completed until about the middle of 1920. As the result of this increase, in 1918 about 46 per cent of the total coke was produced in byproduct ovens. In 1919 the demand for coke decreased very considerably, and while the production of byproduct coke fell off 4 per cent from the 1918 figures, the production of beehive coke fell off 44 per cent from figures for the previous year, as the consequence of which the proportion of byproduct coke produced in 1919 was 56 per cent.

The byproduct ovens now in existence, together with those contracted for during the war and now under construction and nearly completed, it is estimated can furnish a maximum coke production of 36,500,000 tons a year, or 64 per cent of the record high 1918 consumption; or 82 per cent of the 1919 consumption of coke, which although considerably lower than that in 1918, has previously been exceeded in only three years and equaled in one other year.

Beehive Coke Production

These figures without further study might confirm the popularly held idea that the beehive ovens in this country are being replaced by byproduct coke ovens, but this has not been the case. A study of the coke production statistics compiled by the U. S. Geological Survey shows that in the last fifteen years there has been no general decrease in the production of beehive coke. The average annual production of beehive coke during this 15-yr. period is approximately 29,900,000 tons. For the first five years of this period this production averaged 30,100,000 tons, for the next five years 30,400,000 tons, and for the next five years 29,300,000 tons; or, in other words, there has been a falling off in the last 5-yr. period over the first 5-yr. period of only 3 per cent. It is evident, then, that the byproduct coke ovens in the last fifteen years have been built to take care of the increase in the demands of the country for coke, but that, considering the country as a whole, there has been no substitution whatever as yet of byproduct ovens for beehive ovens.

Future Pig-Iron Production

To forecast intelligently the future demand for coke it is necessary, as has been stated before, to consider the probable growth in the pig-iron industry, a fundamental industry of the country and one reflecting so accurately the general business conditions that it is often used as a "barometer of industry." A study of the statistics of pig-iron production as reported by the U. S. Geological Survey shows a practically constant growth in the last twenty years, the annual increase averaging about 1¼ million gross tons per year. The industry has grown somewhat irregularly, periods of reduced production following every few years periods of record production; but the growth given above represents the average growth during this period. The production fell in 1914 because of the poor business conditions prevailing that year owing to the outbreak of the war. It recovered to approximately normal the next year, rose to a record high figure of 39,434,797 tons in 1916, declined very slightly in 1917 and again in 1918, being 38,230,440 tons in the latter year. With the cessation of war demands and the absorption of war stocks of iron, together with the hesitation of business while waiting for lower prices, as well as with the interruptions caused by steel and coal strikes, the production fell in 1919 to approximately 30,500,000 tons. If the normal growth of 1¼ million tons per year had continued to 1920, it is estimated the consumption last year would have been in the neighborhood of 36,000,000

*See Chem. & Met. Eng., vol. 22, No. 17, p. 783.

tons instead of 30,500,000 tons, as was actually the case.

During the war steel was to a very considerable extent cut off from non-essential industries, and a great amount of construction work was postponed. It is reasonable to assume that in the next few years the major part of these accumulated unfilled requirements must be met. Further, the growth in certain industries, such as the automobile and farm tractor industries, will require releatively increasing amounts of steel, and the substitution of steel for wood in bridges, buildings, and for various other uses will continue. Further, there is a possibility of some increase over our pre-war exports. On the other hand, it is unlikely that railroad requirements for steel—a very considerable part of the total requirements in past years—will be so great as previously. Furthermore, the production of pig iron in this country has doubled in the last fifteen years, increasing much faster than the population. In other words, the per capita consumption of steel and steel products has very materially increased in this period. It is evident that this increase cannot go on indefinitely, but opinions differ as to just how near the country is to the point of saturation.

In view of this it is believed that the most accurate estimate that can be made at this time is to assume that the production of pig iron in this country during the next few years will continue to increase at the average pre-war rate of 1¼ million tons per year. Under this assumption pig-iron production in 1924 would be in the neighborhood of 43,000,000 tons, which amount, it is interesting to note, is somewhat less than the present total pig-iron capacity of the country as recently estimated by one of the trade journals. Under this same assumption the production in 1930 would be 50,500,000 tons.

Future Byproduct Coke Production

The coke required to produce 43,000,000 tons of pig iron, together with the amount of coke used for other purposes, would be, based on past experience, approximately 63,000,000 net tons. The byproduct ovens now built and building can supply approximately 36,500,000 tons, or approximately 58 per cent of this—a greater proportion of byproduct coke than there has ever been in the past—leaving, if no new byproduct ovens are constructed, a total of 26,500,000 tons to be furnished by beehive ovens. It is pertinent to note that this is only 89 per cent of the average beehive production for the past fifteen years, and that the beehive production during these fifteen years has fallen below this figure in only three years.

It is entirely possible that sooner or later byproduct ovens will supply from two-thirds to three-quarters of the total coke production, but it is very unlikely that they will displace beehive ovens to any greater extent than this. The iron industry has always been a business of ups and downs, and consquently the coke requirements have fluctuated from year to year. A study of the statistics shows in the last fifteen years four cases in which the production of coke has fallen off very considerably from the previous year, the percentage of decrease ranging from 36 per cent to 15 per cent of the production of the previous year and averaging for these four years 25 per cent. A byproduct oven once built must continue in operation if possible, not only because it must carry much heavier fixed charges on capital invested than the cheaper beehive oven, but if shut down it must be partly reconstructed at considerable cost before placed in operation again. On the other hand, the simple beehive oven can be put into operation after an extensive period of idleness at comparatively small cost. Business considerations would therefore indicate that the maximum production to be expected from byproduct ovens would be that production necessary to supply the minimum requirements, the difference between the minimum requirements and the maximum requirements—that is, the non-continuous requirements—being taken care of by the cheaper and simpler beehive ovens. A study of the statistics of coke production from these two sources for the past few years shows very clearly how much less capable the byproduct production is of fluctuating with the variable demand. For instance, in 1908 the production of beehive coke fell off 38 per cent from the previous year's figure, while the production of byproduct coke decreased 22 per cent. In 1911 the production of beehive coke fell off 21 per cent, while the production of byproduct coke increased slightly. In 1914 the production of beehive coke fell off 33 per cent and byproduct only 12 per cent. In 1919 the beehive production fell off 44 per cent and the byproduct only 4 per cent.

Increase n Byproduct Ovens Improbable

It is very unlikely, however, that in the next five years there will be any considerable number of new byproduct ovens constructed. Not only is the cost of construction more than double the pre-war cost, but the production of byproducts from the coke ovens now built and building will be approximately three times that of the highest pre-war year. Under these conditions, with the extensive world-wide demand for capital, it is difficult to see how any considerable amount of money will be invested in the byproduct coke oven industry, abnormally stimulated during the war, in order to further increase, in a period of high costs, an already plentiful supply of most of the byproducts.

It is possible, however, there will be certain individual byproduct coke ovens constructed where local conditions may be peculiarly advantageous; but it is believed that an allowance for the year 1924 of a million and a half tons of coke from byproduct ovens other than those now built and building is a very liberal one.

We therefore have for 1924 a maximum possible production of 36,500,000 tons of coke from coke ovens now built and building, and an additional allowance of a million and a half tons of coke from ovens which may come into production during this period, making an estimated total byproduct coke production in 1924 of 38,000,000 tons, or 60 per cent of the total coke production. This would require the coking of approximately 53,500,000 tons of coal.

In 1930 to manufacture the estimated production of 50,500,000 tons of pig iron and to meet the other requirements there will be required approximately 73,500,000 tons of coke. It is estimated that byproduct ovens will supply approximately 50,000,000 tons, or 68 per cent of this, leaving 23,500,000 tons to be furnished by beehive ovens. These figures compare with 38,000,000 tons and 25,000,000 tons estimated from these two sources for 1924. In other words, it is assumed that not only will all the increase in coke requirements be furnished from byproduct ovens, but also that byproduct ovens will replace the beehive ovens operating in 1924 to the extent of 1,500,000 tons of coke.

The production of 50,000,000 tons of coke in beehive

ovens would require the coking of approximately 70,000,000 tons of coal.

Yield of Ammonia

Statistics collected by the U. S. Geological Survey prior to the war indicated for the byproduct coke ovens all over the country an average yield of 5 lb. of ammonia per ton of coal coked. During the war, owing to the use of inferior coals and the lower efficiencies during forced production, this yield decreased to slightly less that 4½ lb. It is believed, however, that pre-war conditions can be equaled again and therefore in these estimates an average recovery of 5 lb. of ammonia per ton of coal coked is assumed. It is believed that this figure is liberal, and while in certain cases the recovery may run as high as 6½ lb., in other cases it runs very materially less than 5 lb.

Total Ammonia From Byproduct Ovens

On the basis of 5 lb. of ammonia recovered per ton of coal, we would have an ammonia recovery for 1924 from the coking of 53,500,000 tons of coal in byproduct ovens, of 133,750 tons of ammonia, equivalent to 535,000 tons of ammonium sulphate, and in 1930 from the coking of 70,000,000 tons of coal, 175,000 tons of ammonia, equivalent to 700,000 tons of ammonium sulphate.

Ammonia Recovered in Manufacture of Coal Gas

In the manufacture of coal gas coal is coked in retorts differing somewhat from byproduct coke ovens, but methods of recovery are very much the same. Exact figures for the several past years in the production of ammonia from this source are not obtainable, but as only a relatively small proportion of the total ammonia recovered comes from gas works and this proportion is constantly growing less, a reasonable approximation will be sufficient for our purposes.

In 1915 the U. S. Geological Survey reported a total production from gas works of 12,980 tons of ammonia, and in 1917 of 11,440 tons. These are the only two recent years on which exact statistics are available, but estimates of production during the last eight years show an annual production varying from a minimum of somewhat over 10,000 tons to a maximum of 13,000 tons. The high year was 1915, since when the production has apparently decreased slightly. It is believed that an allowance for 1924 of 15,000 tons of ammonia and in 1930 of 18,750 tons of ammonia from gas works will be ample in view of the experience in the last few years. Further it is believed that the extremely small amount of ammonia from bone carbonizing works can be included in these figures without error.

Total Ammonia Recovered From Coal

We thus have for 1924 as the maximum amount of ammonia that can reasonably be expected to be recovered from coal, 133,750 tons from byproduct coke ovens, and 15,000 tons from coal gas and bone carbonizing works, or a total of 148,750 tons, equivalent to 595,000 tons of sulphate of ammonia, or 122,500 tons of nitrogen. In 1930 we would have 175,000 tons of ammonia from byproduct coke ovens, and 18,750 tons of ammonia from gas works, or a total of 193,750 tons of ammonia, equivalent to 775,000 tons of sulphate of ammonia, or 159,500 tons of nitrogen.

The Fixation of Atmospheric Nitrogen

Commercial Plants

In the past there has been almost no quantity fixation of atmospheric nitrogen within the limits of the United States. For a few years a small arc process plant operated in North Carolina and more recently another small arc process plant has been operating in the state of Washington. Some other experimental and development installations operated on a very small scale, but the aggregate supply from all these sources has been a negligible factor in the country's total supply of nitrogen.

Government Plants

During the war, U. S. Nitrate Plant No. 1, at Sheffield, Ala., using the General Chemical Co.'s modification of the Haber process, and U. S. Nitrate Plant No. 2, at Muscle Shoals, Ala., using the cyanamide process, were practically completed.

Experimental operation had started at Plant No. 1, but the process is not yet developed and considerable further study of the fundamentals of the process and modification of the equipment are necessary before regular production can be secured from this plant.

Plant No. 2 was tested and showed conclusively that it could produce fixed nitrogen at its rated capacity—approximately 45,000 tons per year—at reasonable cost. Altogether No. 2 plant produced about 600 tons of nitrogen in 1918 and about 700 tons of nitrogen in 1919. The production from No. 1 plant was negligible.

Future Production From Government Plants

If Congress authorizes the operation of the two plants for the production of nitrogenous materials to be used in the manufacture of fertilizer as recommended by the War Department, it is estimated that the production from this source will be approximately 45,000 tons of nitrogen in 1924, gradually increasing to 55,000 tons of nitrogen in 1930.

Future Production From Privately Owned Plants

Within the last few months the General Chemical Co. and the Semet-Solvay Co. have joined forces for the further development of the Haber process in this country. It is most unlikely that there will be any considerable tonnage production from this source by 1924, as it is doubtful if the process will be developed on a manufacturing basis much before that time. If this process is worked out, which is still much of a question, it will gradually enter as a production factor and in order to be liberal it is assumed that by 1930 about 25,000 tons of nitrogen may be secured from this source. To secure this production will necessitate the investment of not far from $20,000,000, and it is not believed that this industry will develop any faster than this.

Nitrogen From Imports

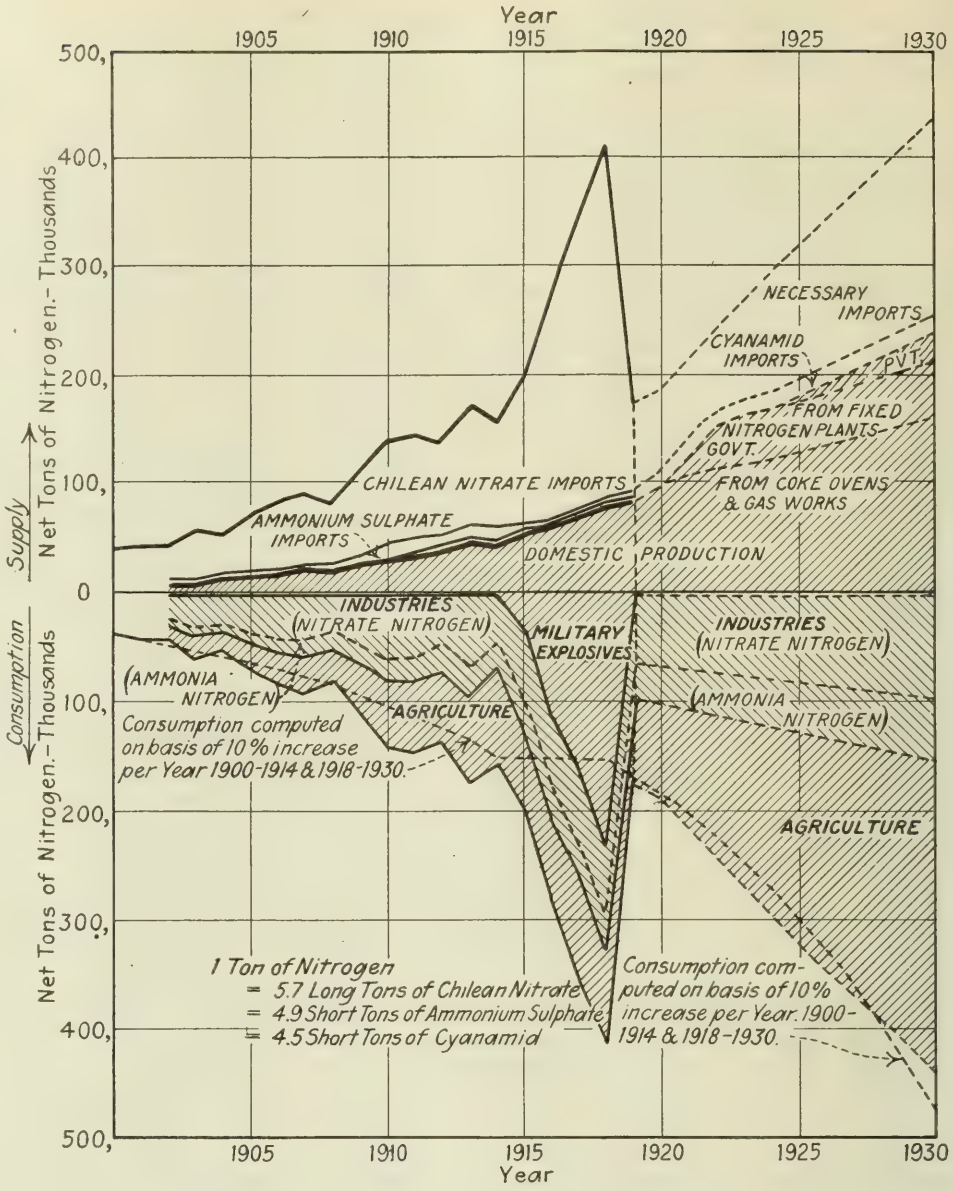
Past Imports

In the past twenty years more than three-quarters of the nitrogen consumed in this country has been imported, principally from Chile in the form of nitrate of soda, usually known as Chilean nitrate.

For a few years before the World War considerable amounts of sulphate of ammonia were imported, for the most part from England, furnishing at a maximum somewhat less than one-fifth of the total nitrogen im-

ported; but during the war England needed this nitrogen at home and imports from this source fell to almost nothing. The plant of the American Cyanamid Co. at Niagara Falls, Canada, for the fixation of atmospheric nitrogen entered into production in 1910 and imports of cyanamide from this plant have steadily increased since that date, but they furnished only a very small fraction of the total nitrogen imported. The main reliance of this country, however, in the past has been the importation of Chilean nitrate and the abnormal war demands were met almost entirely by expansion of this source of supply.

A study of the nitrogen situation indicates that the requirements of the country will in the future as in the past first absorb the domestic production. This will be the case as domestic nitrogen can always undersell any imported nitrogen. It is evident that this is true with the nitrogen from the byproduct coke ovens and gas works, where the cost of production, as is the case with any byproduct, is largely a matter of bookkeeping. This is also true in the case of the Government nitrate plants, which can fix and sell nitrogen at an operating expense less than any probable selling price of imported nitrogen in the next ten or twenty years. The nitrogen which it has been estimated will be produced in the future from privately owned fixed-nitrogen plants will certainly not materialize unless private capital is convinced that nitrogen from this source can undersell, if necessary, any imported nitrogen. In other words, under the conditions that will prevail in the future, when the consumption will be considerably greater than the domestic supply, the price will be controlled by the cost of the imported nitrogen necessary to supply the deficiency in the domestic production, and the imports will therefore just be sufficient to meet whatever deficiency there may be.



ACTUAL AND ESTIMATED SUPPLY AND CONSUMPTION OF NITROGEN IN THE U. S., 1900 TO 1930

Whether most of this imported nitrogen will be in the form of Chilean nitrate or whether some nitrogen may be obtained either from the European byproduct coke ovens or from European fixation plants is immaterial. It is believed, however, that most of it, over and above the relatively small amount contained in the cyanamide imported from Canada, will be furnished by Chilean nitrate, as has been the case in the past.

The imports of nitrogen, other than those of Canadian cyanamide, which it is estimated will furnish 15,000 tons of nitrogen, necessary to supply the estimated deficiency of domestic production in 1924 amount to 112,000 tons of nitrogen, equivalent to approximately 640,000 long tons of Chilean nitrate, and in 1930 to 183,500 tons of nitrogen, or slightly more than 1,000,000 long tons of Chilean nitrate.

Summary

The preceding consideration of the probable consumption in 1924 and 1930 of inorganic nitrogen for agricultural, industrial and military purposes, and the supply to be expected in these same two years from the coking of coal and the fixation of nitrogen within this country and the importation of sufficient nitrogen to meet the deficiency in domestic production, may be summarized as shown in the table.

In order that this forecast of future conditions may be readily compared with the actual conditions prevailing in the past, and in order that the trend of increase may be better studied, the accompanying chart has been prepared.

This chart shows the actual supply and consumption

of inorganic nitrogen for each year since 1900 and the estimated supply and consumption for each year to 1930.

It will be noted by a comparison of the bottom line on the chart showing total consumption with the dotted curve immediately above it that the total use of nitrogen in this country increased at a rate somewhat greater than 10 per cent each year from 1900 to 1914. The tremendous demand for nitrogen for military explosives during the World War materially checked this growth in the peace-time uses of nitrogen from 1914 to 1919. It will be noted, however, that the future consumption of nitrogen is estimated to continue at practically this same rate of growth, at least for the next ten years, and it is believed that the preceding discussion shows that this assumption is conservative.

SUMMARY OF ESTIMATED SUPPLY AND CONSUMPTION OF INORGANIC NITROGEN

Estimated Peace Time Consumption in	1924 Tons of Nitrogen	1930 Tons of Nitrogen
Agriculture	172,000	285,000
Industries	120,000	150,000
Military explosives, assumed	2,500	3,000
Total consumption	294,500	438,000
Estimated Domestic Supply from		
Coking of coal	122,500	159,500
Privately owned fixed nitrogen plants	.....	25,000
Total domestic supply	122,500	184,500
Deficiency in domestic supply if Government plants do not operate	172,000	253,500
Estimated Supply From		
Government fixed nitrogen plants	45,000	55,000
Deficiency in domestic supply if Government plants operate	127,000	198,500
Estimated Imports Necessary		
Canadian cyanamide	15,000	15,000
Chilean or European nitrates, if Government plants do not operate	157,000	238,500
If Government plants operated	112,000	183,500
Proportion of Total Consumption Furnished by Domestic Supply	Per Cent	Per Cent
If Government plants not operated	41.6	42.2
If Government plants operated	56.9	54.7

NOTE—Nitrogen exported from the United States is not included in the above, as amount of future exports is uncertain, and if included only makes the deficiency of domestic supply more marked.

It will also be noted on this chart how the war demand, considerably greater than the entire consumption in this country of inorganic nitrogen for all purposes in any year prior to the war, necessitated importing from Chile in 1918 almost three times as much nitrogen as had ever been imported before, and it shows graphically how greatly dependent this country was during the war on this importation.

The chart shows further how the expansion of nitrogen supply from coke ovens and gas works, even though abnormally stimulated by the war demand, will not furnish in the future half of the nitrogen used in this country, and unless this source of supply is supplemented as soon as possible by the operation of the Government fixed-nitrogen plants, and further supplemented by such development of the private fixed-nitrogen industry that there may be, this country will be even more dependent on imported nitrogen ten years from now than it is at present, and not only will the country be less well prepared from a military point of view but the American consumers, which include directly a very large proportion of the farmers of this country as well as many of the most fundamental chemical industries, and indirectly the greater part of the population, will find it harder than ever to get an adequate supply of nitrogen at a cost within reason.

Influence of Slag and Nitrogen on the Corrosion of Iron

AT THE Boston meeting of the American Electrochemical Society, April 16, 1920, L. T. Richardson presented a paper on "The Influence of Enclosed Slag on the Corrosion of Wrought Iron," in which he noted the controversy between makers of pure steel and genuine wrought iron as to the relative merits of the two materials for resisting corrosion. Referring to Hadfield's, Rosenbain's, and Braune's work on ancient irons, he comes to the conclusion that "those ancient iron objects which have shown such a remarkable resistance to corrosion are made of puddled iron, and it is therefore only natural to expect that iron manufacturers of today in their search for a corrosion-resisting material should attribute the rust-resisting qualities of these old irons to just those properties that characterize wrought iron itself. These distinguishing properties are two in number—a chemical one that the iron is quite pure, and a physical one that the iron has long layers or threads of slag or cinder scattered throughout its mass. Some even go so far as to say that each fiber is coated with an almost infinitesimal film of slag. It almost follows that because of these two different characteristics, the resistance of wrought iron to corrosion should be ascribed to two different causes by two classes of observers—one claiming that the resistance of wrought iron to corrosion is due mainly to its chemical purity; the other contending that it is due to its physical structure.

"The very structure of wrought iron offers a means of testing, to a certain extent, these two theories.

"It is easily seen that in one direction, namely, perpendicular to the slag layers, the metal is not contin-

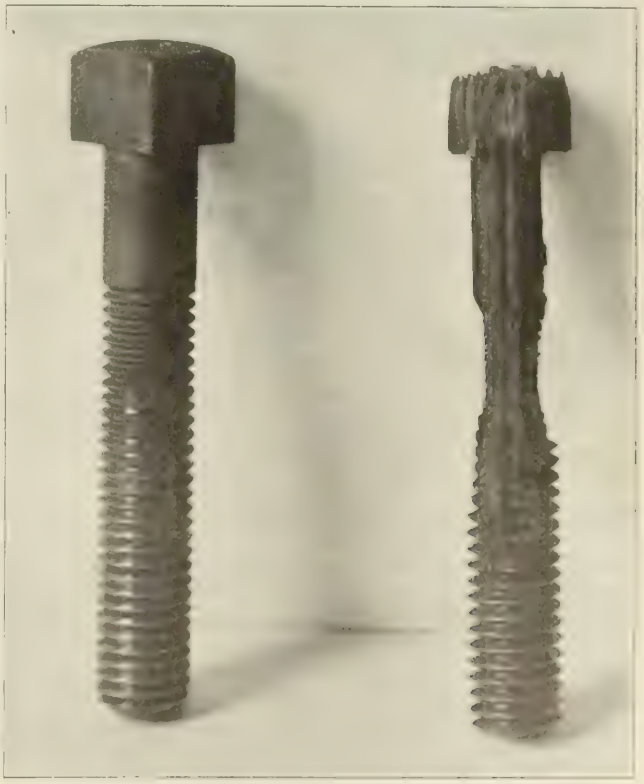


FIG. 1.

At left, open-hearth iron with no slag inclusions; at right, puddled iron with slag dissolved out.

uous and any oxidation of the metal as it penetrates inwardly from the surface must meet layers of slag. In the other direction, however, that is, in a direction parallel to the layers of slag, the metal is continuous and as it penetrates will not meet these layers of slag or cinder. Hence, if corrosion is retarded by slag inclusions, one would expect to find that transverse sections of wrought iron will rust more rapidly than longitudinal sections.

"In order to test out this line of reasoning, transverse and longitudinal sections about $\frac{1}{16}$ inch in thickness were taken from pieces of Swedish iron and wrought iron and subjected to rusting at different times. The pieces were thoroughly annealed and the surfaces made smooth with emery cloth. After weighing and measuring the thickness of each piece in several places, all were placed in a wooden rack, and exposed to the weather.

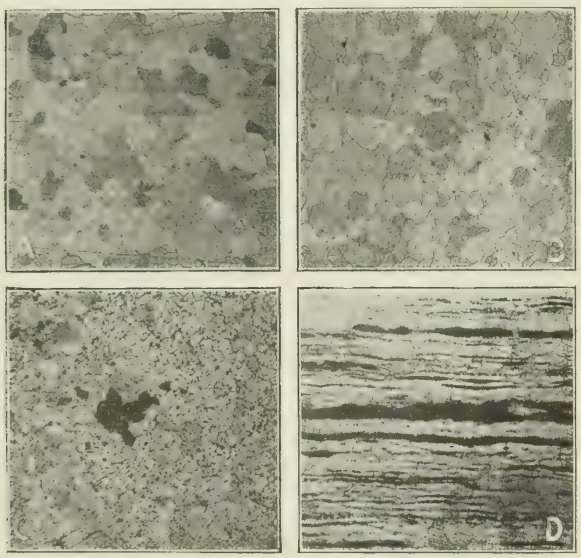


FIG. 2.

A—Transverse section, pure open-hearth iron. × 60.
B—Longitudinal section, pure open-hearth iron. × 60.
C—Transverse section, puddled iron. × 60.
D—Longitudinal section, puddled iron. × 60.

"The analysis of the different irons, the exposure data and the results are as follows:

	Sulphur	Phosphorus	Carbon	Manganese	Silicon	Copper
Steel	0.032	0.079	0.08	0.56	.....	None
Wrought iron (A)	0.044	0.132	0.015	0.095	0.193	None
Wrought iron (B)	0.020	0.100	0.020	0.038	0.180	None
Swedish iron	0.015	0.052	0.015	0.011	0.050	None
Wrought iron (C)	0.026	0.115	0.04	0.05	0.210	0.10

	Time Exposed	Transverse Section Loss in Weight	Transverse Section Depth Pits	Longitudinal Section Loss in Weight	Longitudinal Section Depth Pits
Steel	.....	.....	.....	.....	.....
Wrought iron (A)	6 mos.	0.1178	0.035	0.1101	0.033
Wrought iron (B)	6 mos.	0.0791	0.044	0.0789	0.041
Swedish iron	6 mos.	0.1068	0.026	0.1333	0.026
Wrought iron (C)	2 years	0.153	0.020	0.154	0.025

The loss in weight is in grams per square centimeter and was obtained by cleaning the rusted specimens with a solution of ammonium citrate. The depth of pits was obtained by grinding the surface of the cleaned specimens until the pits on the surface were removed.

"In view of the fact that the corrosion of transverse and longitudinal sections is the same as regards loss in weight and depth of pits, the conclusion has been reached that any superior resistance to corrosion that wrought iron may have is not due to slag inclusions but to some other causes, among which may be mentioned the purity of the iron."

The statement that ancient irons were of a nature and manufacture similar to puddled irons was contradicted by J. A. Aupperle, of the American Rolling Mill Co. He pointed out that prior to 1784, when Henry Cort invented the puddling process, all iron had been manufactured by the direct process, i.e., the ores had been smelted with the use of charcoal. After Henry Cort's invention of the puddling process, wrought iron was produced by this method, which gradually superseded the charcoal iron process. In the puddling process the iron ore is first reduced in a blast furnace, then cast in pigs which are remelted in the puddling furnace. Such iron, therefore, is produced by the indirect process, quite dissimilar to the earlier methods.

However, the speaker was in accord with Mr. Richardson's conclusion that purity in iron is essential to long life, quoting analyses of some rust-resisting irons.

"In our research work we have studied the gas content of iron and steel and the influence of gases upon the rate of corrosion. In the examples cited the nitrogen content will be found extremely low. In fact, I have never analyzed an ancient iron without finding low nitrogen. This is undoubtedly due to the method of manufacture. It is my opinion that the nitrogen content exerts a greater influence upon the rate of corrosion than any other element.

"In contrast with durable irons we have numerous examples of steel which failed in a very short time. All of those which failed in a short time were found to be high in nitrogen. We have had 26-gage bessemer sheets, which were exposed to the weather, fail within thirteen months; other sheets of the same gage lasted thirty-four months.

"In the following table will be found the analysis of a pipe and also a spike, which in addition to containing high nitrogen also contain a high percentage of carbon monoxide. I have also included the analysis of pure iron made in an open-hearth furnace for the purpose of showing that the nitrogen content in the above failures is ten times as high as the nitrogen content of pure iron. This comparison also shows that the carbon monoxide is several times higher in the pipe and spikes which failed than the pure iron.

	Failure of Pipe in Alkali Soil After 14 Mos.	Failure of Spike in Railroad Ties Arizona, After 9 Yrs.	Pure Iron Made in an Open-Hearth Furnace
Carbon	0.090	0.100	0.010
Manganese	0.357	0.405	0.025
Phosphorus	0.098	0.108	0.004
Sulphur	0.049	0.041	0.025
Silicon	trace	trace	trace
Copper	0.014	trace	0.040
Nitrogen	0.041	0.033	0.004
Oxygen	0.032	0.082	0.015
Carbon monoxide	0.052	0.058	0.015

"Based upon the data which we have accumulated, we find the gaseous impurities have a greater influence upon the rate of corrosion than the solid impurities.

"I have been able to dissolve the slag from a sample of puddled iron as shown in Fig. 1. Both the puddled iron and the iron made in an open-hearth furnace were submerged for half their length for 2 hr. in 25 per cent sulphuric acid. The pure iron bolt was attacked but slightly. The slag in the puddled iron bolt had dissolved to such an extent as to indicate the fibrous nature of the product. This test seems to confirm what Mr. Richardson has said about the slag offering no protection from a corrosion-resisting standpoint."

Longitudinal and transverse sections of both classes of materials are shown in Fig. 2.

Synthetic Acetic Acid and Acetone

Description of the Process and Method of Production of Acetic Acid, Acetates and Acetone From Calcium Carbide—Acetylene Generation and Catalytic Hydration—Oxidation of Acetaldehyde to Acetic Acid—Acetone

By J. T. ROONEY

THE great war was responsible for very many interesting industrial developments in which chemistry played a leading part. The progress of hostilities created demands for some materials greatly in excess of their previous rate of production or even any preconceived ideas of war-time necessity.

The extravagant use of artillery by the British on the western front, using cordite as a propellant, required a great quantity of acetone for the manufacture of this explosive, and it was soon discovered that the supply obtainable from wood distillation was entirely inadequate and new possible sources of manufacture were eagerly sought.

Necessity is said to be the mother of invention and to know no law, and so the urgent demands of war gave birth to many new ideas and fostered many new developments. The manufacture of acetone was undertaken from a variety of new sources, including calcium carbide, molasses, kelp, grain, etc., with varying degrees of success. Probably the most interesting, from a chemical point of view, is that including the synthesis of acetic acid from calcium carbide, water and air.

The various steps in this process had been the subject of much research and several patents before the war, but little had been done up to that time on its commercial development. Subsequent events, however, provided a stimulus which resulted in the synthetic production of great quantities of alcohol, acetic acid and acetone in America, France, Switzerland and Germany.

The Shawinigan Water & Power Co. of Montreal, Canada, which controls a large power development and calcium carbide plant at Shawinigan Falls, was approached by the British War Ministry on the possibility of producing acetone synthetically at Shawinigan Falls. The result was that a subsidiary company called the Canadian Electro-Products was incorporated and, after six months of research by the staff of the new organization, construction was begun and in the following eight months a $2,000,000 plant covering fifteen acres was completed and working to capacity. The plant buildings are of brick, steel and fireproof construction throughout, the floors being of concrete and metal lath and the stairways of iron.

GENERAL VIEW OF THE PLANT

Early in 1918, the Imperial Munitions Board, owing to the great need for acetic acid in the manufacture of cellulose acetate for aëroplane construction, instructed the company to discontinue the production of acetone and to confine its efforts to making acetic acid only.

Reactions of the Process

The synthesis of acetone takes place in four steps:

The production of acetylene from calcium carbide.

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$

The hydration of acetylene to acetaldehyde.

$$C_2H_2 + H_2O = CH_3.CHO$$

The oxidation of acetaldehyde to acetic acid.

$$CH_3.CHO + O = CH_3COOH$$

The formation of acetone from acetic acid.

$$2CH_3COOH = (CH_3)_2CO + CO_2 + H_2O$$

Development of the Process

After the nature and extent of the reactions involved in the various steps of the process had been thoroughly investigated in the laboratory, a small building was allotted for an experimental plant, and in this development proceeded on a semi-commercial scale. It was at this stage that most of the difficulties were encountered and overcome. One of the first problems was the selection of a suitable material for a vessel which would withstand the action of weak sulphuric acid with metallic mercury, and it was found that an acid-resisting silicon-iron was the only satisfactory medium.

Another problem which had to be solved early in the game was the preparation of the yellow mercuric oxide, which acts as a catalyst in the conversion of acetylene to acetaldehyde. This material was required in considerable quantities, and the process of making it from nitric acid and metallic mercury with subsequent conversion of the nitrate to oxide by ignition would have proved a troublesome and costly process on a large scale and consequently new methods of preparation were sought. The process finally developed, and with which very excellent results were obtained, was the electrolytic oxidation, at the anode, of metallic mercury to the oxide, using caustic soda solution as an electrolyte.

Owing to the difficulty of obtaining air-liquefying apparatus for the separation of oxygen from the atmosphere, attention was directed to the utilization of air directly for the oxidation of acetaldehyde to acetic acid, and after many experiments with various metallic containers, numerous catalysts, etc., the task was successfully accomplished. It was found that the reaction could not be controlled in iron, copper, etc., owing to the catalytic action of these metals which was responsible for several explosions at this stage, and it was eventually decided that aluminum was the only metal which could be safely utilized in this capacity.

For the conversion of acetic acid to acetone, numerous experiments were made with oxides and carbonates of calcium, magnesium, barium, zinc, manganese, etc., to determine the most suitable catalyst for the reaction, and the best results were obtained by use of hydrated lime containing a little magnesia.

As in every chemical development, a very considerable amount of work was required to determine the best operating conditions for every step of the process.

Plant Equipment and Operation

The hydration of the acetylene to acetaldehyde is carried out in Duriron kettles, 4 ft. dia. x 12 ft. high, built in circular flanged sections clamped together. In operation, a kettle is filled with water to about three-quarters capacity and sulphuric acid added to make a 6 per cent solution, then mercuric oxide charged in at regular intervals while acetylene is introduced at the bottom of the kettle and allowed to percolate upward through the solution. The mercuric oxide is kept in suspension by the action of the entering gas and by mechanical stirrers. These stirrers, three in number, have paddle blades perpendicular to the shafts, the latter extending to the bottom of the kettle, where they fit into guide sockets. Each stirrer shaft is supported from a collar at the upper end which revolves on ball bearings and is connected with bevel gears to a 7½-hp. motor bolted to a framework on the top of the kettle. The relative weakness of acid-resisting silicon-iron made it impossible to construct these stirrers entirely of this material, and as no other metal was adaptable to the purpose, the difficulty was ingeniously surmounted by the use of a steel shaft over which were fitted sleeves of Duriron, cast in sections with paddles and held tightly together by means of a nut threaded on the shaft.

A rubber gasket between each two sleeve sections prevented leakage of acid to the inner shaft. The lower end of the steel shaft was threaded into an iron nut cast in a piece of Duriron, against which the lowest sleeve fitted tightly.

Acetylene gas is admitted into the bottom section of a kettle through a perforated Duriron pipe and rises through the solution, where it is partially converted into acetaldehyde, the unaltered portion passing out with the aldehyde vapor at the top of the kettle and through condensers and scrubbers into a gasometer, from which it is returned by a Nash hydroturbine to the kettles. Additional acetylene is admitted to the system under pressure at the same rate as the gas is being converted. One charge is operated 50 hr., after which it is dumped and the acid and catalyst renewed. A temperature as nearly 70 deg. C. as possible is maintained in the kettle and the aldehyde, which is boiled off and condensed, runs to brine-cooled containers for storage.

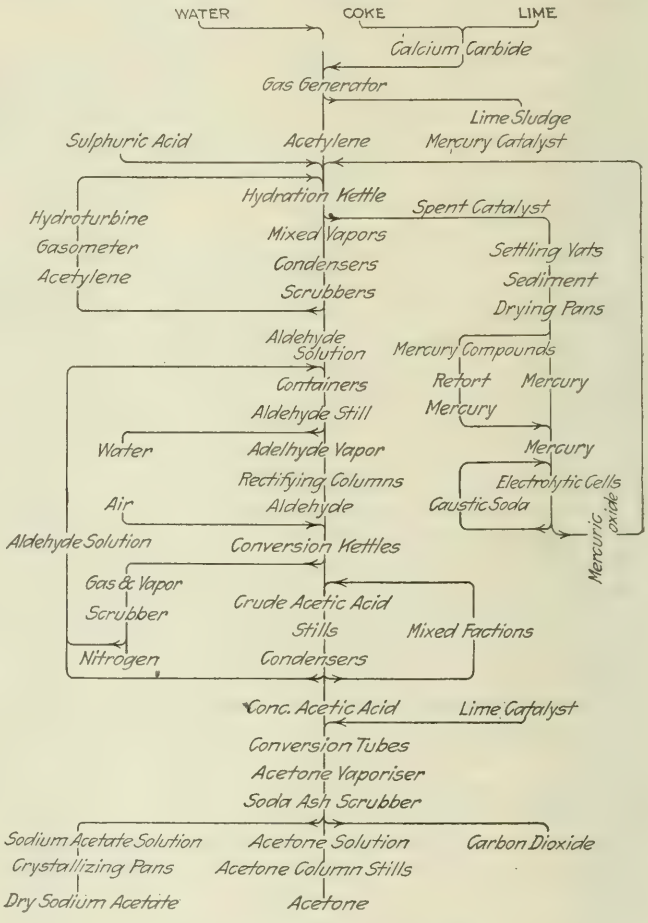
In December, 1918, a disastrous explosion, evidently due to a leakage of acetylene or aldehyde with accidental ignition, wiped out the building in which this part of the process was carried out. Several lives were lost and considerable damage was done.

Acetaldehyde Concentration

Crude aldehyde (from the previous step of the process), a 35 per cent solution in water, is pumped from storage to the still house, where it is concentrated to 99 to 100 per cent and stored again in cooled wrought-iron containers. The motor-driven crude aldehyde pumps are controlled automatically by a float and trip-switch in a small supply tank at the top of the still house. The equipment in this building consists of continuous stills and rectifying columns of cast iron with automatic steam control regulated by vapor tension in the columns. The outlet at the top of the columns is connected to condensers, which are in turn vented to the atmosphere. The addition of a little fine chalk to the crude aldehyde feed neutralized the acidity and added considerably to the life of the apparatus.

Oxidation of Acetaldehyde to Acetic Acid

Pure acetaldehyde, in charges of 1,000 gal., is pumped into heavy iron kettles lined with aluminum, in which the conversion to acetic acid takes place. This part of the process requires the most careful attention of any owing to the extreme sensitiveness of the reaction



FLOW SHEET OF PROCESS

involved and the absolute necessity of the most accurate control. Manganese acetate, ground to 200 mesh, was found to be the most satisfactory catalyst for this reaction.

Air is admitted to the bottom of the kettle under high pressure, helping to keep the catalyst in suspension, and the oxygen is rapidly absorbed. The operation is carried out at a temperature of 60 deg. C. and under a pressure of 65 lb. per sq.in. in the kettle, the pressure being regulated by the rate of admission of high-pressure air and contraction of the outlet of the kettle. The temperature is kept down by circulation of cold water in coils inside the kettle. The dome of each kettle is connected with a set of reflux condensers, which returns liquid aldehyde through a seal to the bottom of the kettle.

The outlet from the kettle is carefully restricted to the cracking of a valve during operation, and the gases which escape pass through a large scrubber, which collects in water any aldehyde that may be carried out with the escaping nitrogen. For safety in operation, each kettle is equipped with duplicate thermometers and pressure gages, which are watched constantly by the operator. There is put into one charge 1,000 gal. of aldehyde, and it requires about 12 hr. to reach an acidity of 95 per cent in terms of acetic acid. It is then considered finished and is dumped. So completely is the oxygen absorbed from the air in this operation that the scrubber gas content seldom exceeds 0.1 per cent. In spite of every precaution, fatal explosions and fires have occurred in this building.

Acetic Acid Refining

The crude acetic acid containing small amounts of aldehyde, manganese acetate, water, etc., is refined by fractional distillation in copper stills with aluminum fractionating columns, dephlegmators and condensers. The aldehyde fraction comes off first and goes to the aldehyde storage; mixed fractions are run with a subsequent charge. Water-white acetic acid, 99.8 per cent pure, is produced by this distillation.

Production of Acetone

In this step of the process, vaporized acetic acid is passed through a heated tube containing a catalyst which effects the decomposition of acetic acid with the formation of acetone, the products passing through a hot scrubber containing soda ash, which converts the unaltered acetic acid into sodium acetate and allows the acetone to pass through into condensers, from which it is obtained in a 20 per cent solution. When this operation was tried on a large scale it was found that the larger conversion tube, measuring 12 in. dia. x 13 ft. in length, did not function so well as the experimental one which had been made from a 4-in. wrought-iron pipe. In the larger installation, steel tubes were used covered with asbestos and mica and wound with 290 ft. of No. 12 nichrome ribbon. The winding was made in several parallel circuits for convenience in temperature control. These tubes were packed with pumice on which the catalyst, hydrated lime, was deposited, but owing to the poor conductivity of the pumice it was impossible to maintain the required temperature of 485 deg. C. A central heating core was then added, but even this did not have the required effect, and the pumice was finally replaced with iron balls coated with lime. Seventy-two such conversion tubes were installed, requiring 12 to 15 kw. each for heating, and these gave a daily production of ten tons of acetone of great purity with an operating efficiency of 85 per cent for the entire period of production. It was necessary, in this process, to renew the catalyst about every two weeks.

Preparation of Mercuric Oxide

The yellow mercuric oxide catalyst used for the conversion of acetylene to acetaldehyde is prepared by the electrolysis of a caustic soda solution in circular cast-iron cells, 6 ft. dia. x 15 in. deep, having the inside walls lined with cement.

A layer of metallic mercury on the bottom of the cell serves as anode. A large sheet-iron cathode, like a spider web in appearance, is suspended below the surface of the electrolyte.

A stirrer revolves between the electrodes to remove the oxide formed from the surface of the mercury and to keep it in suspension. At the end of a run the oxide is washed from the cell with a hose and settled in vats, from which it is used directly in the wet condition. The caustic soda is used repeatedly.

Recovery of Mercury

The recovery of the mercury was another problem involving many difficulties and for which quite an extensive equipment was required. When a charge containing the spent catalyst is dumped from an acetylene conversion kettle it is settled in conical wooden vats, after which the supernatant liquid is siphoned off and passed through a series of settling tanks to catch all the mercury possible. The sediment remaining in the conical vats, consisting of metallic mercury, mercury compounds, etc., is then neutralized with soda ash and charged into covered, steam-jacketed drying pans fitted with stirrers and operated under a full vacuum. When the contents of these pans have been dried, metallic mercury is run off and the remaining material then charged with reducing agents into retorts for distillation. These retorts are oil-fired and the pots were at first made of cast iron, but this material had a very short life and the expense of renewal was excessively high, but later nichrome alloy pots were tried out and gave more efficient service in spite of the greater initial cost.

The extensive handling of mercury in the various steps of the process was the cause of much sickness until proper precautions had been studied and enforced.

A Notable Achievement

This undertaking of the Shawinigan Water & Power Co. was a notable achievement, both from the point of view of the success attained and the remarkably short transitional period from the laboratory research stage to one of large-scale production. It is also a striking example of the major rôle played by chemistry in modern warfare and a proof that Canada did her "bit" in the laboratory as well as on the battlefield. The frequent necessity for use of the regulation army gas mask for protection against lachrimatory gases such as croton-aldehyde, etc., contact with the poisonous mercury catalyst and the ever-existent danger of explosion or fire presented a parallel for life in the trenches and a casualty list equally as deserving of an enduring place on the roll of honor.

When the United States Government entered the war and planned a huge aërial program, great quantities of acetic acid were required for manufacture of cellulose acetate varnish, and it was found expedient, by

CONVERSION TUBES AND EVAPORATION POTS

arrangement with the Shawinigan Water & Power Co., to duplicate, on the spot, the plant at Shawinigan Falls.

This new plant, called the American Electro-Products Co., was about completed and ready for operation when the armistice was signed. So well had the development of the process been carried out in the beginning that, even with the experience gained by a year's operation, only minor variations from the original design were found necessary in building the second plant. The combined plants have a capacity of more than fifty tons of glacial acetic acid per day.

Conclusion

The products of the various steps of the process form possible bases for the manufacture of an unlimited variety of valuable organic chemicals, and the apparatus, in excess of that required to supply a normal acetic acid demand, might readily be adapted to the manufacture of countless new products.

In cost of production, the synthetic process, when associated with the carbide industry, can at present about hold its own with the wood-distillation process and should ultimately entirely displace the latter.

Extensive research by a large staff is now being carried on in the well-equipped laboratories and experimental plant of the Canadian Electro-Products Co. and the company looks with every confidence to the future.

Canada's Foreign Trade for 1919

THE value of Canada's foreign trade in the year ended Dec. 31, 1919, exceeded that of the previous twelvemonth by $82,049,160. Imports in 1919 aggregated $941,007,700, or $30,858,560 more than in the preceding year; exports, $1,241,085,606, or $41,449,143 more; and re-exports, $53,834,766, or $9,741,457 more. With the exception of the record year of 1917, the values for 1919 exceeded those of any other year of the last decade, as Table I shows.

The balance of trade in favor of the Dominion in 1919 was $353,912,672. In trade with the United States, however, Canada had an adverse balance of $285,893,931. That adverse balance has been a potent factor in determining the rate of exchange between the two countries.

The extent to which the various countries of the world participated in Canada's foreign trade during the past three years can be seen from the totals presented in Table II.

Canada during the past year extended credits of $25,000,000 each to Belgium, Rumania, Greece, and France. Orders were placed under these credits as follows: Belgium, $1,734,295; Rumania, $22,373,467; Greece, $8,118,940; France, $5,519,047.

The development of the market for Canadian goods in the United States is emphasized by the figures for the year just closed. The returns show total exports from Canada to the United States for twelve months ended Dec. 31 last amounting to $454,686,294, compared with $433,182,140 in 1918, an increase of $21,504,154, and with $401,479,287 in 1917, an increase of $53,207,007. Imports from the United States for the year at $740,582,225 show an appreciable decline as compared with 1917, when they were $829,847,747, a decrease of $89,265,522, but, compared with 1918, there was only the small decline of $756,079.

This situation is in marked contrast to the trade done with the United Kingdom. For the year the exports to Great Britain and Ireland amounted to $528,035,514, compared with $568,820,873 in 1918, a decrease of $40,785,359, and, compared with $873,706,892 in 1917, a decrease of $345,671,378. Imports from the United Kingdom for the past year at $87,516,819 were higher than in 1918 by $14,637,710, but were lower than in 1917 by $3,619,909.

The large decline in exports to Great Britain is explained by the elimination of huge shipments on war account in both 1917 and 1918, though it is encouraging to note that the shipments of peace-time goods are now showing a substantial, if gradual, gain.

TABLE I. CANADA'S IMPORTS AND EXPORTS, 1910-1919

Calendar Years	Merchandise Imports			Merchandise Exports		
	Dutiable	Free	Total	Canadian Produce	Foreign Produce	Total
1910	$269,759,731	$165,441,076	$435,200,807	$279,859,593	$15,554,838	$295,414,431
1911	320,452,211	183,036,549	503,488,760	279,446,816	17,121,211	296,568,027
1912	418,021,349	218,668,576	636,689,925	341,980,882	20,984,698	362,965,580
1913	438,539,132	221,364,984	659,904,116	436,218,067	24,301,179	460,519,246
1914	302,516,964	179,431,624	481,948,588	379,295,854	49,019,658	428,315,512
1915	261,842,173	189,042,855	450,885,028	614,129,845	39,358,567	653,488,412
1916	422,173,311	345,203,358	767,376,669	1,091,706,463	20,738,599	1,112,445,002
1917	557,636,509	448,394,360	1,006,030,869	1,547,340,855	46,155,194	1,593,496,049
1918	511,105,417	399,043,723	910,149,140	1,199,636,463	44,093,309	1,243,729,772
1919	607,452,288	333,555,412	941,007,700	1,241,085,606	53,834,766	1,294,920,372

TABLE II. ANALYSIS OF CANADA'S FOREIGN TRADE

Countries	Imported from			Exported to		
	1917	1918	1919	1917	1918	1919
United Kingdom	$91,136,728	$72,879,109	$87,516,819	$873,706,892	$568,820,873	$528,035,514
Australia	979,018	6,084,963	1,523,106	8,145,426	11,169,474	13,501,923
British East Indies	13,311,740	17,027,295	13,411,326	4,131,651	2,814,378	6,508,195
British Guiana	8,120,098	5,088,972	8,065,019	2,070,809	2,216,001	2,925,728
British South Africa	510,765	1,331,842	668,723	4,881,526	9,704,215	10,504,740
British West Indies	11,117,883	8,928,909	10,544,539	6,319,644	8,353,709	11,321,072
Hongkong	1,712,920	2,343,958	1,779,067	1,000,475	968,766	437,458
Newfoundland	2,743,597	3,287,340	2,056,900	8,723,489	10,876,310	16,464,383
New Zealand	3,351,394	7,014,313	2,838,863	4,181,290	4,605,116	7,362,218
Other British Empire	1,591,579	1,371,069	1,152,732	1,519,281	2,505,588	7,401,925
Argentina	1,761,799	1,726,489	1,746,044	1,516,914	2,683,179	6,887,395
Brazil	1,036,788	1,128,616	1,607,970	1,088,269	3,825,859	2,141,232
China	1,268,662	1,867,405	1,245,740	1,471,803	2,934,663	4,819,534
Cuba	1,047,062	2,034,654	12,565,712	3,640,784	4,879,779	5,642,675
France	5,715,770	3,754,761	6,784,860	200,289,282	97,378,476	65,114,419
Italy	855,900	642,071	706,358	2,318,838	9,426,652	16,755,931
Japan	11,100,455	13,184,893	12,697,203	3,760,267	10,624,274	7,569,410
Netherlands	1,130,855	582,507	1,504,390	2,102,428	597,008	3,983,389
United States	829,845,747	741,336,304	740,580,225	401,479,287	433,182,140	454,686,294
Other foreign countries	17,692,109	18,533,670	32,012,104	14,992,500	12,070,003	69,022,171
Total	$1,006,030,869	$910,149,140	$941,007,700	$1,547,340,855	$1,199,636,463	$1,241,085,606

The Commercial Synthesis of Sillimanite*

A Description of a Cupola Process for Fusing Alumina and Silica to Form Sillimanite Crystals — Reactions Consist of Forming Carbides Under Reducing, and Combusting Them Under Oxidizing Conditions

By ANDREW MALINOVSZKY

VERY little work has been done on the conversion of the double oxides of alumina and silica or alumina and magnesia into stable crystal phases such as sillimanite and spinel. Many ceramists have tried to mix, without actually fusing, alumina and silica, molecule for molecule, to obtain sillimanite, or alumina with magnesia, to form spinel. Stoichiometrically these mixtures may be made to represent the analytical composition of sillimanite and spinel crystals perfectly, but physically such mixtures are far from having the stable properties of either. The products obtained in such a manner exhibit no more stability than their individual components.

No advantage whatsoever can be claimed for mere physical mixtures of alumina with silica, or alumina with magnesia. The real value of such a combination is obtained only if the components are interdissolved by fusion. Solidifying from solution, the molecules arrange themselves into their stable crystalline phases.

It should be clearly understood that when alumina and silica, or alumina or magnesia, are mixed and exposed, after they have been shaped into brick, to any temperatures lower than fusing, neither new molecular combinations nor crystalline compounds will be made. When such a heterogeneous mixture is made into refractories and placed in service in a furnace, where it is exposed to sudden thermal changes, to slag, to alkaline vapors, or to any other destructive agents existing in a commercial furnace, it will be quickly acted upon and soon destroyed.

Fluxed Sillimanite Not Desirable

The suggestion has been made by a few ceramists that old glass pots be used, pots in which the free silica has been dissolved by the alkalis of the glass, leaving behind a magmatic solution from which sillimanite crystals have formed after the pots were cooled. The addition of such sillimanite is of no more value to the newly built pots than that of common grog. It stands to reason that sillimanite crystals produced from such a magmatic solution in the intimate presence of fluxing solvents are not stable, and their presence can then be of no value. Sillimanite crystals formed under such conditions will be dissolved well below their fusion temperature of 215 deg. C. by the fluxing action of the intimately associated low melting point substances, if heated to a temperature where the adjacent material from which the sillimanite crystals separated out is in the liquid state. In other words, the sillimanite crystals formed as stated above will be attacked by the surrounding material whenever the temperature at which it becomes liquid is reached. It will then act as a solvent for the sillimanite crystals, and the whole mass will fuse at a temperature far below the fusing temperature of sillimanite.

Stable sillimanite or spinel crystals are obtained only when their components are liquefied at the fusing temperature of alumina and silica, or alumina and magnesia. The fusion should not be produced by any fluxing agent, but only under the action of heat at the required temperature of approximately 1,815 deg. C. or above. For illustration, take porcelain bodies containing sillimanite crystals, concerning which many theories have been advanced. Those investigators who came to the conclusion that sillimanite crystals are formed only from an acid solution of silica and alumina, and not from a viscous slag, have demonstrated the actual facts. Adding lime or magnesia does not develop the crystals; it only promotes the liquefaction of the magma. If the body or mix should be brought into a liquid state without the addition of these bases the crystals would have been better developed.

Factors Influencing the Development of Sillimanite Crystals

Many experiments along this line have demonstrated that the presence of a high percentage of lime actually retards the development of the sillimanite crystals. Most authors and investigators have laid great emphasis on the importance of feldspar as favoring the development of sillimanite crystals, for without feldspar no sillimanite crystals seem to be formed in a porcelain body. This statement holds good for porcelain bodies, glass pots and firebricks, as the feldspar dissolves the kaolin and also the flint. At the same time, with porcelain it is demonstrated that lime acts as a retarder in the formation of sillimanite crystals. For in the glass covering the porcelain bodies, sillimanite crystals are never found, but close under the glass more sillimanite than anywhere else in the same body is found to occur.

Sillimanite crystals much larger in size (length and diameter) can be produced without the presence of feldspar, mica, lime or any other fluxing material than when these materials are present. It should be borne in mind that if the components of sillimanite are heated up to their boiling temperature, as is the case in the process about to be described, it is evident that considerable molecular activity must be produced. In building up the sillimanite crystals, the molecules of alumina and silica must follow their turn in the force of the molecular attraction. Thus they become regularly arranged groups of molecules in harmonious vibrating or oscillating relation with one another, and so one molecule after the other comes into equilibrium with one another until the whole magma has been formed into a solid form of a crystalline structure.

The method by which artificial sillimanite crystals are produced consists of crushing aluminous minerals from

*An excerpt from the paper read by the author, entitled "Fused Artificial Sillimanite," before the American Ceramic Society, Philadelphia, Feb. 23, 1920.

1 in. in diameter down, and smelting in a cupola furnace together with a suitable reducing agent in a required amount. It is possible to regulate the volatilization of the silica by proportioning the amount of reducing agent, so that it shall be sufficient to reduce all or a fraction of the silica, leaving only a part of the silica unreduced, so to convert all the charge into sillimanite upon oxidation and fusion.

For instance, the crushed raw material is mixed with coke, the carbon being approximately in molecular proportion to the oxygen contents in the rock or minerals, as indicated in the following equations:

$$2Al_2O_3 + 4SiO_2 + 14C = Al_4C_3 + 4SiC + 7CO_2$$

which upon combustion will give the following with a heat of reaction that will fuse the products:

$$Al_4C_3 + 4SiC + 14O_2 = 2Al_2SiO_5 + 2SiO_2 + 7CO_2$$

The proportion of the mixture is varied, as an excess of carbon over the calculated amount of silica is necessary in order to complete the reductions, as the raw material may contain some iron, lime, etc. On the assumption that the above reactions take place, it is evident that everything present is reduced to carbide. After the carbides are formed, they dissociate, though less rapidly than in the pure state. It depends on the ratio of the combined carbon and the effect of silicon and aluminum upon the quantity and condition of carbon. When SiC gives up its Si, leaving behind C, the silicon ignites spontaneously on coming in contact with the air blast, forming first SiO then SiO_2.

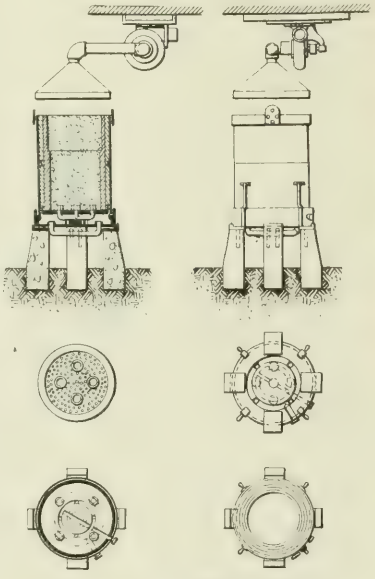


FIG. 1. FURNACE SECTIONS

The reactions between silicon and oxygen are very violent and much heat is produced by the combustion. If iron is present, it usually alloys with silicon and it is either volatilized or sinks to the bottom of the furnace.

Furnace Used for Fusion

Sections of the furnace are shown in Fig. 1. The outside of the furnace is of common iron such as an old boiler shell, or an old smokestack can be used. This is lined with good firebrick. The bricks are then protected with a layer of about 4 in. of the pulverized material to be fused. A tapering mold is placed inside the furnace and the raw material is rammed all around between the furnace and the mold to about 1 in. thick on the top. This will protect the firebrick and at the same time prevent the fused mass from adhering to the firebrick, so it can be discharged freely in a very short time. When the ramming is finished the mold is removed. The gratebars are covered with a layer 1 ft. deep of large lumps of coke. These lumps of coke are placed on the grate bars to protect them from the heat of the fusion zone. Coke is the best fuel for the process, as it does not crush or disintegrate and carries the weight of the charge better than coal. The coke, which has about 44 per cent of voids, proves advantageous in preheating the air.

A 3-ft. layer of fine coke is placed over the coarse layer, then a little kindling wood, on top of which about 16 in. of fines are spread and the fire lighted. The blower is started very slowly at first. After the coke is ignited, the crushed raw material mixed with the crushed coke is fed into the furnace and the speed of the blower is gradually increased to furnish about 18,000 to 28,000 cu.ft. of compressed air per hr. under from 3 to 6 lb. per sq.in. of pressure. In about 2 hr. the charge sinks down and the gases burn in flames above the surface. The blast of the compressed air is forced through the 64-in. fuel bed of coke, being

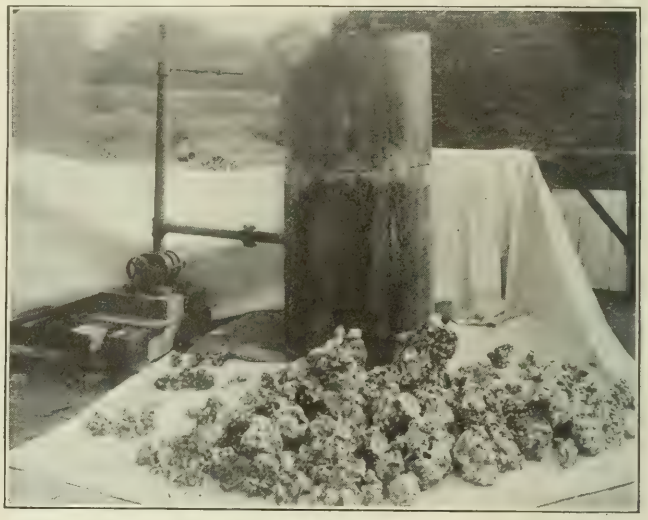


FIG. 2. CUPOLA AND BLOWER, REMOVED SILLIMANITE CHARGE

very well preheated, and so forced through the hot reacting zone under favorable conditions.

The silica is observed condensing on the furnace wall. This period is characterized by the yellow flame coming from the furnace, which later changes to violet and then white. It is very important in this process to have the heat come from the bottom of the furnace. Enough fuel should be bedded at the start to supply the whole process. The furnace must be maintained under such reducing conditions in the beginning as to gradually convert all the elements present to carbide. It should be understood that reduction takes place only at temperatures where solid carbon takes up oxygen from the material. After 3 or 4 hr. the whole charge is brought to a dazzling glowing white heat, the yellow and violet flames indicating the combustion of the Si to SiO and then to SiO_2.

The contents of alumina and silica boils violently, which is made evident by the roaring noise inside the furnace. The silica is volatilized in dense bluish white and later brownish fumes for about 2 hr. After 5 or 6 hr. the reactions are completed and the air is blown into the cupola through the cooling fused mass in order to produce cells resembling diatomaceous earth. The specific gravity of this fused mass varies from 2.62 to 2.86.

The furnace is provided with an exit pipe through which the fumes of silica, potash, sodium, etc., if present, together with the other gases, are withdrawn to a settling system, where they are separated.

From this process it is possible to effect a complete separation between the fused mass, alkalis and silica, if desired, which is a more economical process than the electric furnace. The hood of the furnace can be removed freely to both sides and also lowered or raised. The hood is suspended above the furnace, and suction is applied so as to collect all the fumes. By this means the cupola is aided by a blast at the bottom and suction at the top.

The fused mass can be removed in different ways, as the cupola is so designed as to accomodate varying conditions. The mass can be removed at the bottom with the cupola in place, or the cupola can be removed and leave the chilled fused mass standing in place on the grate bars, or the mass and cupola can be removed, and another cupola, all ready charged, set up on the place, and another operation can be started. With this system a continuous process is established.

Fused Sillimanite

After the fused sillimanite is removed from the furnace it is broken up in a jaw crusher and then reduced to the required fineness. Any metallic iron present is separated out by a specially designed magnetic device.

FIG. 3. SILLIMANITE PRODUCED FROM ST. LOUIS FIRE-CLAY. × 114.

The fused sillimanite obtained by this process is a very stable compound and highly refractory, free from uneven expansion and contraction strains at any temperature.

This process of making artificial sillimanite crystals has also developed some doubts as to whether the crystal development is due only to the influence of slow cooling, as has always been hitherto believed. In the science of petrology it is taught that the volcanic rocks which were cooled on or near the surface of the earth solidified so quickly that the rocks show very small crystals or none at all, often with open texture. Obsidian, which is a glassy lava sometimes called volcanic glass, resembling bottle glass, showing no crystal development, is a typically extreme case. It is composed of from 65 to 78 per cent of SiO_2, from 12 to 17 per cent of Al_2O_3, the remainder being different oxides of iron, calcium and others. The plutonic rocks, on the other hand, solidified deep below the surface, had time to cool slowly and develop a coarse crystalline structure with a very close texture.

The cooling rate theory is not checked with this process, where the mass is brought to the boiling point in from 5 to 6 hr. and cooled down in 1 hr. by a cold blast with 5-lb. pressure to a porous mass resembling pumice in its appearance, having a coarse crystalline structure with the largest sillimanite crystals ever produced. The accompanying illustration, Fig. 3, demonstrates the development of sillimanite crystals from fire clay. The square needle-like formation is very distinctly shown.

Production of Turpentine From Douglas Fir Pitch

Old growth yellow fir stands in certain timber districts of the Northwest contain a large number of what are known as "pitch trees." These trees are usually alive and free from noticeable decay, but frequently rough, burly and quite often twisted or bent well up the trunk, and contain, within a distance of several inches from the surface, pockets or seams filled with pitch. The pitch can be drained from the trees by boring into the seams with an auger, and the pitch collected in receptacle provided for this purpose.

The Northwestern Turpentine Co. has begun operations in a small way in collecting pitch from fir stands and in the production of turpentine and rosin. The pitch is collected from timber under lease, providing that all holes bored in trees shall be plugged after the pitch is removed and that all possible efforts be made to prevent fire hazard. The pitch is transported to Portland in barrels for treatment. The turpentine is recovered from the pitch by distilling with live steam. After the turpentine is removed a commercial grade of rosin is obtained from the residue. The pitch will contain about 25 per cent by volume of turpentine, and about 70 per cent by weight of rosin. In addition it is possible to obtain a small amount of "balsam."

Artificial-Silk Manufacture in Great Britain

The manufacture of artificial silk is being undertaken by the British Cellulose & Chemical Manufacturing Co. at its factory at Spondon, near Derby. Samples of silk thread produced at Spondon have been submitted to weavers, who state that it is of such texture and quality that when converted into articles of clothing they will have the appearance and finish of natural silk. When fully developed the factory at Spondon will employ a large number of workers and produce nine tons of artificial silk a day. Other products which the company is manufacturing, or intends to manufacture. according to the London press, include non-inflammable films, synthetic perfumes, and aspirin; of the last named, six tons per week is being turned out from the company's works.

Mexican Commercial and Industrial Exposition in 1921

The Ministry of Industry, Commerce and Labor has begun preparations for a commercial and industrial exposition to be held in Mexico City in September, 1921, in commemoration of the first centennary of Mexican independence. According to the data given to the press, the exposition will be entirely national in character, and will be confined to exhibits of Mexican raw materials and manufactured products. Invitations are to be extended to all foregin Governments and to chambers of commerce of the principal cities to send representatives to attend the exposition.

Legal Notes

By Wellington Gustin

A Lesson on Filling Orders

In an action by the Burley-Winter Pottery Co. against the Onken Bros. & West Co., the Supreme Court of Wyoming has affirmed the judgment against the pottery company. (183 Pac., 747.)

The pottery company manufactures pottery, crockery, glassware and similar products at Crooksville, Ohio. It charged that it sold and shipped the wholesale house in Wyoming a car of stoneware on a written order.

On the trial the defendant objected to the introduction of the order as evidence on the following grounds:

1. That it is not shown that the person signing the same had any authority to give the order.
2. That the alleged order is void for uncertainty.
3. That it fails to disclose the price of the goods.
4. That there is no sufficient description of the goods.
5. That the order, being for more than $50 is void under the statute of frauds.

Since this contract was one coming under the statute of frauds the order was not admitted and plaintiff was unable to prove its case.

The provisions of this statute of frauds, which should be known and committed by every business man, are:

Provisions of Statute of Frauds

"Any contract for the sale of goods, chattels or things in action for the price of $50 or more, shall be void, unless:

"First. A note or memorandum of such contract be made in writing and be subscribed by the party to be charged thereby; or

"Second. Unless the buyer shall accept and receive part of such goods, or the evidences, or some of them, of such things in action; or

"Third. Unless the buyer shall at the time pay some part of the purchase money."

A Sales Contract Must Be a Signed Memorandum of Sales

The order offered in evidence called for "One car stoneware as per orders shown for same at ¼c. per gal. less than prices sold at" and was signed "Onken Bros. & West Co., Successors to J. E. West Co., Inc., per E. W. Elder."

Plaintiff charged that the goods were sold by its salesman at an agreed price. But the Supreme Court said that in the order, as offered in evidence, the description of the subject-matter of the contract is too indefinite to fulfill the requirements of the statute. "One car stoneware may mean any kind or several kinds of stoneware, and the property could not be identified without other evidence. Nor does the additional statement, 'as per orders shown for same,' render the description of the property any more definite. The names of the parties giving the orders are not stated; but, if that had been done, the orders referred to were not offered in evidence. The order offered in evidence not being such a memorandum as is required by the statute, it was properly excluded. In addition to the insufficiency of the memorandum, there was no competent evidence of a delivery. The only evidence of a delivery was the testimony of the salesman who took the order that to the best of his knowledge the goods, the carload, was shipped according to the orders he had taken. But he admitted he had no personal knowledge of the shipment, was not present, and in fact knew nothing about the shipment."

Rickey vs. Moon Clay & Kaolin Co.

The Court of Errors and Appeals of New Jersey has affirmed the decree of the Court of Chancery in favor of Walter H. Rickey against the Moon Clay & Kaolin Co. and others. It appears that Rickey obtained an option agreement from defendant Moon in 1913 whereby Moon agreed to sell his clay lands in Hamilton township at any time within two years for $6,000 per acre for the best clay lands and $1,000 per acre for the balance. This option was extended and Rickey interested defendant Muschert and persuaded him to secure a loan of $3,000 upon promise to pay Muschert one-tenth part of the profits on the option agreement. Then Rickey got a commission agreement from Moon wherein the latter agreed to pay 10 per cent commission upon all sales of his land. Thereafter the complainant Rickey and Muschert and J. L. Conard entered into what was called the three-party agreement wherein it was stipulated that Muschert was to hold the Moon-Rickey agreements for the benefit of the three, subject to the lien of the loan mentioned. Rickey and Conard were to give their attention and efforts, Conard his professional skill as a lawyer, in advancing the enterprise, which was understood to be defending condemnation proceedings of the Pennsylvania Railroad. Out of the profits Muschert was first to retain $10,000, made up of the $3,000 advanced as a loan, $5,000 advanced to Conard and $2,000 to be later advanced. The agreement then provided that all of the profits should be divided among the three, share and share alike, after the deduction of the $10,000 above mentioned.

The condemnation proceedings failed of realization, and then Muschert, Conard and Moon formed the Moon Clay & Kaolin Co. and took over the clay lands for $206,000 of the capital stock of the company, under arrangement with Moon that he was to sell his holdings to Muschert and Conard for about $50,000. The clay company is now owned by Muschert and Conard, and is operating the clay pits. The complainant Rickey was not permitted to participate. He was practically frozen out, said the court. He then filed his bill to impress the trust of the three-party agreement and for an accounting.

Agreement Involved

The defendants Muschert and Conard answered setting up Rickey's 10 per cent commission agreement, and claimed that they were operating under it in connection with the three-party agreement. They said they were willing to assume Moon's obligation to pay the commission on a sales price of $206,000 to be divided equally between the complainant Rickey and Conard and Muschert, after deducting the $8,000 advances of Muschert. The agreement called for $10,000 to be deducted in favor of Muschert, but this included $2,000 which he was later to advance but did not. The three-party agreement shows clearly the final arrangement of the parties, said the court, and this was that all over the $8,000 was to be divided share and share alike. One-third was, therefore, adjudged to Rickey.

Synopsis of Recent Chemical & Metallurgical Literature

Large Mixer in New French Steel Plant.—*Engineering* (London) has presented considerable information regarding the new modern steel plant of the Société Normande de Métallurgie, Caen, France, in its issues, vol. 107, p. 136, vol. 109, pp. 180 and 292. The accompanying figure is an interior view of the craneway covering the casting pits for open-hearth furnaces, arranged in the left background. Nearer is the pouring side of a 700-ton mixer, for use as a reservoir for the bessemer converters. The mixer itself is 4.83 m. diameter, 8.23 m. long inside brick lining (15 ft. 10 in. x 27 ft.), fired by blast-furnace gas and hot blast from a regenerative checkerwork. Besides main pouring spout there

MIXER IN A MODERN STEEL PLANT

is an auxiliary charging mouth on the same side, while opposite is the main charging mouth and a slag spout. all of which are closely fitted with covers. The block containing gas and air ports is on wheels so it can be moved away from the opening into the mixer, but sufficient clearance at the flue connection is left so that this device is not necessary. The view also shows the traveling mast cranes used almost exclusively about the plant for such purposes as stripping, soaking pit service, billet and charge box handling. The extensive use of reinforced concrete in the building construction may also be clearly seen.

Smelting and Refining of Cobalt Silver Ore.—At the Deloro Reduction Co.'s smelter, silver cobalt ore is smelted in a blast furnace (run with 6-8 oz. blast pressure on account of the large proportion of fines), the charge being calculated to furnish speiss and a neutral slag. The speiss contains Co, 22-25; Ni, 16-18; As, 25; Fe, 18; S, 7; Cu, 1 per cent, and 1,000-2,000 oz. Ag per ton; it is first liquated to recover part of the silver, then ground, roasted, chloridized, washed with water, and treated with cyanide. The silver is precipitated from the solution with aluminum dust, the cyanide being almost quantitatively regenerated. The liquated and the precipitated metal are melted in an oil-fired furnace which is tilted backward into blowing position; the metal after 3 hr. blowing is 992-995 fine, and is refined by another melting. The desilverized speiss is sulphatized and leached; the liquor is first freed from copper and iron, cobalt precipitated with hypochlorite solution, and nickel, after removal of the cobalt, with milk of lime. The hydroxides are filter-pressed, washed, and dried ready for sale, or mixed with charcoal and reduced; the crude metals are separated magnetically from excess of carbon, re-melted in electric furnaces, and granulated by pouring into water. The dust and fume from the various furnaces, collected in a baghouse, are heated in a coke-fired reverberatory, and the pure arsenic trioxide condensed in chambers. The clinker from this operation goes back to the blast furnace for the recovery of silver.—S. B. WRIGHT, *J. Soc. Chem. Ind.*, vol. 38, p. 77A.

Canadian Mineral Production for 1919.—A digest of the 1919 statistics of the Canadian Department of Mines is given in the *Canadian Mining Journal.* The year has been one of transition from a war to a peace basis and the difficulties of making the necessary adjustments have been aggravated by social unrest and by strikes, these resulting in a decrease in the production of metals, coal and minerals during the year. On the other hand, structural materials, asbestos, gypsum and salt showed increases.

The value of products classified as structural materials and clay products was $25,755,000; as non-metallics, $74,919,000; as metallics, $72,402,000 — a total of $173,076,000, a decrease of $38,226,000, or 18 per cent, from that of 1918. The greatest decrease was in the production of nickel and copper; the decrease in value of the products classified as metallics amounted to 37 per cent.

In the amount of the individual metals produced, copper showed a decrease of 37 per cent; gold, with a total production of 767,167 oz., an increase of 10 per cent; lead, with a total production of 43,895,888 lb., a decrease of 15 per cent.

The production of nickel for 1919 was 44,452,953 lb., compared with over 92,000,000 lb. in 1918; of this, 5,063 tons was refined in Canada, compared with 1,204 tons in 1918. The new refinery of the British-American Nickel Co. at Deschenes, Que., which will soon be in full operation, will have a capacity of 7,000 tons of nickel and 3,500 tons of copper per year. There will also be a precious metal refinery, and platinum, palladium, iridium, gold and silver will be produced.

About 25 oz. of platinum and 62 oz. of palladium were produced during the year. Silver production was 15,675,134 oz., compared with 21,383,979 in 1918. The Ontario production was 76.1 per cent of the total. The zinc produced was 15,869 tons, a slight decrease.

The output of iron ore was, from the Canadian point of view, most disappointing, being the lowest recorded for nineteen years and amounting to but 195,970 tons. Of the iron ore charged to blast furnaces but 4.4 per cent, or 78,000 tons, was of domestic origin. Of the imported ore, 519,722 tons came from Wabana, N. F., and 1,154,473 from the United States.

Of asbestos, 153,069 tons of crude and milled fiber was produced, valued at $10,723,032, compared with 143,456 tons in 1918, valued at $8,870,707.

Canada produces less than half its total coal consumption. For 1919 the total used was 28,768,099 tons; of this, 13,586,300 tons was produced locally. The production of byproduct coke shows an increase during the year; sixty Koppers ovens were completed

at Sydney, twenty-five Willputte ovens at Sault Ste. Marie, and thirty Lomax ovens at Anyox, B. C. Imports of coke decreased from 1,165,590 tons in 1918 to 383,374 tons in 1919.

During the year there was a decided increase in production of all structural materials such as cement, clay products, lime, sand-lime brick and building stones.

Of salt, 148,302 tons was produced, which is an increase of about 10 per cent over 1918. The discovery of potash mineral associated with the salt deposit at Malagash is attracting considerable interest. The Brunner-Mond (Canada) Co. completed and placed in operation a plant at Amherstburg, Ont., for the manufacture of soda ash from brine.

The crude oil production was 240,970 bbl. (35 Imp. gal.—42 U. S. gal.), of which 90 per cent came from the oil fields of southern Ontario. Canada imported about 13,000,000 bbl. of petroleum oils, crude and refined, during 1919, an increase of 857,000 bbl. over the previous year.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

Reserve Dry Cell.—The cell consists of two parts—a zinc container which serves as the negative electrode when the cell is in use, and a bobbin or cartridge containing the positive carbon electrode and the usual mixture of carbon, electrolyte and manganese dioxide. This bobbin is provided with a thin paper wrapper and is dipped in a celluloid solution so that a waterproof coating is formed which prevents evaporation of the electrolyte. The upper part of the cartridge is sealed with pitch held in place by a band of zinc having a projecting peripheral bead which is designed to engage with a similar bead on the zinc container and thus lock the parts. The interior of the zinc container is coated thinly with flour paste. When it is desired to use the cell, the bobbin is taken out, the celluloid coating and paper wrapper removed and the bobbin replaced after having added sufficient water to the zinc container to thoroughly moisten the coating of flour, which now serves as a filler between the zinc and the mix. (1,329,946; HARRY D. BATCHELOR of Lakewood, Ohio, assignor to National Carbon Co.; Feb. 3, 1920.)

Stabilizing Lead Azide Detonators.—When mixed with blasting gelatine, lead azide may be handled safely and yet it retains its powerful detonating properties. From 1 to 20 per cent of blasting gelatine may be used, according to consistency desired. (1,329,525; WALTER G. HUDSON of Wilmington, Del., assignor to E. I. du Pont de Nemours & Co.; Feb. 3, 1920.)

Sodium Compound of Salvarsan.—The use of salvarsan is attended with certain disadvantages. The compound is sold as the dihydrochloride, and this acid must be exactly neutralized just prior to injection. The neutral solution cannot be kept, since oxidation proceeds rapidly, with the formation of a violent poison. Neo-salvarsan may be used directly, but is less effective. UMETARO SUZUKI of Tokio, Japan, prepares the sodium compound of salvarsan in the following manner: 5 g. of diamino-dihydroxy-arsenobenzene-dihydrochloride, $(C_6H_3NH_2OHAs)_2.2HCl$, is dissolved in alcohol and treated with sodium ethylate or methylate until a few drops give a clear solution in water. The whole liquid is poured into ether and 5 to 6 g. of yellow-brown precipitate is obtained. The operations should be carried out in a non-oxidizing atmosphere. The compound is soluble in water and physiological salt solution and contains from 22 to 23 per cent arsenic. It does not require neutralization and there is no tendency toward the formation of poisonous compounds through oxidation. (1,330,288; Feb. 10, 1920.)

Production of Cyanides.—Of the many compounds present in the reaction product of the Bucher process, only sodium cyanide is soluble in liquid ammonia. The extracted residue may be returned to the process. Indeed, the catalyst seems to improve. Prior to and during the leaching process, air must be excluded, as cyanate will be formed. This is also soluble in liquid ammonia. (1,329,652; JOHN C. CLANCY of Freeport, N. Y., assignor to the Nitrogen Corporation; Feb. 3, 1920.)

Rust-Preventing Solution.—Oxidation of iron and steel structures such as bridges and freight cars can be arrested by spraying with a solution composed of 70 parts of 50 per cent phosphoric acid, 20 parts of glucose or glycerine with sufficient water to make 100 parts, all by weight. After 24 hr. the surface is washed with strong soapy water, dried and oiled or painted. (1,329,573; WILLIAM H. ALLEN of Detroit, Mich.; Feb. 3, 1920.)

Stable Nitrostarch.—The carbohydrate material is subjected to a preliminary treatment whereby it is swelled or puffed in a manner resembling the puffed cereals now on the market. The porous condition permits nitration to proceed quickly and uniformly. Mixed acid containing 30 per cent HNO_3, 64 per cent H_2SO_4 and 6 per cent H_2O is used at a temperature of 40 deg. F. The carbohydrate material is kept beneath the surface of the acid by means of a perforated plate. The nitrated product is separated by removing the perforated plate and pouring water gently on the surface of the acid. The product floats on the water and is removed, washed and boiled in two successive baths of very weak acid. The product is now stabilized by boiling in a solution of a sodium soap. Further washing is followed by centrifuging and drying at 100 deg. F. (1,329,353; GEORGE R. ANCHORS of Landing, N. J.; Feb. 3, 1920.)

Manganese Dioxide Depolarizer.—Under certain conditions, the reaction between a manganous salt and sodium hypochlorite may be made to yield a deep black dioxide having good conducting properties. The hypochlorite solution is preferably added to a boiling slightly acid solution of $MnSO_4.4H_2O$ of such a concentration that the boiling point is about 103 deg. C. (1,330,738; CARLETON ELLIS and ALFRED A. WELLS of Montclair, N. J., assignors by mesne assignments to National Carbon Co.; Feb. 10, 1920.)

Recovering Sulphonic Acids From Mineral Oil Sludge.—Sludge produced in sulphonating mineral oil is dissolved in water (100 parts sludge to 150-200 parts H_2O) and allowed to stand for 8 to 12 hr. Heat is generated, SO_2 is evolved and the free oil rises to

the surface and is decanted. The solution is neutralized with lime and the precipitated calcium sulphate filtered off. The clear wine-colored solution contains the calcium sulphonate, which may be salted out by adding sufficient calcium chloride. The product is water-soluble and may be used for saponifying purposes or for the production of detergents suited for use in salt water. (1,330,624; ROBERT E. DIVINE of Cincinnati, Ohio, assignor to the Twitchell Process Co.; Feb. 10, 1920.)

Destructive Distillation of Wood.—In order to prevent "cracking" of the oils and gums formed during the destructive distillation of wood, DAVID L. HANSON of Wilmington, N. C., introduces a current of superheated steam and air into the retort and hastens the removal of the vapors by the use of a suction fan. (1,330,632; assigned to the Pine Nene Products Co.; Feb. 10, 1920.)

Plates for Electrolytic Lightning Arresters.—This invention relates to a method for the preliminary treatment of plates which are to be used in electrolytic lightning arresters, with a view to increasing the breakdown voltage. The process, as described by JOHN COULSON of Wilkinsburg, Pa., may be applied to aluminum, tantalum, platinum or magnesium, but is ordinarily used with the first of these. Aluminum plates are dipped in 1 per cent HF, then in 5 to 10 per cent HCl, and finally in 5 to 10 per cent HNO_3. The acid treatment accomplishes much more than a mere surface cleansing or etching, and appears to penetrate to a considerable distance beneath the surface of the plates. In fact, in the case of thin plates, the acid appears to entirely permeate them, and to completely remove the traces of impurities which are present. This is evident since the acid treatment entirely prevents the formation of blisters which appear when untreated plates are subjected to heat, and which result from the presence of impurities in the interior of the plates. The electrical characteristics of plates pickled in the foregoing manner are found to be materially altered, their admittance being greatly increased as well as their ability to resist high voltages. After the formation of the asymmetric conducting film the plates are preferably heat-treated at 500 to 600 deg. C. for 2 to 3 hr. This increases the breakdown voltage about 25 per cent. (1,330,581; assigned to Westinghouse Electric & Manufacturing Co.; Feb. 10, 1920.)

Manufacture of Bleaching Powder.—Chlorine and lime are passed counter-currently through a rotating horizontal cylinder provided with lugs on the interior so that the mass is mixed and prevented from sticking to the walls. The exterior of the cylinder is cooled by a stream of water in order to overcome the heat of reaction. (1,330,495; ALFRED RUDGE of Gateshead, England; Feb. 10, 1920.)

Anhydrous Metallic Chlorides.—The anhydrous chlorides of aluminum, magnesium and the cerium groups of rare earth metals may be prepared by passing a mixture of chlorine and producer gas (substantially free from hydrogen) over the heated oxide, hydroxide or oxalate of the metal in question. (1,331,257; WILLIAM HEAP of Stockport and EDGAR NEWBERG of Manchester, England; Feb. 17, 1920.)

Recovering Nitrogen Oxides.—Two methods for the recovery of nitrogen oxides from mixtures with air are described by PHILIPPE A. GUYE of Geneva, Switzerland. The gases may be cooled below —20 deg. C. and absorbed in a solvent such as CCl_4 containing C_2Cl_6 or CBr_4. Or, the oxidation of the nitric oxide may be so regulated that a mixture of N_2O_3 and NO_2 is obtained. Upon cooling the oxides below —80 deg. C., a liquid is obtained which is essentially a solution of nitrogen peroxide in nitrous anhydride. If the oxidation is carried to such an extent that only NO_2 is present, this solidifies upon cooling and tends to clog the condensing coils. (1,331,104 and 1,331,105; Feb. 17, 1920.)

Lead Plating.—With the aid of a certain flux, lead plating of iron or steel sheets or other articles may be accomplished in a manner similar to galvanizing. The flux used by ROBERT J. SHOEMAKER of Milwaukee, Wis., consists of 80 per cent zinc chloride, 15 per cent sodium chloride and 5 per cent tin chloride. By means of a frame, a considerable amount of the flux is maintained on the surface of the molten metal at the point at which the work enters. A thin layer of flux covers the rest of the bath. An alloy of 85 per cent lead, 10 per cent antimony and 5 per cent tin is recommended for the production of an adherent uniform coating, free from pinholes. (1,330,399; Feb. 10, 1920.)

Ammonium Nitrate.—The mixture of nitrogen oxides produced by the catalytic oxidation of ammonia is, as a rule, absorbed in water in the presence of oxygen to form a solution of nitric acid. For the production of ammonium nitrate, this acid solution is neutralized with ammonia, giving a dilute solution of NH_4NO_3 which must be concentrated and crystallized. Losses occur in the absorption tower, during neutralization and during evaporation. JAMES R. PARTINGTON, GEORGE J. JONES and THOMAS K. BROWNSON of London, England, have developed a direct neutralization process yielding dry ammonium nitrate. The nitrous gases are cooled to remove the excess of water formed during the catalytic oxidation:

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

and are then mixed with sufficient air or oxygen to convert the nitric oxide to nitrogen dioxide:

$$2NO + O_2 = 2NO_2$$

This gas is now mixed with ammonia, air and water vapor in the proportions indicated by the equation:

$$4NH_3 + 2H_2O + 4NO_2 + O_2 = 4NH_4NO_3$$

By careful regulation, the ammonium nitrate is obtained as a fine, dry powder which is collected by passing through chambers containing baffle plates. It is evident that nitrous gases from other sources such as the denitration of spent acid may also be used in this process. (1,330,136; Feb. 10, 1920.)

Chromium Sulphate.—The chromium sulphate used in the leather industry is usually prepared from chromate or bichromate by reducing, precipitating the hydroxide, filtering, washing and dissolving the hydroxide in sulphuric acid. FRANK M. MOONEY of Montreal, Que., claims that the following method gives a product which is free from reducing agents which have a harmful effect upon the gelatine in the hide.

$$Na_2Cr_2O_7 + H_2SO_4 = Na_2SO_4 + 2CrO_3 + H_2O \quad (1)$$

$$2CrO_3 + Na_2S_2O_3 = Na_2SO_4 + Cr_2O_3 + SO_2 \quad (2)$$

$$Cr_2O_3 + 3H_2SO_4 = Cr_2(SO_4)_3 + 3H_2O \quad (3)$$

Reaction (2) is not complete unless the solution is boiled to expel the sulphur dioxide. The precipitate of chromic oxide is washed thoroughly and then boiled with sulphuric acid to form the sulphate. (1,330,131; Feb. 10, 1920.)

Industrial Excursions of the A. C. S. St. Louis Meeting

THE entertainment committee of the St. Louis Section of the American Chemical Society more than amply provided an opportunity to get better acquainted with St. Louis for those who had come to the fifty-ninth meeting of the society. Automobile tours made it possible for the visitors to see the parks, Art Museum, Washington University and the Missouri Botanical Garden, as well as several of the chemical plants, of which we give some descriptive notes as follows:

The Laclede-Christy Clay Products Plant

On Thursday afternoon, April 15, a large party visited the plant of the Laclede-Christy Co., located in the southwestern section of St. Louis. This plant is devoted almost entirely to the production of refractories in all shapes and sizes. There are two shaft mines and one open pit mine located adjacent to the plant proper. The plant is equipped with forty periodic kilns for the burning. The total consumption in clay at this plant is 600 tons per day for refractory purposes and 100 tons for production of tile. Both wet and dry process brick is produced. Clay is crammed directly from the mine to the dry pans and thence into the dry presses and subsequently to the waste heat-drying oven. The period of drying occupies about seventy-two hours and the burning about forty-eight hours. Both cones and pyrometer control are used in regulating the kilns. The wires for pyrometer control are all run into a central dispatching station, where multiple switches permit the operator to read the temperature on each kiln.

A thoroughly equipped ceramic laboratory was installed about twenty years ago and continues in operation under the charge of experienced ceramists. Clays are analyzed and classified. Their texture and other physical characteristics are noted. Furnace gases and slags are analyzed as carefully as the clays have been and their action on the burned clays is recorded. As a result the clay mixtures have been standardized and the uniformity of finished products is thus made certain. Many special refractories are made to meet special furnace conditions.

The wet process is also used for making firebrick and sewer tile. Here the proper mixture of clay is moistened with water and passed through an extrusion press of the vertical type with the clay discharged from the side of the cylinder. It does away with the ordinary laminations so common in the pug mill.

There is also being produced in this plant a Laclede-Christy chain grate stoker for firing boilers. The present capacity on these stokers is one per day but will shortly be increased to two or three per day. The plant is a model of cleanliness and efficient operation.

The National Lead Works

The same members who visited the Laclede-Christy Clay Products Co. were next taken to the National Lead Works, located near the former plant.

The material arrives at this plant in the form of pig lead, which is roasted in furnaces for the production of both red lead and litharge, a large bulk of which is sold to the Electric Storage Battery Co., of Philadelphia, for use in manufacturing battery plates. Located in the same building over the lead furnaces is a complete milling plant which brings the oxides to the proper consistency for both the battery and paint trade. By far the largest amount of lead, however, is used in the manufacture of white lead.

In this process the pigs are put through a stamping machine,which stamps out thin perforated circular plates of metallic lead. These, in turn, are placed in refractory pots, in the bottom of which is a quantity of 2½ per cent solution of acetic acid. The pots are porous so that the acid will percolate through the sides of the vessel in about five and one-half hours. A layer of pots is first set on the floor in a concrete bin covered with several inches of tanbark; other layers are built up until eleven tiers in all have been constructed. The whole is covered with tanbark and a pair of flues is introduced at the top for carrying off the gas. The building in which this is carried on is about 600 ft. long and 200 ft. wide, and an enormous quantity of material is fermenting continuously. This requires a large outlay of capital, as the acetic acid and lead are permitted to ferment with the tanbark over a period of 100 days.

When the fermentation process is completed, the pots are emptied into large conveyor boxes, which are carried to mills operating on the principle of the old-time millstone. The subsequent separation by screen-

EAST ST. LOUIS WORKS, MONSANTO CHEMICAL COMPANY

ILLINOIS GLASS CO., ALTON, ILL.

ing removes the white lead from the unconverted metallic lead and the former is thoroughly milled and ground in oil. The entire milling process is the most important feature of the white lead manufacture. Is is finally loaded in cans and sold under the name of Dutch white lead.

Monsanto Chemical Co.

The East St. Louis plant of the Monsanto Chemical Co. afforded more than a few hours diversion from the strenuous division meetings. The old chamber acid plant was inspected first. A testimonial for steel frame work construction could easily be obtained from a study of the operation of these chambers.

The muriatic acid retorts and tile piping and scrubbers were observed next. Perhaps the only feature found worthy of note here was the method of lining tank cars for shipments of hydrochloric acid. Ordinary saturated tar roofing felt and pitch were being used in alternate plies in somewhat the same fashion as in the construction of a specification roof.

The platinum contact oleum works next excited the curiosity of the visitors. The segment ring type of catalyzers were used with no preheating counter-current arrangements.

Some surprise arose to find a new quarter of a million dollar chamber plant almost ready for operation. The latest improvements, such as rotary sulphur burners, nitric acid weirs, etc., were included in its equipment.

Before leaving the plant, the new installation of Allen-Moore caustic soda-chlorine cells was examined. The general impression obtained from the trip was that continued expansion of the East St. Louis plant is scheduled to follow just as has been the case of its organic sister on the west side of the Mississippi.

The Standard Oil Refinery at Wood River

About 300 took advantage of the excursion to the Wood River plant of the Standard Oil Co. Friday, and subsequently to the plant of the Illinois Glass Co., at Alton, Ill.

A thorough inspection was made of all of the apparatus at the Wood River plant, which is capable of handling about 15,000 bbl. of crude oil per day. This plant produces ready for the market all the lighter distillates, petroleum, coke, paraffine wax ready for candle manufacturers, fuel oil and road oils. The company is building a new plant for the additional production of lubricating oils, as well as a large refrigerating system for use in the paraffine plant.

Very close chemical control is maintained throughout all steps of the processes and in conjunction a research laboratory is operated. One of the striking features of the plant is the fact that a large number of the stills are fired by coal. It is found cheaper to buy Illinois coal at approximately a price of $2 a ton rather than burn up the oils and distillates obtainable from the processes. The plant is equipped throughout with every precaution against fire and explosion, and the stills are so arranged that in case any of the material catches fire the combusion will be confined to a small area.

Crude oil is pumped in by pipe line from the Texas and Oklahoma fields, as well as a considerable quantity arriving by tank car. The systems of storage and tanks and stills cover about 1,500 acres of ground.

Illinois Glass Co.

On the arrival of the excursion at Alton the members were entertained at lunch by the Illinois Glass Co. and later taken over for a thorough inspection of the plant. This plant covers seventy-five acres of ground and is equipped with ten 300-ton-capacity continuous glass tanks equipped with thirty bottle-blowing machines producing 1,500,000 bottles daily, ranging in capacity from $\frac{1}{8}$ oz. to 12 gal. Three hundred and fifty tons of coal are gasified in producers and oil is consumed to an extent of 20,000 gal. daily. The daily consumption of other raw materials, including sand, lime and soda ash, is 300 tons. A complete box factory with a capacity of 10,000 boxes daily and a corrugated paper products mill with a daily production of twenty-five tons operates in conjunction with the plant.

The machinery is entirely automatic from the time the bottle-blowing machine picks up the glass batch from the revolving glass pot until the finished product is delivered to the packing room. Each automatic bottle-blowing machine consists of a base carried upon wheels supporting a central column, having six or more arms that revolve about this central axis. To each arm is attached a "blank" and blow-mold, and these are the principal features of its mechanism. As the machine revolves and each blank mold passes successively over the tank of molten glass, a valve opens and the glass is drawn into the blank mold by a vacuum process.

Each blank mold holds exactly the quantity of glass needed for making a bottle of given size, and thus the weight of every bottle is accurately measured and uniformity is secured.

After the glass is gathered into the blank mold the machine makes a quarter revolution, during which time the neck is formed. Then the blank mold opens and falls away, exposing the glass, the blow mold then rises and closes around the hot metal, air pressure is applied, and as the machine completes its revolution the glass is forced against the wall of the molds, giving the exact shape of the bottle to be produced.

In using compressed air the pressure is held steady and uniform so that the glass is evenly distributed throughout the bottle. It is this even distribution that

largely gives strength and uniform capacity to bottles made by the automatic process. The finished bottle is delivered automatically into a suitable receptacle, from which it is carried to the annealing oven, where it is tempered before being packed and shipped.

These annealing ovens are from 70 to 80 ft. in length, with floors composed of metal strips so arranged that they are drawn along slowly by large gear wheels driven by electric motor. It requires six to ten hours for a bottle to travel through the annealing oven, and the temperature at the front end, or machine end, where the bottle is first placed, is about 1,100 deg. F. The annealing oven is divided into air chambers, each cooler than the previous one, so that a bottle traveling through has its temperature gradually reduced until it reaches the rear end, where the temperature is practically the same as the outer air.

Missouri glass sands are mined by the company and shipped by rail to Alton. Even to those who have visited many manufacturing plants, the workings of the Illinois Glass Co. appeal as a marvelous mechanical achievement.

Scientific Apparatus Makers Meet

THE second annual convention of the Association of Scientific Apparatus Makers of the United States of America was held in Washington, April 22 and 23, under the chairmanship of C. S. Stoelting.

Apparatus Standardization Criticized

A special committee reported on a resolution with respect to the calibration and certification of apparatus by the National Bureau of Standards. It was emphasized that this work was of great concern, as at the present time much difficulty in getting prompt reports on apparatus tests is causing difficulties in deliveries of calibrated equipment. On request, W. D. Collins of the Bureau of Chemistry, chairman of the American Chemical Society's committee on standardized chemicals and standardized apparatus, discussed the work of his committee. He pointed out that the American Chemical Society has seriously considered establishing its own laboratory to do this calibration work, and suggested the possiblity that the Association of Apparatus Makers and the American Chemical Society might well co-operate to this end.

The very general importance of an official Government certification of calibrated apparatus was emphasized as one of the important reasons why an independent laboratory should not be established. Various means for co-operation with the Bureau of Standards were discussed, including the possibility of stationing men representing the association at the Bureau in order to expedite the work by actual assistance in it. There was evident a general desire on the part of the membership in attendance to have the testing work separated from the research work of the Bureau, in order that the testing work would not suffer through the desire of individuals or the Bureau to concentrate on research. Some such alternative placing the work upon a clean-cut business basis was favored rather than the effort to establish an independent laboratory.

Apparatus Standards Committee Report

J. M. Roberts reported for the committee on apparatus standards. Major N. E. Reasoner of the Medical Corps, U. S. Army, discussed the variety of apparatus which the Army had been compelled to procure during the war period. However, he pointed out that many points in apparatus form were of no consequence to the user except for interchangeability and therefore the user is interested primarily in standards of performance rather than the manufacturing standards under discussion. Dr. W. D. Collins also reported on the work of the American Chemical Society committee on guaranteed reagents and standardized apparatus. He pointed out that no manufacturers were represented on his committee partly because of the thought that other manufacturers might fear to give full information to the committee if a representative of their competitors were on the committee proper. However, it was pointed out that this committee of the Chemical Society would be very glad to co-operate with the committee of apparatus manufacturers.

The basis of determining the number of sizes and styles of apparatus by means of sales records was discussed at length. It was pointed out that this is a good guide in certain ways, but that so long as a multitude of sizes or styles is listed a great many of them will be ordered, although a much smaller number of varities would probably suit everyone just as well. In this connection several apparatus company representatives pointed out that in the future it was their plan to carry in stock all equipment listed in their catalogues and therefore that the number of items listed was to be very greatly reduced in the future.

In the course of this discussion several glassware manufacturers who are not dealers and therefore do not sell to users were represented. The problems which these makers of glassware meet in changing molded ware were particularly emphasized and it was urged that the problems of these persons be carefully taken into account before the Chemical Society or the apparatus makers' association committees reach final conclusions. Interchange of blue-prints or furnishing of blue-prints of each form of apparatus to the committees was suggested as the best way to undertake the work, especially that of the American Chemical Society committee.

The report of the apparatus standardization committee covering certain specifications for beakers, balances, and other apparatus was adopted by the association with the understanding it was not binding upon the membership, but with the recommendation that all members changing their catalogues during the coming year be guided by its recommendations.

Pyrometer Section

The session of the pyrometer section of the Association dealt principally with the matter of pyrometer materials. Considerable progress was reported, but no definite recommendations were reached at these sessions.

College of City of New York to Give Engineering Degrees

The Board of Trustees of the College of the City of New York has authorized the granting of degrees of Chemical, Civil, Electrical, and Mechanical Engineer on the satisfactory completion of a curriculum requiring five years. The announcement of the details of the curricula will shortly be issued. This is one of the steps taken by the College of the City of New York in the direction of closer co-operation between industry and colleges and universities.

Current Events
in the Chemical and Metallurgical Industries

Engineering Conference

The governing boards of four founder engineering societies met in Chicago April 19 and 20 under the auspices of the Western Society of Engineers. These four societies are the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

On Monday evening there was a joint engineering society dinner at the La Salle Hotel. At this dinner A. Stuart Baldwin, past president of the Western Society of Engineers, was toastmaster. Speakers were Arthur C. Davis, president of the American Society of Civil Engineers; Arthur Fletcher, representing the American Institute of Mining and Metallurgical Engineers; Fred J. Miller, president of the American Society of Mechanical Engineers, and Calvert Townley, president of the Electrical Engineers.

The purpose of this meeting was to form plans for better co-operation between the national societies in giving service to the public and securing proper publicity for the professions in general. The Western Society of Engineers presented plans as to how this may be brought about in Chicago, and they are now being considered by the various societies.

The Chicago Chemists' Club

The first get-together meeting of the Chicago Chemists' Club was held as an informal dinner in the quarters at the City Club building on the evening of April 21 with about sixty members in attendance. W. Lee Lewis of Northwestern University delivered a talk on gas warfare redolent with the fumes of butyl mercaptan and other interesting odors. He called attention to the early history of conflict by the use of poisons, commencing with the snake, skunk, et cetera, in animal life and continuing through the savage races to the more recent inauguration into modern warfare by the Germans. Statistics were presented to the effect that only 2 per cent of the casualties die in gas attacks while 24 per cent are lost under shell fire. Gas warfare is most humane and at the same time most effective. This in spite of the propaganda put forth in the United States and England when the Germans first employed chlorine against the Canadians. The talk was concluded by a plea for the maintenance of our activities in the development of new gases and a protest against the retirement of General Sibert to an inactive position in the Army.

Chicago Section, American Ceramic Society

The Chicago Section of the American Ceramic Society met with the Illinois Clay Manufacturers' Association at the Hotel LaSalle, Chicago, on April 20 and 21. The chief event of the occasion was an informal dinner on Tuesday evening with H. T. Bellamy, chairman of the Chicago Section, presiding. H. P. Matzen, of the Carrier Engineering Corporation, presented a paper on "Humidity Drying." I. E. Hardy made a plea for more scientific methods in the enamel brick industry, and informal addresses were given by other members of the two associations.

During the meetings on Tuesday afternoon the forced draft system of burning was informally discussed, and Prof. E. W. Washburn, of Illinois University, delivered an address on "Some of the Factors Involved in the Drying of Clay Wares." "The Tunnel Kiln" was presented by Conrad Dressler and Prof. Carl B. Harrop; C. W. Parmelee of University of Illinois offered a paper on "The Composition of a Paving Brick as Related to Its Rattler Test." The sentiment of the various members during all the discussion called for a greater application of science to the problems of the brick industry, and many members spoke in high appreciation of the work being done by the various universities along these lines.

American Foundrymen's Association to Have New Department

At the annual meeting of the American Foundrymen's Association to be held in Columbus, Ohio, Oct. 4 to 8, a new department will be added to the program to be known as the non-ferrous casting section. At the meetings of this section, papers and discussions of interest to the practical brass and aluminum foundrymen will be presented.

It is understood that the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers will hold a meeting in Columbus during the same week and it is proposed to have a joint session of the non-ferrous section of the American Foundrymen's Association and the Institute of Metals Division of the A.I.M.E.

The other sections that will be represented on the program of the American Foundrymen's Association are the gray iron section, the steel foundry section, the malleable iron section, and the industrial relations section, and in conjunction with these meetings will be held the usual exhibit of foundry and machine shop tools, equipment and supplies.

Meeting of Northern Ohio Section American Ceramic Society

The Northern Ohio Section of the American Ceramic Society met recently in Detroit under the direction of Dr. A. F. Gorton, chairman, and Charles H. Stone, Jr., secretary. Twenty-seven members in all attended this meeting.

The various plants in the vicinity of Detroit were visited, including the Jeffery-DeWitt Co., manufacturer of porcelains for the Champion Spark Plug Co., of Toledo, the Detroit Star Grinding Wheel Co., the Ford Motor Co., and the Pewabic Pottery Co. Luncheon was served at the Detroit Athletic Club and in the evening an informal dinner was enjoyed.

Data From Washburn's Testimony

In the course of his recent testimony before the Senate Committee on Agriculture, Frank S. Washburn presented some interesting data on the consumption of nitrate and ammonia nitrogen and on the estimated future production of ammonium sulphate. These figures are given in Tables I, II and III.

TABLE I. DEMAND FOR NITRATE NITROGEN IN UNITED STATES, 1914[1]

	Per Cent
Sodium nitrate used by fertilizer manufacturers	28
Sodium nitrate used by farmers (bought unmixed)	17
Nitric oxide used in manufacture of sulphuric acid	7
Nitric oxide used in fortifying mixed acid	17
Mixed acid for nitration	12
Oxidizing agent in glass manufacture	6
Oxidizing agent in explosives (as $NaNO_3$)	8
C. p. chemicals for miscellaneous chemical uses	5
	100

[1]Total demand equivalent to 540,000 tons $NaNO_3$.

TABLE II. CONSUMPTION OF AMMONIA COMPOUNDS IN UNITED STATES, 1914[1]

	Per Cent
Ammonium sulphate used in mixed fertilizer	55
Anhydrous ammonia for refrigeration	12
Aqua ammonia for refrigeration, soda ash, explosives, etc.	33
	100

[1]Total demand equivalent to 270,000 tons $(NH_4)_2SO_4$.

TABLE III. AMMONIUM SULPHATE PRODUCTION

	Capacity of byproduct ovens		Surplus over anticipated demands	
	Nitrogen Tons	Ammonium Sulphate Tons	Nitrogen Tons	Ammonium Sulphate Tons
1918	95,000	455,000	20,000	100,000
1919	90,000	450,000	10,000	50,000
1920	111,000	555,000	25,000	125,000
1925	142,000*a*	710,000		
1930	170,000*a*	850,000		
	204,000*b*	1,020,000		
	239,000*c*	1,195,000		

a.—Assuming normal increase in pig iron production and that coke required will come from new byproduct ovens.
b.—Assuming one-half of existing beehive ovens to be replaced by byproduct ovens.
c.—Assuming all existing beehive ovens to be replaced by byproduct ovens.

With regard to the cost of water power at Muscle Shoals, Mr. Washburn said:

"They are proposing now to spend $25,000,000 for a 100,000-hp. plant. That is $250 per hp. Let us assume you could use all of it throughout the year and have no losses from idle time. Five per cent on the cost of your power, nothing else, is $12.50 a horsepower year. Yet these gentlemen in making their estimates have referred to $1.69 for power in one case and in another case about three times that amount. It is true that they did not intend to cover the interest when they mentioned those amounts, but to talk about a cost of $1.69 per horsepower year is so misleading that the mind gets to operating on the basis of $1.69 and forgets that the interest alone that this Government has to pay out, in this period of the highest taxation it has ever known, will be $12.50 a year per hp. My estimate of the cost of producing hydroelectric power at Muscle Shoals is as follows:

Administration and labor		$100,000
Maintenance and supply		60,000
Depreciation, obsolescence, insurance and extraordinary repairs:		
Power house, dam and lock		408,900
Equipment		251,500
Contingencies		60,000
Interest, 5 per cent		1,250,000
Steam plant standby:		
Maintenance	$25,000	
Supplies	15,000	
Heat and light	7,500	
		47,500
Entire total		$2,177,900
Cost per kw.-year		$29.00
Cost per hp.-year		21.77
Cost per kw.-hr.		.0033

"The cost is not only prohibitive but here is the crime in that thing:

"About 90 per cent of the cost of that water power is interest and other percentage items that depend upon cost.

"The Government's position is not only to build the Muscle Shoals hydro-electric plant at a time when taxes are the highest and put $25,000,000 into that item alone, but they propose to do it when labor and materials are the highest this country ever has known. That is not the worst of it. They already have a power plant and they will produce the power and produce it at Government expense at no greater cost than their waterpower after they get it."

"Ten Commandments" for Trade

The Canadian Reconstruction Association, which has long been actively associated with the "Made in Canada" campaign, has formulated the following "Ten Commandments for Canadian Trade":

1. *Buy Canadian products.* In doing so you develop the home market, encourage factory expansion, provide employment for new populations, and create bigger and better markets for all kinds of farm produce. New factories, expansion of old factories, greater production, more workers, and better agricultural market mean national progress.

2. *Import only necessities,* and then only if similar Canadian articles or substitutes are not available. With Canadian money at a discount of 10 to 15 per cent, exchange with the United States is costing Canadian consumers between $75,000,000 and $100,000,000 a year.

3. *Produce to the limit in field and factory.* Increased production means new wealth and is essential to the success of any effort to reduce imports and promote export trade.

4. *Co-operate, conserve, specialize, standardize.* These are the means to maximum production of high-quality goods at minimum cost.

5. *Develop export markets.* Foreign business gives stability to trade. It reduces unit costs, benefits domestic consumer, affords employment to factories and workers in times of depression, and corrects adverse exchange by improving the trade balance.

6. *Utilize Canadian services.* Ship by Canadian carriers through Canadian ports. Patronize Canadian railways, Canadian steamships, and Canadian banks. Place insurance in Canadian companies. Employ Canadian architects, engineers, scientists, and other experts. Spend vacations in Canada.

7. *Manufacture raw materials to final stages in Canada.* Hundreds of millions of dollars are lost annually to the Dominion, and especially to Canadian wage earners, by the exportation of raw materials and semi-manufactured products.

8. *Use science for the determination and development of natural resources.* Industrial research will reveal new wealth, improve industrial processes, and help to relieve our economic dependence upon outside sources for fuel, iron, and other essentials.

9. *Make quality the hall mark of Canadian products.* In return for public support of the home market Canadian manufacturers should provide products that compare favorably with imported goods and Canadian workers should recognize good workmanship and maximum production as their standards.

10. *Be fair to capital.* Canadian money should be encouraged to invest at home and foreign capital attracted to promote Canadian industrial expansion.

Langmuir's New Conceptions

Dr. Irving Langmuir in his address before the National Academy of Sciences at Washington, Tuesday evening, April 27, presented an entirely new theory on the structure of matter. Explaining that his conclusions led to a new conception of energy, force, time, space, magnetism and all the general properties of matter, Dr. Langmuir asserted that "space and time have a structure analogous to that of matter."

Heretofore, the speaker said, the usual conception of the relative order of the components of matter has been atoms, electrons, molecules and particles. His observations add a new division, smaller even than the atom, which he has named the "quantel."

It consists of two parts, he said, positive and negative, present everywhere in space, moving in all directions with the velocity of light and capable of passing through matter. They constitute what has heretofore been known as the "ether of space" and cause all of the phenomena of light, electricity, mass and energy.

"The structure of everything that is" can be built up out of his conception of the quantel, Dr. Langmuir said. The theory explains all of the mysterious relationships heretofore known to exist between spectral lines, he asserted, predicting that it would lead to the discovery of many new relationships.

Chandler Medal Presented to Willis Rodney Whitney

On Tuesday evening, April 27, Dr. Willis R. Whitney gave an address entitled "The Littlest Things of Chemistry" to an attentive and eager audience, all of whom had braved an unusually cold April shower and many of whom drew "standing room only" tickets, that they might see the first presentation of the Chandler Medal since the entrance of the United States into the World War. Could Dr. Whitney have guessed that his associate, Dr. Langmuir, was going to launch quantels down in Washington one hour before his own address, he would probably have not used either the superlative, comparative or picturesque and just called his address: "Some Real Dope on Electrons." The interpretation of the theory that has been built up around this conception of matter affords more than a fascinating pastime. Dr. Whitney justified his belief in the electron theory of matter by showing that he actually makes use of it in his research. The argon rectifier and many other electrical devices are based on phenomena that can only be understood on the electron basis. No attempt will be made to give the details of the address, as it does not lend itself well to abstraction and will be published in full in the June issue of the *Journal of Industrial and Engineering Chemistry*.

Address

After stating that he had never heard so many ideas on chemistry expressed in a single hour, Dr. Chandler presented the medal with the following remarks:

"It is my privilege to present to Dr. Willis Rodney Whitney the Chandler Medal. I appear as the representative of the more than 500 of my old pupils and other friends who in 1910 established this foundation in honor of their old professor. One of these founders graduated as early as 1847, and several others during the succeeding years prior to 1864, when I began with Profs. Egleston and Vinton to teach in the newly founded School of Mines.

"I was deeply gratified when I learned from Prof. McKee that the distinguished Dr. Whitney had consented to deliver the annual lecture. The name is dear to me, and suggests a possible blood relationship between us. My mother was a Miss Whitney of Boston.

Academic Record

"Dr. Whitney was born at Jamestown, N. Y., on Aug. 22, 1868. He graduated at the Massachusetts Institute of Technology in 1890, receiving the degree of S.B. In 1896 he received the degree of Ph.D. at Leipzig. He has been most successful as a teacher of chemistry, having filled the following positions at the Institute of Technology:

1890-1892—Assistant instructor in sanitary chemistry.
1892-1894—Instructor in sanitary chemistry.
1898-1901—Instructor in theoretical chemistry and proximate analysis.
1901-1904—Assistant professor in theoretical chemistry.
1904-1908—Non-resident associate professor of theoretical chemistry.
1908—Non-resident professor of chemical research.

Research Experience

"Since 1900 Dr. Whitney has been the director of the research laboratory of the General Electric Co. at Schenectady, and recently during the war has been a member of the Naval Consulting Board and director of research work at Washington. Words and time fail me to give you any adequate idea of the number, variety and importance of the researches which have been successfully conducted by him and his willing assistants and associates during the past twenty years. Some idea of the magnitude of his activities can be realized from the fact that he has developed the research laboratory at Schenectady from its inception till now he has the direction of more than 150 persons working with him.

"It would require a series of lectures to lay before you an adequate account of the various important results which have been developed under Dr. Whitney's direction. The first radical improvement in the carbon incandescent filament since Edison first produced it was due to Dr. Whitney's personal work. The 'Gem' lamp which he developed with its 'metallized' filament, embodying a new form of carbon, gave 25 per cent more light with the same wattage than the standard carbon filament lamp. Still greater improvements resulted in his laboratory when the drawn wire of tungten gave us the 'tungsten lamp,' then the gas-filled half-watt lamp. Then in arc lighting the laboratory developed the magnetic electrodes, and produced the most successful arc lamp of today.

"Did time warrant, I would gladly tell you about numerous other wonderful discoveries and inventions in the practise of the industrial arts which Dr. Whitney suggested and inspired in his twenty years of research work, and also remind you of the numerous scientific papers he has published in the journals.

The Presentation

"Now, Dr. Whitney, permit me to present to you, as representative of the president and trustees of Columbia University and the more than 500 alumni and friends who established this foundation in 1910, the Chandler Medal, in recognition of your wonderful and successful labors in the application of physics and chemistry to the industries of this country."

New International Chamber of Commerce

The new International Chamber of Commerce, projected at the International Trade Conference at Atlantic City last October, will be formally organized, it is announced by the Chamber of Commerce of the United States, at Paris during the week of June 21. Invitations have been sent out by the American group of the International Organization Committee to business and industrial associations, asking them to name delegates to participate in the organization meeting. About one hundred delegates from the United States are expected to attend.

The International Organization Committee, which was provided for at the International Trade Conference, is to meet at Paris in advance of the general organization meeting, which will be held in June, to prepare and report a plan of permanent organization, the basis of which was drafted and approved at the International Trade Conference. Plans will be presented by the organization committee for a strong and active international chamber. Steps will be taken for the creation of a permanent international headquarters; officers will be elected, and the work of the chamber will actually be started.

The International Chamber succeeds the old International Congress of Chambers of Commerce, which ceased to function with the outbreak of the World War in 1914.

Aims of the Organization

The specific aims of the organization as outlined by the committee on organization are:

To create a permanent international headquarters to centralize all data concerning economic subjects and social conditions, the facts relating to the respective needs, present production, and future possibilities of each country; to act as an instrument of co-ordination which will suggest trade regulations and legislative measures to facilitate and encourage the development of economic commerce; to inform public opinion, through the publication of facts, with regard to business conditions, and through the dissemination of views of technical experts and business men; to put at the disposal of all official organizations the reports and conclusions prepared by these experts and business men.

Constitution of the Chamber

The committee on permanent organization of the International Trade Conference agreed tentatively that the constitution of the new chamber should provide, among other things, for: A board of directors composed of two members selected by each nation; an international headquarters, with one representative of each nation attached to it, assisted by technical experts, all to be under direction of a general secretary; a corresponding bureau in each country; membership to consist of chambers of commerce, commercial organizations, banking and similar associations, firms, corporations and individuals holding associate but not voting membership; meetings of the membership every two years; a system of referenda to be issued during the interval between the biennial meetings of the members.

Other Objects of the Association

Other objects of the association are: To make import and export trade easier; to remove international friction, much of which begins with commercial differences; to safeguard international trade against waste and fraud; to increase the total production of the world, and make the product available to the people of the world; to standardize international documents, practices, and laws affecting commercial intercourse; to increase mutual profitableness of international transactions; to cultivate personal acquaintanceship among business men and bankers of the different nations of the world, and in this manner lessen international prejudices and misunderstandings.

At the first meeting in June only the five countries participating in the International Trade Conference—the United States, Belgium, Great Britain, France, and Italy—will be represented. Later, business organizations in the other principal countries of the world will be taken into membership.

The Short Course in Ceramics at Illinois University

The two weeks' course in clay working recently closed at the State University, Champaign, Ill., was attended by thirty-five students, ranging from the younger men of the industry to prominent executives of the corporations. Work had been carefully planned by the faculty so that an extremely large mass of detail was presented in the short time allowed. In addition to Dr. E. W. Washburn's immediate staff, other members of the university organization who are specialists in lines relating to the clay business assisted with the instruction. E. W. Tillotson, of the Mellon Institute at Pittsburgh, conducted a course in glass manufacture. A. V. Bleininger, U. S. Bureau of Standards, Washington, D. C., lectured on refractories and burning operations.

This effort on the part of an enthusiastic educational organization makes for definite progress in bringing even the most humble clay worker to a realization of the opportunity for increased profits through the adaptation of scientific methods in manufacture of clay wares. The methods of procedure as outlined for use in studying the work in any particular case were so simple that the non-scientific producer would find them easily adaptable.

Aside from the many data carried away by the students there was an added inspiration to higher things for the ceramic art instilled by the earnest lecturers of the course. One student had attended the school for three successive times simply for the enthusiastic impulse he received for the work of the months following.

The faculty gave a smoker at the Beta Theta Pi house for the students of the short course, with invitations to the upper classmen of the regular ceramic engineering courses. Speeches of warm appreciation for the work done by the faculty were made by those in attendance.

Electrochemical Colloquium

The Electrochemical Colloquium for research men in New York and vicinity is being held at 7.45 p.m. on the second and fourth Mondays of each month, in Room 301, Mines Building, Columbia University. A theoretical paper and an industrial paper are reviewed and discussed each time. The Colloquium is a democratic effort by men of varying grades of distinction to keep abreast of the important electrochemical researches of the present day, both in the United States and abroad. All who are interested are invited to participate.

The Vocational School of the C. W. S.

Throughout the U. S. Army training schools for recruits have been organized in fulfillment of the slogan "Enlist and learn!" The Edgewood Arsenal has become headquarters for the Chemical Warfare Service, and here are gathered the recruits, of whom about 1,250 have enlisted since the beginning of the year. These are raw recruits and they have the option to enter the vocational school or not, and the choice of subjects offered for study. This extra training consists in three hours' daily school work five days a week for eleven months a year. Dr. Allen Rogers of Pratt Institute, Brooklyn, is the educational director with rank of "consulting expert" in connection with the War Plans Division operating under a special appropriation by Congress. Other teachers are in the Civil Service. The courses already established are, 1, Electricity; 2, Automobile Mechanics; 3, Machine Shop Practice; 4, Printing; 5, Commercial Course; 6, Grade Work (for illiterates and those who have not completed a grammar school course), and 7, Chemistry.

The vocational training schools have proved a veritable life-saver for the Army, in that the young men of from twenty to twenty-five years of age who enlist are generally a fine lot of fellows. They are ambitious and want to prepare themselves for a good career. Present enlistments in the C. W. S. are for only one year, but it is hoped that this will soon be changed to a three years' term, and thus give the authorities a chance to provide strong courses.

The old barracks are now used for classrooms, and mess halls have been fitted over for shops. One wing is used for automobile mechanics, another for electricity, still another for machine shops, and another for the chemical laboratory. Teachers live in the old Fourth Battalion Headquarters.

About 600 of the 1,250 recruits are taking vocational courses at the present time.

The Courses Provided

The courses in detail are:

Electrical Department. Recruits are taught wiring, etc., together with enough of the principles of electricity to make them journeyman electricians.

Automobile Mechanics. The first rush was for this course because it was thought to be a chauffeur school, and that it would provide opportunities for joy rides. Later on the less thoughtful applicants dropped out. The men are taught assembling and repair work, with driving as a later accomplishment. The shops are but partly equipped with six or eight cars at present, but about thirty cars in all are expected.

Machine Shop Practice. This includes bench work, lathe and general tool work to fit them to be machinists.

Printing. A regular apprentice course.

Commercial Course. Includes accounting, stenography, typewriting and general business.

Grade Work. This provides for illiterates who are learning to read and write. It teaches English to the few foreigners (mostly Italians) who do not speak the language, and it provides a course in citizenship.

Chemistry. This trains men to work as laboratory assistants and to engage in chemical factory work.

The Chemical Warfare Service needs men not only trained to throw bombs, but also those who can repair and drive trucks, electricians for the electrical equipment, men competent as mechanics for machine shop work, men to help in the laboratories, clerks in the offices and printers for the confidential circulars which in practice are frequently distributed. Later on carpentry and plumbing will be added.

There are now over 100 vocational schools in the Army, counting this of the C. W. S. as one. During the coming summer it is planned to organize a month's camp for teachers only, for conference and for the purpose of improving the system of the educational work.

Personal

Major Earl J. Atkinson has been assigned to the command of Edgewood Arsenal. Major Atkinson organized and commanded the first gas regiment in France. He has been serving as engineer instructor at Camp Benning.

M. W. Bray and J. A. Staidl have recently joined the staff of the Forest Products Laboratory. Their work will consist in a study of analytical methods for wood and wood pulp.

Dr. F. G. Cottrell, chief metallurgist of the U. S. Bureau of Mines, will be the recipient of the Willard Gibbs Medal for this year at the May meeting of the Chicago Section of the American Chemical Society, May 21, 1920.

Spencer A. Colville, formerly with the New Amsterdam Gas Co., has been appointed as associate gas engineer of the Bureau of Standards. The Bureau of Standards and the American Gas Association have completed arrangements and secured the aproval of the American Engineering Standards Committee, to be joint sponsors in preparation of the proposed national gas safety code which was partially developed by the Bureau of Standards several years ago, but laid aside because of war work of the bureau. He will assist in these investigations, under the direction of Dr. E. B. Rosa, chief physicist of the bureau, and W. M. Berry, in charge of the Gas Engineering Section.

Prof. C. H. Desch, who has been appointed to the chair of metallurgy in the University of Sheffield (England), was presented by the instructors and students of the evening classes of the Royal Technical College, Glasgow, with a suit case, to mark his departure from the college.

Assistant Professor J. W. E. Glattfeld returned to the University of Chicago on April 1. For three months he has been making researches at the Desert Laboratory of the Carnegie Institution, Tucson, Ariz.

E. J. Mehren, editor of *Engineering News-Record*, has sailed for Europe to study conditions in England, France and Germany and will be abroad until the latter part of August.

H. F. J. Porter will give an illustrated lecture at the Engineers' Club, New York City, May 5. His topics will be "Cornelius Henry Delamater, the Business Man" and "Captain John Ericsson, the Engineer."

Carleton W. Reade, formerly chief chemist for the Delta Chemical Co., Wells, Mich., is now chemist for the Marinette & Menominee Paper Co., Marinette, Wis.

William Kent Shepard, assistant professor of mechanical engineering, Mason Laboratory, Yale University, will take a position about the middle of June with The Barrett Co. at Edgewater, N. J., as head of the division of engineering research.

C. G. Stupp is now assistant chief chemist of the research department of The Barrett Co. at Edgewater, N. J.

The officers of the Association of Scientific Apparatus Makers elected for the coming year were as follows: President, M. E. Leeds; vice-president, H. N. Ott; secretary-treasurer, J. M. Roberts; members of the board of directors, C. M. Stoelting, Mr. Evans, Walter Eimer and L. G. Wilson.

Obituary

GEORGE W. KETTER, who was in charge of electrical installations for the Electric Furnace Construction Co., Philadelphia, died at Claremont, N. H., on April 22, after a short attack of pneumonia.

ELI HILLES LARKIN died at St. Louis, April 16, 1920, in his eighty-first year. Mr. Larkin received his early education in the schools of St. Louis and completed his professional education as a chemist in Germany. With the late Henry V. Scheffer, he founded the co-partnership of Larkin & Scheffer, manufacturing chemists, which later became the Larkin & Scheffer Chemical Co., a corporation, and continued in business in St. Louis until 1911. The firm of Larkin & Scheffer originated the commercial manufacture of liquid anhydrous ammonia in 1879. Mr. Larkin designed the first anhydrous ammonia shipping cylinder, which, improved and perfected, has made possible the operation of isolated ammonia type ice-making and refrigerating plants throughout the world. In 1890 the ammonia business of the Larkin & Scheffer Chemical Co. was acquired by the National Ammonia Co., and until his death Mr. Larkin was a director of that company and technical superintendent of its St. Louis factory. Mr. Larkin was a bachelor, a studious devotee of the science of chemistry and a successful developer of methods for the commercial manufacture of many chemical products. His conspicuous characteristics were a quiet modesty and generous practical charity and philanthropy. His practice was to discover worthy objects of charity and deserving philanthropy and promptly and directly to relieve the one and aid the other. His numerous benefactions were as a rule anonymously bestowed. In his will he bequeathed about $200,000 to various religious and charitable institutions, and in addition he provided liberally for the David Ranken, Jr., School of Mechanical Trades. The "Larkin Foundation," established in the Ranken School of Mechanical Trades, provides for instruction in power plant operation, refrigerating, heating, for lecture courses in technical subjects, and for financial assistance to desirable students.

OLIVER SHEPPARD PICHER, president of the Eagle-Picher Lead Co., died after a short illness of pneumonia, at his home in Winnetka, Ill., on Monday, April 26. Few, even of his business associates, knew of his illness, and his death came to all as a terrific shock. He was a man of unusual vigor, great ability and an exceptionally winning personality, and had built up an organization characterized by a spirit of marked unity of purpose and personal loyalty on the part of each individual, so that every man in the company feels his death as a personal loss. He was an accountant, a metallurgist, a mining engineer, a chemist, a manufacturer and a financier. He was born at Springfield, Mo., but spent his boyhood and youth in California. He was a graduate of Leland Stanford University and Columbia Law School. After finishing his law course he spent three years in the office of the Hon. Elihu Root of New York. Later he went to Joplin, Mo., where his father, Judge O. H. Picher, was president of the Picher Lead Co., with the intention of practicing law there, but soon became interested in manufacturing and abandoned the law for business. In 1906 he became secretary of the Picher Lead Co., a position which he held for three years, until he was elected president to succeed his father, who had retired and gone to live in California. In 1916 the Eagle White Lead Co. and the Picher Lead Co. were merged into the Eagle-Picher Lead Co., and Mr. Picher became president of the consolidated companies, a position which he filled with great brilliancy and success until his death. In 1904 he married Emily Stanton, and had four children, two sons and two daughters, all living. He was director and chairman of the finance committee of the American Zinc Institute. He was a member of the Society of Colonial Wars, Sons of the Revolution, and Columbia Chapter of Alpha Delta Phi.

Current Market Reports

The Non-Ferrous Metal Market

New York, May 3, 1920.—The copper market is strengthening and better business is expected next week. The lead and zinc markets are dull, and prices have declined slightly since last week. Tin is holding its own, 61¼c. being quoted up to April-May, 61c. up to June-July. The freight congestion keeps the market quiet.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent.	32@33
Antimony, wholesale lots	10.00@10.50
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	61.00
Lead, New York, spot	8.87½
Lead, E. St. Louis, spot	8.50
Zinc, spot, New York	8.50
Zinc, spot, E. St. Louis	7.95

OTHER METALS

Silver	oz.	$1.14
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.50
Cobalt	lb.	1.50
Magnesium (f.o.b. Niagara Falls)	lb.	1.60
Platinum	oz.	142.00
Iridium	oz.	250.00
Palladium	oz.	142.00
Mercury	75 lb.	100.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled, (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	23.00
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	34.50
Seamless high brass tubing	30.50

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	21.75@22.75
Aluminum, sheet scrap	21.25@22.50
Copper, heavy machinery comp	13.50@14.00
Copper, heavy and wire	13.50@13.75
Copper, light and bottoms	12.25@12.75
Copper, heavy cut and crucible	14.75@15.00
Brass, heavy	7.50@ 8.00
Brass, light	7.00@ 7.50
No. 1 clean brass turnings	8.25@ 8.50
No. 1 comp. turnings	10.25@10.75
Lead, tea	5.25@5.40
Lead, heavy	7.00@ 7.25
Zinc, scrap	4.25@ 4.50

The Iron and Steel Market

Pittsburgh, Pa., April 30, 1920.

Transportation conditions, as affected by the rail strike, may have improved materially, but the iron and steel industry itself feels little improvement. On the whole the industry is as much hampered as it has been at any time since the strike started about three weeks ago. While there is some increase in the movement of material, that is largely if not wholly offset by the exhaustion of stocks, particularly of coke at blast furnaces, and by the accumulation of finished products at steel mills.

The Southern and Eastern Districts are scarcely affected, but the iron and steel industry of the Central West has its main arteries of communication, both between parts of the industry and with customers, almost completely clogged. The movement of Connellsville coke has been about one-half the normal, and the movement that occurs is chiefly in solid trainloads, which can be got through only to certain points, chiefly to the lower Monongahela valley, while a few trainloads have gone to the Mahoning and Shenango valleys. There is fairly complete communication with Buffalo. As to the byproduct coke plants, those at Cleveland are doing poorly, while the Lorain plant is running almost full, the Youngstown plants are practically idle and the Benwood, W. Va., plant is operating.

Considering the iron and steel industry as a whole, production of pig iron and finished steel is in the neighborhood of 80 per cent of normal, while shipments of finished steel are hardly much more than 60 per cent of normal.

The iron and steel markets are extremely apathetic. There is a large collection of discouraging factors—discouraging alike to buyers and sellers. Money conditions are, of course, altogether unsatisfactory, with loans for commercial purposes difficult to obtain and with investors generally unwilling to engage in new projects. The outlook as to the willingness of labor to function has been growing poorer again. Strikes are threatened in various cities of machinists, molders and members of other crafts, and even the iron and steel industry itself is again the seat of considerable unrest.

Steel prices in general remain as formerly, the policy of nearly all the independents being to hold to their various prices, which represent premiums for delivery, it being the delivery that varies rather than the price.

Occasional exceptions to this general principle are now noticed, in that in a few special cases in the past week large independent mills have sold merchant bars and structural shapes at the Steel Corporation or Industrial Board prices, 2.35c. for bars and 2.45c. for shapes. The same mills, however, continue to quote their former prices on ordinary business, 2.90c. to 3c. on bars and 3c. to 3.10c. on shapes.

Pig Iron

It is not clearly established whether the production or the consumption of merchant pig iron is curtailed the more by the rail strike, but if the curtailment in production was the greater early in the strike it is likely that with the strike's prolongation the curtailment in consumption will prove the greater. This trend arises from the fact that coke is being got through in solid trainloads to merchant furnaces in some instances, while the distribution of pig iron is very difficult and foundries are running out of stocks, either of pig iron or of coke. Pig iron stocks in consumers' hands are not large, as deliveries of late have been chiefly of iron bought after the pig iron advance was well under way. There is no weakness apparent in pig iron prices, however, but rather the reverse. A technical advance over the market of a few weeks ago is recorded, in that the only quotable market now is the prompt market, there being no interest whatever in second half, while until recently the second half market was the chief part of the market. At that time the valley market stood at $42 for bessemer, $41.50 for basic and $42 for foundry, but now, on the basis of recent sales for early deliveries the quotable market is: bessemer, $42.50; basic, $43; foundry, $43, f.o.b. valley furnaces, freight to Pittsburgh being $1.40.

Chemical and Allied Industrial Markets

New York, April 30, 1920.

The transportation situation is the direct cause of the present depression in these markets. Prices are exceptionally high, but there is very little business being transacted, on account of there being no available material. Originally the car shortage was the stumbling block and the present nominally lifted freight embargo has practically exhausted spot supplies. Producers are unable to obtain the crude material and have been forced to curtail their production to such an extent that it will be some time before they will be in a position to consider new contracts. Shipment by truck has been attempted in some cases, but for long hauls has failed, as the cost is prohibitive. Quotations as received are invariably prices at the works with no mention of shipment made.

General Chemicals

Acetic anhydride came up from 60@65c. per lb. of last week to 65@75c., with slightly better than the usual business manifested, while *acetic acid*, due to extreme shortage, is listed at $3.50@$4.50 per cwt. for 28 per cent, $6.50@$8 for 56 per cent, and $15.50@$17.50 for 99½ per cent glacial, with the latter figure in all cases the most common. Quotations on *aluminum sulphate*, commercial, are nominal, as there is practically no material to be had. Small sales are reported at 2@3c. per lb., and as high as 3@4c. is being asked for *iron-free* grade. Under the pressure of increasing demand and dwindling supplies, *chloroform* came up from 29@32c. per lb. of last week to 32@38c., this situation also applying to *iodine*, resublimed, previously listed at $4.10@$4.30, but now quoted 35@40c. higher. Producers are unable to meet the demand on *magnesium sulphate*, and a considerable shortage of spot material has placed this item in practically a nominal position, current quotations ranging from $3.50@$4.25 per cwt. for U.S.P. and $3.25@$3.60 on commercial.

The extreme shortage of *bleaching powder* and both grades of *soda ash* has held these materials firm at previous levels; inquiry both foreign and domestic continues very heavy, but little actual business has been reported. *Sulphuric acid* remained firm, with very little material coming into the market. It is reported that even with better transportation facilities manufacturers would not be able to cope with the present heavy demand; 60 deg., tank cars, is quoted at $14@$18, 66 deg. at $22@$35 per ton, depending upon the quantity. No change has occurred in *barium* products; chloride remains nominally quoted at $150@$175 per ton, while nitrate holds firm at 10@12c. per lb.

Coal-Tar Products

Buyers of coal-tar products are not inquiring as heavily as before, probably realizing the crisis this market is facing. Plants are being forced to shut down owing to the lack of raw supplies and the inability to ship whatever material is being turned out. Trucking has been resorted to rather extensively but at a very heavy cost and it is the opinion of many that if conditions do not become easier very soon many of the plants will have to shut down completely.

Naphthalene is the latest to join "the nominally-to-be-had-items-at-this-price," 15c. per lb. being asked for both flake and balls, but they can be obtained at this price only in small quantity with no guaranty regarding shipment. One large producer of this item cleaned up his supply the early part of last week, the old contract price of 8@9½c. per lb. prevailing, and is now out of the market. *H* acid is listed as high as $2.25 per lb. in very small quantities, while *paranitraniline* came up to $1.65 per lb. under pressure of extremely short supplies. *Cresol*, U.S.P., also in the same position, is quoted at 18@19c. per lb., against 16@18c. of the previous report. *Aniline oil* held firm at the former level of 34@45c. per lb., with considerable difficulty in locating supplies; the *salts* are better at 46@50c. than the previous report of 42@48c. per lb. Short supply brought about by recent heavy demand has sent all grades of *cresylic acid* up, 97-99 per cent, straw color, in drums, being $1.10@$1.20, against 95c.@$1.10 of last week; 95-97 per cent, dark, in drums, is $1@$1.05, against last week's price of 85c.@$1, while 50 per cent, first, is listed at 65@75c. per gal., which is 5c. better than previously reported.

Naval Stores

There has been no business heard of in the naval stores market during the week. Shortage in the primary market, coupled with a complete tie-up of coastwise shipping, has effectually paralyzed the New York market. An attempt was made to send material by rail to relieve this stringent condition, but hardly had the cars started rolling when the railroad strike was called, cutting New York completely off from the primary market. The complete output is being diverted to the export trade and some material is being sent inland by rail wherever conditions will permit. Rather than quote prices which have no meaning and which do not represent actual sales, figures have been placed in the table that have been obtained from producers and which it is generally understood will hold upon the arrival of material from the South.

Vegetable Oils

There was very little change in the general conditions of the vegetable oil market during the week, prices being

well maintained except in *linseed*, which fell off slightly in futures, $1.72 per gal. being asked for May-June delivery and $1.62 for July-December. The freight embargo has affected the former rise in *cottonseed*, which is now back at the former levels of 16@17c. per lb. for summer yellow and 21@23c. per lb. for winter yellow, with very little activity exhibited on the part of the buyers.

Miscellaneous Materials

Fluorspar — We are advised that 700 tons of gravel fluorspar has been sold for $25 per net ton, f.o.b. mines, southern Illinois, with no analysis guaranty, contracts reading "Fairview Washed Gravel Fluorspar." Also, 1,250 tons were sold at the same price and same shipping point with an average guaranty of 85 per cent calcium fluoride and not over 6 per cent silica, while a small tonnage was sold at the same point, packed in barrels, with no analysis guaranty, at $37.50 per ton. Producers in this territory are not desirous of accepting contracts for acid grades of fluorspar and have refused to make any quotations on these grades. During the past few weeks the demand has become more active, but a good many of the fluorspar companies are pretty well sold. It is asserted that they are holding a certain portion of their tonnage for an expected increase in price.

Quotations on *graphite* remained unchanged during the week. Mexican amorphous graphite is being sold at $55@$60 per short ton; Korean, 3¾c. per lb.; Madagascar, 9c.; Ceylon, 4¾@16c., according to quality.

Feldspar is still in a nominal position; material is piling up at the mill with no transportation facilities available. The price holds firm at $13.50@$18 per ton.

Chicago, Ill., April 28, 1920.

In any report of existing market conditions, full recognition must be given the abnormal state of affairs due to the transportation troubles of the past few weeks. The chemical industry, in common with most others, was affected in two ways, viz.: Inability of manufacturers to ship completed products and the additional time consumed in securing delivery on shipments in transit have materially increased the money burden which the producer has to carry; the great reduction in the volume of receipts in Chicago has produced almost famine conditions in many lines, and prices, when quoted, are either nominal or greatly inflated.

Today's reports are to the effect that the strike is a failure and that the railroads are operating at a high percentage of normal. Even if this is true, it will take a good while to untangle the physical tie-up of cars and longer to get dealers' stocks and users' reserve stocks back on a normal basis. Frequently exhausted stocks mean sky-high prices. Now, however, consumers apparently recognize the futility of attempting to do the impossible, and actual demand is about as light as supply. As a result, prices are stationary. This maintains the market on a sane basis for the resumption of trading when traffic begins to move. What few fluctuations have been noted are in an upward direction.

Heavy Chemicals

The alkali products continue to lead in demand and, while current quotations are nominal, there is no doubt that this line is getting stiffer every day. With makers all booked to capacity for months ahead and with local stocks exhausted, further advances seem probable. It being distinctly a sellers' market, quotations are above those of two weeks ago. *Caustic soda* is going on contract for future delivery at 6½@7c. in cars f.o.b. works. Producers report output hardly sufficient to cover contracts, so spots will be scarce and high for some time. *Soda ash* is nominally quoted at from 3¾@4½c., average being about $3.85 per cwt. Some few small local transactions were recorded at about 4¼c. per lb. Production of *bleaching powder* seems less than market requirements, drums are hard to get and transportation tied up. Current quotation for carloads at factory is 4@4½c. per lb. The same applies to *sal soda*, on which quotations are heard ranging from $1.35 per cwt., f.o.b. factory, to $1.60 per cwt. out of depleted stocks.

The market on various grades of *alcohol* goes through the motions of making quotations. There being practically no goods, they mean but little. *Ethyl* grade is quoted at $4.85@$5.50 per gal. for delivery "when possible," and current actual transactions range all the way from $6 to $8. The quotation on *methyl* remains unchanged at $3 per gal. for 190 proof. The same is true of *denatured* at $1 per gal. There is no definite market for *formaldehyde*, each sale being the subject of negotiation. Only small lots are changing hands, transactions being in the neighborhood of 65c. per lb.

Previously noted interest in *glycerine* continued, 26c. per lb. being current on c.p. grade. *Aqua ammonia*, held firm by producers at 8¼c. per lb., has been run up in spot transactions to above 10c. in some cases. This high price does not seem justifiable. *Sal ammoniac*, unchanged at 16c. per lb. for white granulated, remains in heavy demand. Old contracts for *chlorine* are now being covered by withdrawals. New contracts are offered at 8⅛@8⅜c. per lb., while spots stand at about 8½c. Former firmness in *sodium nitrite* remains, today's price being 26c. per lb.

Acid stocks are practically exhausted. The long-continued weakness of these prices seems to have been corrected by the present shortage, and while no advances of moment are noted, it is believed that when conditions return to normal, existing quotations will be firmly maintained. Transactions in spots are so small as to be negligible, hence no prices are quoted at this time.

Coal-Tar Products

With shortages in crudes, intermediates and derivatives all more acute than ever before, and with all current transactions being influenced by conditions altogether abnormal, it seems useless to attempt to name prices on coal-tar products which are, at best, purely nominal. It is sufficient to say that, with makers of crudes sold up far in advance, the market bids fair to hold firm. The same is true of intermediates, with the added fact that holders of supplies are offering them, and in some cases closing sales, on excessive prices.

Vegetable Oils

The impossibility of securing goods is only equaled by the lack of buying interest, in vegetable oils, a combination which leaves a market almost wholly devoid of interest. With an uncertain future ahead on *linseed oil*, $2.05 per gal. is being quoted in barrels, f.o.b. Chicago, and $1.82½ in cars in bulk. These prices are practically the same as those of four weeks ago. Current quotation on *cottonseed oil* is, for crude, 17c. per gal., prime summer yellow, 18c. per gal., sellers' tanks. *Cocoanut oil* in sellers' tanks, f.o.b. coast, is quoted at 17¼c. for Manila grade, and *corn oil* in tanks for local delivery at 16c. In general, these quotations are nominal, there being but few actual transactions.

Flotation Oils—Naval Stores

Although Savannah price is down to $1.91 per gal. on *turpentine*, the local market has failed to follow, the price being maintained at $2.57 per gal. in barrels, $2.40 in cars. This is justified by the fact that Chicago stocks are completely exhausted and it has not yet been possible to secure local delivery on any of the recent shipments from the South. Jobbers are forced to trace their cars and, upon locating them in Hammond, Gary, East Chicago or wherever they may be resting, send motor trucks to bring the goods on into the city. Thus an enormous addition is put on the cost. It is a condition that may be relieved any day, at which time the price will drop materially. Consumers, aware of the facts, are buying only such supply as is their absolute immediate requirement. There being no supply of flotation oils, hence no trading, nominal quotations show no change from a fortnight ago. The same is true of rosin in the various grades.

Fertilizers

The very great curtailment of operations in the stock yards occasioned by the railroad troubles served to cut off both production and demand. Such quotations as are available are of no value as transactions are practically nil.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	–	$0.65 – $0.75
Acetone	lb.	$0.19 – $0.20	.21 .22
Acid, acetic, 28 per cent.	cwt.	3.50 – 4.00	4.00 –
Acetic, 56 per cent	cwt.	6.50 – 7.00	8.75 – 9.00
Acetic, glacial, 99½ per cent. carboy	cwt.	15.50 – 16.00	16.50 – 17.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 .86	1.17 1.18
Hydrochloric (nominal)	lb.	.08 –	.09 – .10
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.14 –
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P.	lb.	–	4.00 –
Nitric, 40 deg.	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg.	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.58 – .59
Phosphoric, Ortho, 50 per cent solution	lb.	.22 – 23	24 – .25
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 18.00	–
Sulphuric, 60 deg., drums	ton	–	–
Sulphuric, 66 deg., tank cars	ton	22.00 – 25.00	–
Sulphuric, 66 deg., drums	ton	35.00 – 40.00	–
Sulphuric, 66 deg., carboys	ton	36.00 – 40.00	–
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P.	lb.	1.50 – 1.60	1.65 – 1.70
Tannic (tech.)	lb.	–	.60 – .90
Tartaric, crystals	lb.	–	.75 – .80
Tungstic, per lb. of WO	lb.	–	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.50 – 3.50	–
Alcohol, denatured, 188 proof (nominal)	gal.	–	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	–	.98 – 1.02
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08½	.09 – .09½
Alum, chrome lump	lb.	.17 – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03¼ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.08½ – .12	–
Ammonium sulphate	lb.	.07 – .08	.08½ –
Amylacetate	gal.	–	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	–	.13½ – .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	–
Barium chloride (nominal)	ton	150 00–160 00	165.00 – 175.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.10 – .11	.11 .12
Barium sulphate (precip.) (blanc fixe)	lb.	.03 – .03½	.05½ – .06
Bleaching powder (see calcium hypochlorite)		–	–
Blue vitriol (see copper sulphate)		–	–
Borax (see sodium borate)		–	–
Brimstone (see sulphur, roll)		–	–
Bromine	lb.	.85 – .90	–
Calcium acetate	cwt.	2.00 – 2.05	2.10 –
Calcium carbide	lb.	.04½ – .04½	.04¾ – .05½
Calcium chloride, fused, lump	ton	22.00 – 25.00	30.00 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.35 – 5.00
Calcium peroxide	lb.	–	1.50 – 1.70
Calcium phosphate, monobasic	lb.	–	.75 – .80
Calcium sulphate, pure	lb.	–	.25 – .30
Carbon bisulphide	lb.	.07 – .08	.09 – .10
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	–	.80 – 1.05
Caustic potash (see potassium hydroxide)		–	–
Caustic soda (see sodium hydroxide)		–	–
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.07½ – .08	.08½ – .09
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	–	2.00 – 2.05
Copperas (see iron sulphate)		–	–
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	–	.65 – .70
Copper sulphate, crystals	lb.	.08½ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		–	–
Epsom salt (see magnesium sulphate)		–	–
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)		–	–
Glycerine	lb.	–	.24½ – .26
Iodine, resublimed	lb.	–	4.35 – 4.40
Iron oxide, red	lb.	–	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	.14 – .14½	.15 – .18
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	–	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	–	1.50 –
Magnesium carbonate, technical	lb.	–	.12 – .14½
Magnesium sulphate, U. S. P.	100 lb.	3.50 3.55	3.60 – 4.25
Magnesium sulphate, commercial	100 lb.	–	3.25 – 3.60
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.16 – .17	.17½ –
Phosgene (see carbonyl chloride)		–	–
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	–	.35 – .37
Potassium bichromate	lb.	.36 – .37	.40 – .46
Potassium bitartrate (cream of Tartar)	lb.	.53 – .56	.57 .58
Potassium bromide, granular	lb.	–	.85 .90
Potassium carbonate, U. S. P.	lb.	–	.85 .88
Potassium carbonate, crude	lb.	.21 – .25	.26 .28
Potassium chlorate, crystals	lb.	.14 – .16	.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .35
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	–	.65 – .95
Potassium prussiate, red	lb.	$0.90 $1.00	$1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.38 – $0.41
Potassium sulphate (powdered)	ton	$225.00 – 240.00	–
Rochelle salts (see sodium potas. tartrate)		–	–
Salammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)		–	–
Salt cake	ton	28.00 – 32.00	–
Silver cyanide (nominal)	oz.	–	1.25 –
Silver nitrate (nominal)	oz.	–	.74 .74
Soda ash, light	100 lb.	–	3.50 3.60
Soda ash, dense	100 lb.	–	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09½ – .10
Sodium bicarbonate	100 lb.	2.25 2.60	2.75 – 3.00
Sodium bichromate	lb.	.39 – .41	.42 .43
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 .07½
Sodium borate (borax)	lb.	.09 – .10	.10½
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	–	.12 – .14
Sodium cyanide, 96-98 per cent.	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.50 – 5.50	7.00 – 7.50
Sodium hyposulphite	lb.	–	.03 .04
Sodium molybdate	lb.	2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.22 – .24	.24 – .25
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .2	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.50 – 1.70	1.75 – 2.00
Sodium sulphide, crystal, 60–62 per cent (cone)	lb.	.09 .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.23 – .24	.25 – .26
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 –
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.13 –	.13½ – .15
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ .12½	.13 – .15
Zinc oxide, U. S. P.	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 — $1.10
Alpha naphthol, refined	lb.	1.40 — 1.60
Alpha naphthylamine	lb.	.40 — .50
Aniline oil, drums extra	lb.	.34 — .45
Aniline salts	lb.	.46 — .50
Anthracene, 80% in drums (100 lb.)	lb.	.90 — 1.00
Benzaldehyde (f.f.c.)	lb.	2.00 — 2.10
Benzidine, base	lb.	1.25 — 1.35
Benzidine, sulphate	lb.	1.20 — 1.25
Benzoic acid, U. S. P.	lb.	.90 — 1.10
Benzoate of soda, U.S.P.	lb.	.80 — 1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 — .36
Benzol, 90%, in drums (100 lb.)	gal.	.25 — .31
Benzyl chloride, 95-97%, refined	lb.	.35 — .40
Benzyl chloride, tech.	lb.	.25 — .35
Beta naphthol benzoate	lb.	.50 — .65
Beta naphthol, sublimed	lb.	.70 — .90
Beta naphthol, tech.	lb.	.45 — .55
Beta naphthylamine, sublimed	lb.	2.25 — 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 — .19
Ortho-cresol, in drums (100 lb.)	lb.	.23 — .25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 — 1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 — 1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 — .75
Dichlorbenzol	lb.	.08 — .10
Diethylaniline	lb.	1.40 — 1.50
Dimethylaniline (nominal)	lb.	—
Dinitrobenzol	lb.	.30 — .37
Dinitroclorbenzol	lb.	.25 — .30
Dinitronaphthaline	lb.	.45 — .55
Dinitrophenol	lb.	.34 — .36
Dinitrotoluol	lb.	.40 — .45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 — .40
Diphenylamine (nominal)	lb.	.55 — .65
H-acid (non inal)	lb.	2.25 — 2.50
Metaphenylenediamine	lb.	1.15 — 1.80
Monochlorbenzol	lb.	.12 — .15
Monoethylaniline	lb.	.70 — 1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	.15 —
Naphthaline, flake	lb.	.15 —
Naphthaline, balls	lb.	.15 —
Naphthionic acid, crude	lb.	.70 — .85
Nitrobenzol	lb.	.14 — .19
Nitro-naphthaline	lb.	.40 — .50
Nitro-toluol	lb.	.20 — .30
Ortho-amidophenol	lb.	3.75 — 4.25
Ortho-dichlor benzol	lb.	.15 — .20
Orthonitrophenol	lb.	.80 — 1.25
Ortho-nitro-toluol	lb.	.25 — .40
Ortho-toluidine	lb.	.25 — .45
Para-amidophenol, base	lb.	2.50 — 3.50
Para-amidophenol, HCl	lb.	2.50 — 3.25
Para-dichlor-benzol	lb.	.08 — .12
Paranitraniline	lb.	1.65 —
Para-nitro-toluol	lb.	1.55 — 1.60
Paraphenylenediamine	lb.	2.60 — 3.00
Paratoluidine	lb.	2.00 — 2.50
Phthalic anhydride	lb.	.65 — .75
Phenol, U. S. P., drums (about 240 lb.)	lb.	.12 — .25
Pyridin	gal.	.90 — 2.50
Resorcin, technical	lb.	4.25 — 4.50
Resorcin, pure	lb.	5.25 — 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.50 — .52
Salicylic acid, U. S. P.	lb.	.55 — .60
Salol	lb.	.90 — 1.00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.25	—	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.38	—	$0.39
Beeswax, refined, light	lb.	.40	—	.41
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1. (nominal)	lb.	.80	—	.88
Carnauba, No. 2, regular (nominal)	lb.	.60	—	.70
Carnauba, No. 3, North Country (nominal) . . †	lb.	.45	—	.46
Japan	lb.	.21	—	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.09¾
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.11¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.....	—	.13½
Paraffine waxes, refined, 133-135 m.p.	lb.	.14	—	.15
Paraffine waxes, refined, 135-137 m.p.	lb.	.16	—	.16½
Stearic acid, single pressed	lb.	.26	—	.27
Stearic acid, double pressed	lb.	.32	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref	gal.	.52

*Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$16.95	—	$18.75
Rosin E-I	280 lb.	18.75	—	19.00
Rosin K-N	280 lb.	19.00	—	21.00
Rosin W. G.-W. W	280 lb.	20.50	—	21.50
Wood rosin, bbl	280 lb.	15.50	—	18.50
Spirits of turpentine	gal.	.....	—	2.50
Wood turpentine, steam dist	gal.	2.35	—	2.40
Wood turpentine, dest. dist	gal.	.....	—	2.00
Pine tar pitch, bbl	200 lb.	8.40	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.92	—	.95
Rosin oil, second run	gal.	.94	—	.97
Rosin oil, third run	gal.	1.00	—	1.05
Rosin oil, fourth run	gal.	1.10	—	1.15

* (See New York market letter)

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½	—	$0.42
Upriver coarse	lb.	.30½	—	.32
Upriver caucho ball	lb.	.32½	—	.33
Plantation—First latex crepe	lb.	.44	—	.45
Ribbed smoked sheets	lb.	.44½	—	....
Brown crepe, thin, clean	lb.	.42	—	....
Amber crepe No. 1	lb.	.40½	—	.41½

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls	lb.	.20	—	.23
China wood oil, in bbls	lb.	.24	—	.24½
Cocoanut oil, Ceylon grade, in bbls	lb.	.18½	—	.19½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.20	—	.21
Corn oil, crude, in bbls	lb.	.17¾	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.16	—	.17
Cottonseed oil, summer yellow	lb.	.18½	—	.19
Cottonseed oil, winter yellow	lb.	.21	—	.23
Linseed oil, raw, car lots	gal.	1.84	—	...
Linseed oil, raw, tank cars	gal.	1.79	—	...
Linseed oil, boiled, car lots	gal.	1.87	—	...
Olive oil, commercial	gal.	2.75	—	3.00
Palm, Lagos	lb.	.15½	—	.16½
Palm, bright red	lb.	.14½	—	.17½
Palm, Niger	lb.	.14	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.23
Peanut oil, refined, in bbls	lb.	.25	—	.26
Rapeseed oil, refined in bbls	gal.	1.62	—	1.64
Rapeseed oil, blown, in bbls	gal.	1.68	—	1.70
Soya bean oil (Manchurian), in bbls N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14	—	.14½

WH. FISH

f.o.b. [illegible] pressed Menhaden	gal.	$1.17	—	$1.18
[illegible] bleached Menhaden	gal.	1.20	—	1.22
bleached Menhaden	gal.	1.23	—	1.24
[illegible]haden	gal.	1.34	—	1.36

York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$38.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Blanc fixe, dry	lb.	.04½	—	.05½
Blanc fixe, pulp	ton	30.00	—	50.00
Casein	lb.	.15	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50	—	18.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, New	net ton	30.00	—	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00	—	65.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	.07½
Graphite, crucible, 86% carbon content	lb.	.....	—	.08
Graphite, crucible, 87% carbon content	lb.	.....	—	.08½
Graphite, crucible, 88% carbon content	lb.	.....	—	.09
Graphite, crucible, 89% carbon content	lb.	.....	—	.09½
Graphite, crucible, 90% carbon content	lb.	.....	—	.10
Graphite, crucible, 91% carbon content	lb.	.....	—	.10½
Graphite, crucible, 92% carbon content	lb.	.....	—	.11
Graphite, crucible, plus 92%	lb.	.....	—	.12½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, orange, fine, nominal	lb.	1.50	—	....
Shellac, orange, superfine	lb.	1.60	—	1.65
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	20.00	—	30.00
Talc, imported	ton	60.00	—	70.00

*Nominal

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.22
Ferro-manganese, 70-80% Mn	gross ton	200.00	—	250.00
Spiegeleisen, 16-20% Mn	gross ton	60.00	—	65.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25	—	2.75
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	200.00
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	.90	—	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V	lb.	6.50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70	—	$0.85
Chrome ore, 48% and over	unit	1.00	—	1.25
Coke, foundry, f.o.b. ovens	net ton	12.00	—	14.00
Coke, furnace, f.o.b. ovens	net ton	11.00	—	12.00
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00	—	30.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	.....
Rutile, 95% TiO_2	lb.	.11	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.65
Rivets, structural, ¾-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.85
Sheets, No. 10 blue annealed	100 lb.	4.00
Sheets, No. 28 galvanized	100 lb.	6.20

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

SALINAS—The Bd. Educ. plans to build a 2-story high school here. A chemical laboratory will be installed in same. Wyckoff & White, archts.

Connecticut

MIDDLETOWN — Henry Bacon, 101 Park Ave., New York City, archt. and engr., will receive bids until May 23 for the construction of a 2-story chemical laboratory for the Wesleyan University, 374 High St. Estimated cost, $500,000. Noted March 10.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Dept., plans to build an aëronautical engine-testing laboratory.

Illinois

CHICAGO—The Columbia Colortype Co. is building a 6-story, 123 x 177-ft. building on the northeast corner of Calumet Ave. and 21st St. Estimated cost, $600,000. R. C. Wieboldt, 1534 West Van Buren St., contractor.

KEWANEE—The Kewanee Boiler Co. has awarded the contract for the construction of plant extensions including new 80 x 1,750-ft. buildings, to the Lackawanna Bridge Co.

Iowa

CUSHING—The city has awarded the contract for the construction of a sewage disposal plant to Ward & Weighton, 516-17 Davidson Bldg., Sioux City, at $10,995.

DANA—The Bd. Educ. will receive bids until May 17 for the construction of a 2-story, 56 x 86-ft. consolidated school building. A chemical laboratory for general work will be installed in same. Estimated cost, $100,000. Guy Meredith, secy. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, archts.

DES MOINES—The Dempster Mfg. & Supply Co., 201 East Court Ave., has awarded the contract for the construction of a 1-story, 120 x 180-ft. foundry and machine shop on East Court Ave., to A. H. Neumann & Co., 519 Hubbell Bldg. Estimated cost, $100,000.

GILMAN—The School Bd. is having preliminary plans prepared for the construction of a 2-story consolidated school. A chemical laboratory will be installed in same. Estimated cost, $100,000. R. J. Paul, pres. Keffer & Jones, 204 Masonic Temple, Des Moines, archts.

GOWRIE—The Bd. Educ. is having preliminary plans prepared for the construction of a 3-story, 65 x 100-ft. school building. A general chemical laboratory will be installed in same. Estimated cost. $125,000. Clarence Strand, secy. Keffer & Jones, 204 Masonic Temple, Des Moines, archts.

MEDIAPOLIS—The Bd. Educ. is having preliminary plans prepared for the construction of a 3-story consolidated school. A chemical laboratory will be installed in same. Estimated cost, $160,000. J. E. Berry, secy. Keffer & Jones, 204 Masonic Temple, Des Moines, archts.

MORNING SUN—The Bd. Educ. will receive bids until May 8 for the construction of a 2-story, 56 x 130-ft. school building. A general chemical laboratory will be installed in same. Estimated cost, $200,000. O. F. Beller, secy. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, archts.

PACKWOOD—N. E. Olliver, secy. of the Bd. Educ., will receive bids until May 7 for the construction of a 2-story, 58 x 99-ft. school building. A general chemical laboratory will be installed in same. Estimated cost, $125,000. W. E. Hulse & Co., 210 Masonic Temple, Des Moines, archts.

YARMOUTH—The Bd. Educ. is having preliminary plans prepared for the construction of a 3-story consolidated school. A chemical laboratory will be installed in same. Estimated cost, $100,000. C. C. Featherby, secy. Keffer & Jones, 204 Masonic Temple, Des Moines, archts.

Kansas

OSAWATOMIE—The Missouri Pacific Ry. plans to build a modern water treating plant, here. Estimated cost, $61,700.

Kentucky

LOUISVILLE—The Stoll Oil Refining Co., 733 River Road, will build a 1-story, 44 x 60-ft. filter house and is in the market for filter house machinery, etc. Work will be done by day labor.

Maryland

BALTIMORE—C. M. Anderson, arch., 324 North Charles St., will soon award the contract for the construction of a 3-story, 61 x 76-ft., addition to tinware enameling and stamping plant for the Natl. Enameling & Stamping Co., Race and Ostend Sts. Estimated cost, $100,000.

CURTIS BAY (Baltimore P.O.)—The Union Acid Wks. have awarded the contract for the construction of a 2-story, 200 x 500-ft. acid plant on Aspin and Railroad Aves., to the Whiting-Turner Constr. Co., Stewart Bldg., Baltimore. Estimated cost, $200,000. Noted Jan. 14.

HAGERSTOWN—The Washington Co. School Comrs., Courthouse, are having plans prepared for the construction of a high school. A chemical laboratory will be installed in same. Estimated cost $150,000. R. E. Staley, 247 South Prospect St., supt. A. J. Klinkhart, 54 West Washington St., archt.

Massachusetts

CAMBRIDGE—The Lever Bros. Co., Portland St., has awarded the contract for the construction of a 6-story, 90 x 190-ft. factory for the manufacture of soaps, to the Stone & Webster Eng. Corps., 147 Milk St., Boston. Estimated cost, $350,000.

CHELSEA—Leon E. Gingras, 156 Marginal St., has awarded the contract for the complete remodeling of tannery building on Marginal St., to Tuck & Gilman, 34 School St., Boston. Estimated cost, $65,000.

HOLYOKE—The Hampden Glazed Paper & Card Co., Riverside, has awarded the contract for the construction of a 2-story manufacturing plant, to the Casper Ranger Constr. Co., 2 Bond St. Noted May 4.

NATICK—The New England Pressed Steel Co. has awarded the contract for the construction of a 1-story, 55 x 85 ft. factory addition, to A. Jensen Co., Sawin St. Estimated cost, $25,000. Noted March 31.

WEST SPRINGFIELD (Springfield P. O.)—McClintock & Craig, engrs., 33 Lyman St., Springfield, will soon award the contract for the construction of a 1-story, 90 x 200-ft. factory for the manufacture of electrical specialties, for the Wico Electric Co., 44 Avon Place. Estimated cost, $75,000. Phelps Brown, pres.

Michigan

MARYSVILLE—The village is having plans prepared for the construction of a semi-permanent water supply system consisting of pumping station, filtration plant, etc. Estimated cost, $200,000. Robert Gordon, engr.

Minnesota

FOREST LAKE—The Bd. Educ. plans to install a chemical laboratory in the new high school here. Foss & Foss, St. Cloud, archts.

JAMESVILLE—The village will receive bids until May 7 for the construction of a sewage disposal plant consisting of an Imhoff tank, etc. R. R. Brown, village recdr.

OLIVIA—The Bd. Educ. is having plans for the construction of a 2-story high school here. A chemical laboratory will be installed in same. Estimated cost, $185,000. W. L. Alban, Endicott Bldg., St. Paul, archt. Terry Schulte Eng. Co., Endicott Bldg., St. Paul, engr. Bonds have been voted for the project.

SACRED HEART — The Independent School Dist. 40 rejected all bids for the construction of a 2-story high school here. A chemical laboratory will be installed in same. W. L. Alban, 347 Endicott Bldg., St. Paul, archt. Terry Schulte Eng. Co., 484 Endicott Bldg., St. Paul, Engr.

Missouri

ST. LOUIS—W. R. Coney & Co., New York City, have purchased the plant of the Mutual Brewery Co. on the northeast corner of Boyle and Duncan Aves., here, and plan to convert same for bleaching and coloring materials.

ST. LOUIS—The Crunden Martin Mfg. Co., 21st and Gratiot Sts., plans to build a 6-story factory building on the southeast corner of 2nd and Cedar Sts. The building will be used to house a manufacturing plant for galvanized enamel ware. Estimated cost, $500,000.

ST. LOUIS—The General Electric Co., Pierce Bldg., is building a plant for the manufacture of electric light bulbs on the corner of Union and Brown Aves. Estimated cost, $300,000.

Nevada

FALLON—The Humboldt Potash Co. plans to construct a large chemical plant, here. The plant will operate on potash from the extensive deposits in the Dixie Valley. The New York Syndicate has secured control of 36,000 acres in the Dixie Valley and plans to build first unit of plant on same.

New Jersey

NEWARK—The Amer. Brake Shoe Co., 30 Church St., New York City, has awarded the contract for the construction of a 1-story foundry on Ave. L between Mary and Paris Sts., to James Stewart, 30 Church St., New York City. Foundry equipment will be installed in same. Estimated cost, $400,000.

New York

BUFFALO—The Amer. Brass Co., Grand and Meadow Sts., Waterbury, Conn., will build a 165 x 650-ft. rolling mill at 446 Military Rd. Estimated cost, $600,000. Work will be done by day labor.

BUFFALO—The Dept. of Pub. Wks. received bids for the delivery of 80,000 lb. of liquid chlorine from the Mathieson Alkali Wks., Inc., 25 West 43rd St., New York City, $5,920; Electric Bleaching Gas Co., 18 East 41st St., New York City, $5,920; Hooker Electrochemical Co., 25 Pine St., New York City, $5,968. Noted April 14.

BUFFALO—The Donner Union Coke Corp., Abbey and Bell Sts., has filed plans to construct a 1-story, 8 x 28 x 31-ft. steel laboratory and a 1-story, 15 x 17 x 26-ft. first aid building. Estimated cost, $10,000.

BUFFALO—The General Drop Forge Co. has awarded the contract for the construction of a 1-story, 60 x 100-ft. forge shop and a 1-story, 100 x 100-ft. heat treating plant, to J. C. Cowper Co., Fidelity Bldg. Estimated cost, $200,000.

GREYCOURT—The Comr. of Correction, Municipal Bldg., will receive bids until May 7 for the furnishing of all labor and material for the construction of a sewage disposal plant for the New York City Women's Farm Colony, here.

JAMAICA—The A. L. Read Co., Jamaica Ave. and 121st St., Richmond Hill, has awarded the contract for the construction of a 2-story, 70 x 125-ft. leather factory, to Barney Ahlers, 110 West 40th St., New York City Estimated cost, $75,000.

LONG ISLAND CITY—The Elcaya Co., 148 Madison Ave., New York City, plans to build a 4-story laboratory on First St. between Reeve and Freeman Aves., here.

LONG ISLAND CITY—S. L. Reily, archt. and engr., 112 West Adams St., Chicago, Ill., will soon award the contract for the construction of a 4-story factory for the manufacture of oil products, for the P. Van Iderstine Construction Co., Greenpoint Ave.

SYRACUSE—The M. L. Oberdorfer Brass Co., 804 East Water St., has awarded the contract for the construction of a brass factory at Messina Springs, to the A. & T. Constr. & Eng. Co., 115 South Salina St. Estimated cost, $500,000. Noted Feb. 25.

North Carolina

CHERRYVILLE—The Cherryville Foundry Wks. has plans prepared for the construction of a foundry for the manufacture of gray iron castings. C. C. Dellinger, prop.

North Dakota

McVILLE—The Council has awarded the contract for furnishing a concrete septic tank, etc., to Gedney & Murphy, Fargo, at $25,877. Noted April 21.

Ohio

CANTON—The Superior Sheet Steel Co. plans to build a 1-story 120 x 500-ft. steel building on Louisville Rd. Estimated cost, $200,000.

CLEVELAND — The city will soon award the contract for the construction of a filtration plant, etc., at Baldwin. Estimated cost, $200,000. A. V. Ruggles, City Hall, engr. Noted March 23.

WARREN—The Warren Iron & Steel Co. is having plans prepared for the construction of a 1-story, 120 x 300-ft. rolling mill. Estimated cost, $150,000. Watson Eng. Co., Hippodrome Bldg., Cleveland, archt. and engr.

Oklahoma

HENRYETTA — C. A. Strecker, Oklahoma City, plans to remodel plant recently purchased here and equip it with the Duwell process for refining gasoline, naphtha and kerosene.

PRYOR—The city voted $35,000 bonds to improve waterworks, including purification plant, etc. V. V. Long & Co., Colcord Bldg., Oklahoma City, engr.

TULSA—The Oklahoma Steel Castings Co. has purchased a 9½-acre site west of Pearl St. and south and east of the Santa Fe R.R. Company's main line and plans to construct a plant on same. The company will manufacture steel castings of either acid or basic steel for the oil industry, etc. Estimated cost, $100,000. Clarence B. Douglas, mgr.

Pennsylvania

JEANETTE—The Amer. Window Glass Co., Farm Bank Bldg., Pittsburgh, is having plans prepared for the construction of a 1-story, 42 x 182-ft. building.

PITTSBURGH—The McKenna Brass & Mfg. Co., 1st and Ross Sts., plans to build a 4-story, 53 x 80-ft. addition to present plant. Estimated cost, $175,000. James T. Steen & Sons, Fulton Bldg., archts.

ROCHESTER—The H. C. Fry Glass Co. has awarded the contract for the construction of a 1-story, 80 x 200-ft. glass factory to the Austin Co., Union Arcade, Pittsburgh. Estimated cost, $110 000.

Rhode Island

PAWTUCKET—The Fales & Jenks Machine Co., 320 Dexter St., has awarded the contract for the construction of a 3-story, 45 x 80-ft. manufacturing building addition on Pine St., to Willmarth Mackillop, Inc., Freeman St. Estimated cost, $50,000.

South Carolina

GREENWOOD—The Bd. Educ. plans to build a 3-story college for women. A chemical laboratory will be installed in same. Estimated cost, $100,000 T. W. Cothran, contg. engr.

Texas

BASTROP—The city will soon receive bids for the construction of a 2-story, 58 x 60-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $30,000. H. F. Kuehne, 824 Littlefield Bldg., Austin, archt.

DALLAS—The Eastland Oil & Refining Co., Security Natl. Bank Bldg., is having plans prepared for the construction of a lubricating unit to oil refinery, including equipment for refining oil and preparing lubricating oil as one of the products. Estimated cost, $350,000. H. P. Williford, 3501 Harvard Ave., engr.

DALLAS—The School Bd. is having plans prepared for the construction of a 3-story high school on Haskell and McKinney Sts. Chemical laboratory equipment will be installed in same. Estimated cost, $250,000. W. B. Ittner, Bd. Educ. Bldg., St. Louis, Mo., archt.

MEMPHIS—The Memphis Cotton Oil Co. will soon receive bids for rebuilding main building which was recently destroyed by fire and installing new machinery in same. Estimated cost, $200,000

MERCEDES—The Independent School Dist. is having plans prepared for the construction of a 1-story, 157 x 217-ft. high school here. A chemical laboratory will be installed in same. Estimated cost, $75,000. H. F. Kuehne, 824 Littlefield Bldg., Austin, archt.

NECESSITY (Caddo P.O.)—The Alamo Refining Co., Eastland, plans to purchase a 5-acre site and build a plant on same. The plant will be built on a unit basis. J. R. Evans, mgr. G. B. Dartoise, chief engr.

West Virginia

CLARKSBURG—The Bd. Educ. will soon award the contract for the construction of a junior high school. A chemical laboratory will be installed in same. J. N. Hess, Empire Bank Bldg., secy.

Wisconsin

KENOSHA—Allen Sons Co., North Main St., is having plans prepared for the construction of a sewage disposal plant. Estimated cost, $50,000. Vaughn & Meyer, Security Bldg., Milwaukee, engrs.

SHEBOYGAN FALLS—C. S. Weisse Tanning Co. will build a 3-story, 84 x 248-ft. tannery on Buffalo St. Estimated cost, $150,000. Work will be done by day labor. Noted April 21.

ST. CROIX FALLS—The Bd. Educ. engaged W. L. Alban, archt., 347 Endicott Bldg., St. Paul, to prepare plans for the construction of a 2-story, 53 x 90-ft. high school, here. A chemical laboratory will be installed in same. Estimated cost, $75,000. F. R. Nash, principal.

Ontario

ELMIRA—The city plans to construct a sewerage system. Septic tanks will probably be installed in same. Estimated cost, $30,000. H. Johnston, Kitchener, engr.

TORONTO—The Barrett Co., 17 Battery Pl., New York City, has awarded the contract for the construction of a roofing factory, to James Stewart, 30 Church St., New York City. Estimated cost, $400,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold its sixth annual convention at the Planters Hotel in St. Louis, May 10 and 11.

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept, 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold regular meetings on May 7 and June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS will meet in St. Louis May 27 to 29.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18, inclusive.

THE AMERICAN ZINC INSTITUTE will hold its spring meeting May 10 and 11 at the Congress Hotel, Chicago, Ill.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK announces the following lectures for the spring semester of 1920 to be delivered in the Doremus Lecture Theater: "Chemical Naval Warfare," Friday, May 7, at 4 p.m., Prof. James Kendall, professor of chemistry at Columbia University; "Fighting Fire—Firefoam," Friday, May 14, at 4 p.m., F. A. Epps. chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA plans to hold its annual convention in the Auditorium Theater, Chicago, Ill., May 19, 20 and 21.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (London) will hold its annual meeting May 6 and 7, 1920, at the House of the Institute of Civil Engineers, Great George St., London, S. W. 1. The retiring president, Eugene Schneider, will induct into the chair Dr. J. E. Stead, the president-elect. The autumn meeting of the Iron and Steel Institute (British) will be held at Cardiff, by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE MINE INSPECTORS' INSTITUTE OF AMERICA will hold a meeting at Cleveland, Ohio, July 13, 14 and 15.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 and 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NEW JERSEY CHEMICAL SOCIETY plans the following: Monday evening, May 10, regular meeting; Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J., regular meeting and ladies' day.

THE SOCIÉTÉ CHIMIE INDUSTRIELLE will hold a meeting at the Chemists' Club, May 14.

THE SOCIETY OF COTTON PRODUCTS ANALYSTS will hold its eleventh annual conventoin at the Grunewald Hotel, New Orleans, La., May 10 and 11.

THE SOCIETY OF CHEMICAL INDUSTRY, American Section, will hold a meeting, May 21, at the Chemists' Club.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

THE TAYLOR SOCIETY, the national organization for the promotion of scientific management in industry, will hold a meeting May 6, 7 and 8 at Rochester, N. Y., under the auspices of the Industrial Management Council and the Manufacturers' Council of the Rochester Chamber of Commerce.

Industrial Notes

HOLZ & Co., metallurgical engineers and dealers in testing equipment, announce the organization of a filtration department. The new department, under the management of Frank H. Lowenfels, is prepared to supply or prepare specifications for all types of laboratory and plant filtration equipment. In connection with this service, a complete line of Franklin filter paper will be placed on the market.

THE B. F. GOODRICH RUBBER CO. has equipped the grain elevator of the Pennsylvania R.R. at Canton, near Baltimore, with approximately 8½ miles of conveyor belting. This represents the largest single order of belting ever shipped, and it required seven box cars to transport it from Akron to Baltimore. The belting totaled 44,254 ft. and weighed 131 tons. The capacity of one of the 48-in. horizontal carrier belts is 350,000 bushels of grain in a 10-hr. day.

THE MATHIESON ALKALI WORKS, INC., announces that it is handling direct the sales of all its products, and that the executive and general sales offices have been moved from Providence, R. I., to 25 West 43d St., New York City.

THE ST. LOUIS DRUG AND CHEMICAL CLUB has been formed in St. Louis, Mo., with 100 charter members.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. MATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 | New York, May 12, 1920 | *Number* 19

The One And T'other

TWO members of the editorial staff were in conference. We shall refer to them as One and T'other. "I don't know whether my reading has been ill-chosen or not," said One, "but somehow I find little in current journals except complaint and grumbling about persons and parties in opposition. The only agreement I find is that everything is going to the devil, and, to prove it, it seems as if any old argument would do. If I look into the *New Republic* it almost appears as if the cats and dogs were upon us because we do not invite the cats and dogs to have their way and rule us, whereas from the *Review* I gather that the great threat of our dissolution is the healing balm of the *New Republic.* That the Hearst papers should stir up hatred and anger is to be expected, for this is their meat and drink; but publications that have heretofore been edited with conscience are charging either President WILSON or Senator LODGE with guilt for all the evils that may come upon us. Have we become a nation of common scolds? Have we no more constructive minds? Were our thinking men killed in the war?

"All this leads me to believe that it is high time for us to take a hitch in our belts; to put an end to unceasing complaint and to think up things that are worth while. The way to get out of misery is to plan to get out of it, and it looks to me as if most present efforts were addressed to inviting it to come in and overwhelm us. That would prove the contentions and fulfill the prophecies of nearly everybody. This thing is unwholesome and it doesn't help a little bit. Don't you think it would be timely to sound the slogan to call for more ideas and less poison gas? The blamed thing is getting on my nerves! I feel that people should turn over a new leaf and attend to business. Then we may find that things are not so threatening after all, provided always intelligent persons will use their heads rather than their wrath.

"The subject isn't exactly within our province, but I think the idea should be put over. What do you think about it?"

T'other editor spoke of the complimentary dinner given at the Waldorf to HENRY P. DAVISON on the preceding Saturday night. One had not been there, while T'other had, and the latter said that he too had had the material for an editorial in the back of his head, that during Mr. DAVISON'S speech it had assumed form, and, although the roads were different, it might be that the conclusions drawn were similar.

It appears that there were between 700 and 800 persons present at the dinner, and the preliminary laudatory addresses about the chairman of the War Council of the Red Cross were of a sort to make him very proud. But when the guest of the evening, who had won his way to fame and fortune by sheer ability, was called on to reply, after making acknowledgment of the words of praise, he stated that he would not apologize for the time he might take or for what he was about to reveal.

And there followed a picture of middle Europe, from the Baltic down through Poland, Czechoslovakia, Austria, Rumania, Serbia, Albania and Armenia that was drawn from facts. Famine stalks throughout the continent. Disease, especially typhus, is a plague. So is tuberculosis. There are no medicines. There is no sanitation. Over most of the territory there are hardly any doctors and such as there are lack all facilities. One doctor to from 50,000 to 100,000 persons with neither medicines nor transportation facilities couldn't do very much, and this is the situation over a great part of the area. The land is neglected and the people are flocking to the cities. Government changes in name every few weeks, but only in name. It does not exist in fact. Money has no value, so they cannot buy. In Vienna an ordinary automobile sold for sixteen times the former yearly salary of the Prime Minister. A mania for dancing has arisen in that great city where there is not one meal a day for the population, and wherever there is music the hungry people gather and dance until they fall exhausted. "That is not joy," said the speaker; "it is madness." When Russia changed her coat and fought for the Germans instead of against them she took 300,000 Allied soldiers and put them in a camp. There are 150,000 of these left alive and they will not last much longer.

These are just a few points of the speech that T'other editor recalled. Then he quoted some more.

"What do Europeans think of America now?" asked the speaker. "They say," he replied, "that we came over and helped magnificently; not because they called us, but for a great principle. When the Armistice was signed the President himself went over to make sure that principles of liberty should be included in the terms of peace. They say they believed that the great power and influence and ability of the American people were with them to secure a righteous peace, to read its terms into the treaty, and to help in the organization of reconstruction, which is one of the most difficult of human undertakings, especially among war-worn, crippled and distracted peoples. Then, they say, we have turned our backs on them. But now," he continued, "we have to do with the situation and not with what they say." And he declared it as his conviction after serious deliberation that the situation had got beyond the control of private initiative. It is so horrid, so ghastly, so immense, that only governments can stem the tide. England has been sorely stricken.

but she is coming through. She can take care of herself. France needs materials, and the country has been wretchedly mangled, but she has grand courage and she will take care of herself. The same may be said of Italy. The United States, on the other hand, is the only nation that has in abundance what that broad strip of hell needs. If the matter is taken in hand by our own Government, without the blight of politics at either end, and provision made for an army of mercy with doctors and food and sanitary engineers and the capacity to maintain order among people crazed by want and grief and misery, then England will follow to the limit of her ability, Japan will come along, and so will Holland and the Scandinavian countries and through a mighty effort the human conflagration may be extinguished. But if we do not do this thing; if we declare that it is none of our business and let them rot, the greater danger is not remote, but very near and very pressing, that all human effort will be unable to put down the triumph of madness over civilization.

"There," said T'other editor, "is the thing we need: the big vision, the big view. All of a sudden it seems as if the American people had dwindled, become little and mean and shabby in character. The big things we did before and during the war are all over with, and now we squabble. But even if this has become an epidemic degeneration of the mind, and men who once stood with clear vision, looking ahead, are now screaming in the halls of Congress like fighting cats and we have learned to despise them, it is no excuse for us if we imitate them. The world is in a parlous state and there's trouble in the air. The public intelligence is not high; not as high as it usually is. The popularity of some political candidates shows this. So the only safe attitude for thoughtful men is to take the long view, to look far ahead and to play the game fair. There never was a time when the responsibilities of every thinking man were so great and pressing as they are today."

And the editors agreed that at this point was the meeting of the roads. The more we mind our obligations the less we need fear for our rights. The Golden Rule still holds!

Senator Moses Answers a Question

MANY years ago there used to stand on Broadway near Wall street an old peddler who sold gum-drops; a grinning old remnant that appeared to enjoy his day at the market without doing anything, for we never saw him make a sale. He merely offered his wares—and smiled. Some wag had hung about his neck a sign which he maintained through the years as his contribution to the cheer of life until—and this, too, was long ago—he disappeared with other sweepings. The sign read "Terrible Excitement! Ferocious Slaughter of Prices! Giant Gum Drops Formerly 2c. Each Now 3 for 5c."

We are reminded of the episode by one of similar subtlety lately recorded in the transactions of the United States Senate. The Honorable GEORGE H. MOSES of Concord represents the sovereign State of New Hampshire and within that Commonwealth large quantities of dyes are used. Just as one star differeth from another star in glory, so one textile manufacturer differeth from another in opinion. We have no census of opinion of the New Hampshire mill authorities in regard to the pending legislation to maintain the coal-tar dye and allied industries as American institutions, but probably some favor the Senate bill and some hope for its defeat with a view to getting cheaper dyes from Germany pretty soon. We are also without specific information as to the relations of Senator MOSES with various textile manufacturers of his State, nor do we know what co-ordination of opinion as to public affairs may obtain between them. But Senator MOSES is against the dye bill; tooth and nail opposed to it. And Senator KENYON of Iowa, who back in 1914 claimed to be more "broad-minded" than the rest of us in considering the invasion of Belgium and German war methods, agrees with Senator MOSES about dyes.

Now, all persons familiar with chemical industry know that for the present this bill is necessary to maintain these establishments. Just because manufacturers usually have objected and probably will object to the lowering of duties on or the encouragement of importations of what they make, we need not be blind to present facts. The Senate bill is necessary to maintain the industry here no matter who makes money or loses it. And with it is coupled the development and maintenance of chemical preparedness for war. The American Chemical Society at its St. Louis meeting unanimously indorsed it, and neither dye producers nor any other type of manufacturer controls the American Chemical Society. To defeat the bill would be a great blow to national preparedness. Every chemist knows that.

But Senator MOSES opposes it. At the same time he is acting as advance agent for the candidacy of General WOOD for the Presidency. He went to Wilmington, Del., where he proclaimed the good General's many desirable qualities, while in Washington he had been engaged in opposition to the dye bill. Then CHARLES K. WESTON, of E. I. du Pont de Nemours & Co., wrote to Senator MOSES that he had listened with interest to his address and especially to his exposition of the General's favorable attitude toward national preparedness. Mr. WESTON also said he was outlining a publicity campaign in regard to the proposed dye legislation and he asked Senator MOSES to set him straight on the apparent contradiction of his attitude toward General WOOD'S candidacy on the one hand and toward the dye bill on the other. He signed himself frankly as of the publicity bureau of the du Pont company. It is a large manufacturer of high-class dyes and is intensely interested in the industry.

The question was perfectly fair and straight. We do not understand how Senator MOSES can be at once for preparedness and against the industrial development of organic chemistry to which the dye industry is the key. To anyone familiar with the situation this is a hard nut to crack. We should like very much to have it explained. We mean intelligently rather than oratorically explained. But on Friday last Senator KENYON of Iowa arose in all his dignity and cautioned his brother Senators against the sinister influences at work, not against the bill but for it. "I have in my hand," he exclaimed, "a letter addressed to a certain Senator who is opposing this bill and is also one of the managers of the candidacy of a certain gentleman for President of the United States . . . which is . . . a threat to the Senator in relation to that candidacy if he does not cease his opposition to the bill."

This brought the thinkers in from the cloak room and Senator KENYON proceeded to say that "This letter is used with the full knowledge and consent of the Sena-

tor, who *resents* it. And I am sure I ought to say that . . . General WOOD also resents the letter."

The crux of the whole matter is the resentment of Senator MOSES at a simple, honest question. We can hardly agree with Senator KENYON that he "ought to" say General WOOD resents it unless he really does; and even then it would be impolitic to advertise the fact. As a matter of fact, General WOOD was quoted Sunday as saying that he knew nothing of the letter until reading it in the newspapers. If the Senator could answer the question we suppose he would. Being unable to square himself with the facts as to preparedness, he "resents" it—and Senator KENYON makes the noise.

The Senate of the United States has not done itself proud during the last two years. The post-war degeneration in ideals and constructive thought from which the whole world has suffered has shown its incidence with peculiar sharpness upon that body. The resentment of the venerable Senator from New Hampshire is very like the great excitement of the late aged philosopher of the sidewalk. It is humorous, but not convincing.

Channels of Steel Consumption

IT IS always difficult to make even an approximate quantitative analysis of the consumption of steel in the United States. There always seems to be more steel consumed than can be accounted for, and when one comes to the item "all other," to be made up by difference, the proportion of that item is likely to be very large. The difficulty is experienced both when steel consumption is far below normal and when it is above normal. In "lean" years, like 1908 and 1914, there seemed to be scarcely any demand for steel, yet the production was at 50 or 60 per cent of capacity and there was a certain utilization of existing stocks besides.

As it is a matter of tonnage, outputs and capacities should be set down definitely. Disregarding rolled iron, which has run something like a million and a half tons a year for quite a while past, the production of finished rolled steel in 1906, when the industry operated fully at capacity throughout the year, was 17,401,911 gross tons.

As the finished product of one manufacturing process is the raw material of the next, the definition of "finished steel" must be by reference to process of manufacture. In the nomenclature employed in making up the statistics "finished rolled steel" is steel after it has experienced its last hot-rolling process, and of course also after the attendant shearing. Accordingly black plates for tinning as well as black sheets for use as black sheets or for galvanizing are considered rather than sheet bars, skelp is considered rather than welded pipe, the rods are weighed rather than the drawn wire or the rod billets, and thus with other commodities. In both 1912 and 1913 the output was a shade over 23,000,000 tons, and as 1912 saw light operation early in the year and 1913 light operation late in the year, the production and consumption in the twelvemonth July 1 to June 30 may be taken at 25,000,000 tons, likewise the capacity. In 1916, when capacity was increasing, and when late in the year transportation difficulties interfered with production, the output was 30,557,818 tons. There has not been even an approximate test of capacity since then, but the finished rolled steel output in ordinary times runs 76 per cent of the ingot output, and the ingot output in March, after continued increases for several months, was at the rate of 45,200,000 tons a year, from which it may be estimated quite accurately the rolled steel output was at the rate of 35,000,000 tons a year. Capacity under moderately favorable working conditions is about 40,000,000 tons a year, and let us hope that the estimate will soon be put to the test of actual experiment.

One is called upon, therefore, to analyze about 3,000,000 gross tons a month, or 35,000,000 gross tons a year. It is a very difficult task to find the channels of consumption that will absorb so much, but this does not suggest that the consumption does not occur or that it cannot occur for any length of time, since similar difficulties have been experienced ever since the steel industry has been in existence, yet the steel consumption of past years is an accomplished fact.

It used to be a custom to assume that "the railroads" consume 30 or 40 per cent of the steel output. It is doubtful whether that was ever true, and it certainly is not true now. The railroads will consume 2,000,000 tons or so of rails this year. Orders for steel cars have mounted to a few tens of thousands of cars. Steel wheels are included in the production statistics but cars being ordered do not all have steel wheels, so that at best twenty gross tons of steel per car would cover the case, meaning a consumption this year in car building of only between 1,000,000 and 2,000,000 tons. Locomotives will take but a fraction of this amount, and track repair material, steel for signaling and various miscellaneous uses but a fraction again of that. Car repair material, however, easily involves several hundred thousand tons, repairs lately required being so extensive as occasionally to require four or five tons of steel per car. In bridges, buildings, viaducts, etc., the railroads are doing very little. The requirements of the railroads of the country, all told, therefore, are not running much beyond 5,000,000 tons a year, and certainly they are far under 10,000,000 tons.

The individual skyscraper is an imposing example of steel consumption, but not many skyscrapers are erected in a year, and at this time such construction work is particularly rare. It is a very large skyscraper that required 10,000 tons of structural steel for the framework, and the incidentals of piping, elevators, etc., do not involve half again as much. The consumption of steel in such large buildings will do well if it runs into seven figures this year.

Estimates were that slightly more than 2,000,000 passenger automobiles would be built this year. The heavy cars are rare, the light cars numerous, and the average weight of all probably lies between 2,500 and 3,000 pounds, so that one gross ton of finished rolled steel per car would cover the case, this accounting for between 2,000,000 and 2,500,000 tons for the year, or not more than 10 per cent of the total production of the industry.

Thus far we have found about 10,000,000 tons out of the 35,000,000 tons to be accounted for. The remaining 25,000,000 tons is "all other," by difference, including agricultural implements and machinery of all descriptions, tools, hardware, pipe for oil development and transport, oil and other tanks, steel for small buildings, particularly "portable" garages, exports and a few other items.

Western Chemical & Metallurgical Field

California Fruit Growers Exchange Research Laboratory

The California Fruit Growers Exchange, a co-operative, non-profit, non-capital stock organization of 10,000 growers of citrus fruits, has established a research laboratory for the purpose of conducting investigations along fundamental lines on chemical problems relating to the citrus fruit industry. The first work of the laboratory will be in connection with the utilization of the lower grades of fruit.

Lemon growers of the California Fruit Growers Exchange in 1914 established the Exchange Byproducts Co. at Corona, Riverside County, which has since then been engaged in the production of U.S.P. citric acid and lemon oil from cull lemons. Later, the orange growers organized the Exchange Orange Products Co. for the purpose of utilizing the lower grades of oranges in the manufacture of marmalade and other products.

The research laboratory of the exchange is for the purpose of working out the problems incident to the production of new products from all varieties of citrus fruits and of co-operating with the byproducts factories in their chemical problems, while each byproducts factory has also its own plant control laboratory and chemists. Other lines of work will be taken up later.

The laboratory is located in the building of the Exchange Byproducts Co. at Corona. C. P. Wilson, for many years with the Bureau of Chemistry of the U. S. Department of Agriculture and for the last three years chief chemist of the Exchange Byproducts Co., will have charge.

Prospective Power Development in California

There are at present ninety-one power plants in the State of California which are operated by the large power companies. The transmission lines of these companies are to a large extent interconnected and more complete interconnection and the enlargement of existing connections are now under construction. Of these plants sixty-seven are hydro and twenty-four are steam; The installed generator capacity is 513,000 kw. for the hydro plants and 279,000 kw. for the steam plants, a total of 792,000 kw., or 1,063,000 hp. This is the largest system of interconnected companies in the world, the combined output for the year 1919 being more than three billion kilowatt-hours.

There are at present under construction thirteen power plants with a total installed generator capacity of 270,500 kw.; of this, 85,000 kw. will be steam generated. These additions, listed below, will be completed within a year and indicate a total installed primary in condition for operation in April, 1921, of more than 1,400,000 hp.

The outstanding feature of these developments is not the magnitude of the installed power, but the fact that the various plants are interconnected and the length of the interconnected transmission lines, which extend from Oregon to Mexico. One essential requirement for power to be supplied to industries is reliability; the interconnection, together with the favorable climatic conditions, practically assures this. Taken together with weather which permits of maximum production throughout the year, this will result in California becoming an increasingly important industrial section of the country. Statistics recently published by the *Electrical World* indicate that approximately 10 per cent of the potential power is now developed in Califorina, which practically assures the future supply.

	Power	Kw.
City of Los Angeles:		
San Francisquito Creek, July 1, 1920.....	Hydro	20,000
San Joaquin Light & Power Corp.:		
Bakersfield, June 1, 1920.....	Steam	12,500
Kerckhoff, Oct. 1, 1920.....	Hydro	30,000
McKittrick, Jan. 1, 1921.....	Steam	15,000
Southern California Edison Co.:		
Big Creek, Nov. 1, 1920.....	Hydro	16,500
Kern River No. 3, Nov. 1, 1920.....	Hydro	30,000
Long Beach, March 1, 1921.....	Steam	35,000
Big Creek No. 8, March 1, 1921.....	Hydro	22,500
Pacific Gas & Electric Co.:		
Oakland, Nov. 1, 1920.....	Steam	12,500
Pitt River, Jan. 1, 1921.....	Hydro	24,000
Los Angeles Gas & Electric Corp.:		
Los Angeles, Jan. 1, 1921.....	Steam	10,000
Southern Sierras Power Co.:		
Adams Plant, Jan. 1, 1921.....	Hydro	2,500
Great Western Power Co.:		
Feather River (Caribou), March, 1921.....	Hydro	40,000
Total		270,500

The Smelters Steel Co.

The Smelters Steel Co., of Seattle, Wash., is now producing soft gray iron castings of unusual toughness and purity from magnetite iron ore in an electric furnace in one operation. G. Lewis Casey has been working on the problem for many years and has developed the process to such an extent that economic success appears to be assured. There is a good market on the Coast for soft gray iron; unfilled orders at $65 per ton indicate that the quality of the product is satisfactory to the consumers.

The company's plant, which consists of a modern foundry building and fireproof transformer room, is located on a 5-acre tract, with about 1,000 ft. of water frontage, at Seattle. Four 440-kva. transformers are already installed. One furnace is in operation, a second under construction, and as soon as this is finished two additional furnaces are to be built; the estimated output will be 15 tons per day.

Magnetite iron ore, containing over 52 per cent iron with but small amounts of deleterious impurities, is obtained from an extensive deposit on Dean Channel, B. C. The deposit is at tidewater and the ore can be easily bunkered for shipment by boat to Seattle. In addition to the ore deposit the company owns a valuable water power near the mine and a tract of timber land. The manufacture of charcoal will be undertaken.

The British Columbia Government is particularly anxious to develop an iron and steel industry within the province and negotiations are now under way with the Smelters Steel Co. looking toward the establishment of a smelting plant at the mine. With the iron bounties act, assuring $3 per ton on all pig iron produced, and with further possible assistance from the iron ore supply act, the erection of a plant costing approximately $500,000 at the mine at no far distant date seems a possibility.

The Metallurgical Research Department of the Utah State School of Mines

Equipment of a Wide Variety of Types Is Available for Testing Ores in the Intermountain Region—Besides General Work in Ore Dressing, This Station Is Doing Much Work on Chloride Volatilization and Oil Shales

By L. W. CHAPMAN

THE Metallurgical Research Department of the State School of Mines was established by the Utah Legislature in 1913 for "finding ways and methods of profitably treating low-grade ores, of securing a higher percentage of extraction of metals from their ores, for obtaining other information that shall have for its object the benefit of the mining industry and utilization and conservation of the mineral resources of the state and for the publication and distribution of bulletins."

By an agreement with the United States Bureau of Mines the work of this department is under the direction of metallurgists of the Bureau assigned to duty with headquarters at the University of Utah.

At present the technical staff of the U. S. Bureau of Mines connected with this department is as follows:

Thomas Varley, metallurgist in charge.
C. A. Wright, hydrometallurgist.
J. C. Morgan, assistant chemist.
E. P. Barrett, assistant chemist.
R. E. Head, metallurgical assistant.
H. D. Gavin, refinery engineer.
L. C. Karrich, junior refinery engineer.

The present staff of the Department of Metallurgical Research, State School of Mines, University of Utah, consists of:

Joseph F. Merrill, director.
R. H. Bradford, professor of metallurgy.
Robert S. Lewis, professor of mining.
J. R. Phoenix, analyst.
H. W. Clark, laboratory assistant.

From 1913 until the Legislature met in 1919, $7,500 had been appropriated yearly by the state to carry on this research work. The last Legislature, however, increased the amount $5,000 a year and appropriated $25,000 for the ensuing two years. During 1918 certain mining companies and business men of Salt Lake City and other parts of the state subscribed $21,000, which, together with an additional $15,000 appropriated by the state, was used for the enlargement of the buildings, increasing library facilities and remodeling and buying new equipment for the ore-dressing and metallurgical laboratories.

A large fireproof building (shown in Fig. 1) 75 ft. long, 40 ft. wide and two stories high has been erected and the offices of the U. S. Bureau of Mines and the Department of Metallurgical Research, as well as laboratories and lecture rooms, have been installed.

Up-to-date machinery for ore dressing and flotation and other equipment necessary for properly carrying on research and experimental work have been installed, making one of the most complete and up-to-date laboratories of its kind in the United States.

Provision has been made for six fellowships during the fiscal year 1919-1920. Each of these fellowships pays an annual income of $720 and covers a period of twelve months. The holders of these fellowships are required to register for courses of instruction in the University of Utah and become candidates for the master's degree, and, while these "fellows" are under the general direction of the metallurgist in charge, the detailed supervision is under other Bureau of Mines metallurgists and chemists and the professors of mining and metallurgy of the University of Utah.

Ore-Dressing Laboratories

For testing ores by gravity concentration and flotation it is necessary that the laboratories should be designed to handle ores in amounts varying from a sample of only a few pounds to lots of several tons in weight. The sampling room for the metallurgical laboratories is equipped with all machinery necessary for fine grinding and the reduction of comparatively large samples to small and easily handled bulk. The equipment consists of an Allis-Chalmers gyratory sample grinder, a Universal jaw crusher having an opening 3½ x 6 in., Allis-Chalmers laboratory rolls 4 x 9 in. in size, a McColl disk pulverizer having 9½-in. disk, and an Iler disk pulverizer having 6-in. disk. Five sets of Jones sample splitters of different sizes are used for cutting out the final sample.

Some special grinding has been done on graphite ores. For this purpose a 12-in. Burr mill of Sprout-Waldron manufacture has been installed.

The designs of modern concentrating plants are usually based upon the results of small-scale tests on the ores to be treated. These tests are generally divided into two classes. The first or preliminary testing is

FIG. 1. METALLURGICAL BUILDING, UNIVERSITY OF UTAH

done on lots of a few pounds only. The larger or controlling tests are carried out on machines which will handle from 150 lb. to as much as a ton of material in an hour. Experience indicates that the results obtained from the first or preliminary tests, if they are carefully done, give a very reliable indication of the work to be expected in the larger testing plant and also in the commercial mill.

For the work of coarse concentration two Hartz jigs are available. The larger jig has two compartments, each 7 x 15 in. in size. The smaller jig has two compartments, each 4 x 6 in. These jigs have an automatic concentrate discharge and the usual adjustable eccentric drive. For the work of fine concentration several tables are available, a Wilfley table 12 x 24 in., a 15 x 30-in. Deister Plat-O table and an Overstrom Universal table 18 x 44 in. The effect that different styles of riffling may have is noted by using interchangeable table decks.

There is also a half-size Deister-Overstrom finishing table which is set up independently of the other machines and is provided with a mechanical feeder with a capacity of approximately 75 to 100 lb. of ore, which can be fed at a uniform rate over this table. There are also two half-size Wilfley tables which can be riffled according to the nature of the ores and sizes treated.

FIG. 2. PART OF FLOTATION LABORATORY

The laboratories are equipped with a small ball mill with a capacity of 3 kg. (7 lb.) of ore, which makes it possible to crush any wet material to be treated by flotation.

An Abbe jar mill equipped with Silex pebbles is also provided, with a capacity of approximately 3 kg. of ore. By having the two kinds of fine grinding mills, it is possible to get comparative data on the effect of crushing with iron balls against iron with that of pebbles against Silex lining.

Flotation Laboratory

The flotation laboratory (Fig. 2) is equipped with a variety of testing machines, of the mechanical, pneumatic, and combination types. These consist of a small Callow testing machine operated entirely by air agitation; a Jones-Belmont machine, having a capacity of about 2 kg. (4.5 lb.) of ore, which is a combined air and mechanical agitation machine; a small K. & K. machine which is an aërating and a mechanical type machine, and a Federal-Varley machine which is the straight mechanical agitation type somewhat similar to the M. S. machine, having a capacity of from 3 to 5 kg. (7 to 12 lb.) of ore. There are also two small Janney laboratory size machines which are used for small-scale straight mechanical agitation tests, and a Ruth flotation machine which is of the mechanical agitation type, the impeller being arranged in such a manner as to create a suction of air through the hollow impeller.*

These machines differ in size and capacity so that samples ranging from ½ to 5 kg. (1 to 12 lb.) can be treated at a time.

Suction filters are used for dewatering the products, and gas and steam heaters are provided for drying all the products made. A small Root blower is provided in the laboratories which gives the proper amount of air for the pneumatic machines. This can be controlled in order to give any volume or pressure desired.

A large supply and variety of various flotation oils and other reagents used in flotation are kept on hand. These are renewed from time to time, as it has been found that the oils change their characteristics somewhat in long standing.

Arrangement of Equipment for Tonnage Tests

The object of having the equipment arranged for large-scale tests so that quantities of a ton or more of ore can be handled at one time, applying the same treatment as that given in commercial concentrating plants, is twofold:

First, so that the results of the small-scale tests may be substantiated by larger scale experiments.

Second, so that students of the School of Mines and Engineering may have a chance to carry out tests under direction and thus gain experience of operating the various machines and also of making the metallurgical calculations that are required in a report on a complete concentration test.

The keynote of the large-scale testing laboratory is flexibility; an ore can be crushed to comparatively coarse size and can then be treated on jigs or, after fine grinding in one of the various mills, it can be treated on concentrating tables, on slime tables, or by flotation. If a complex lead-zinc-iron ore is to be tested, provision is made either for regrinding the middling or for drying and roasting the same, followed by magnetic separation of the zinc and iron.

The crusher used is of the Dodge type, size of opening 7 in. x 9 in., speed 260 r.p.m. The usual size of the crushed product is from ½ to ¾ in., a size most suitable for the set of Allis-Chalmers 12 x 16-in. rolls operating at a speed of 155 r.p.m. These rolls can be set to crush to any desired size, but usually produce material ¼ in. or under. From the rolls the ore passes to an elevator having a lift of 32 ft., delivering the product to screens.

The first screen is a double-cone trommel 30 in. long. The inner screen has ⅜-in. holes and the outer screen ¼-in. holes, and is used to give a product suitable for further sizing with a Mitchell vibrating screen. This screen has a large capacity, is very efficient, and can be readily changed so that any desired size can be obtained as an undersize product.

Ball Mills and Fine Crushing Equipment

When fine crushing for table and flotation concentration is desired, the undersize material from the first screen passes directly to two storage bins, each holding approximately one ton. From these two bins the

*For a general description of most of these machines see an article by Fahrenwald in Chem. & Met. Eng., vol. 19, pp. 77 and 129.

ore can be distributed to any one of four grinding machines together with necessary amount of water.

(1) A No. 32 Marcy mill in which steel balls are used as the crushing medium. The mill has a maximum capacity of about one ton per hour at 35 r.p.m. when crushing to 8 mesh. The overflow or slime goes to a pump.

(2) A 3-ft. x 8-in. Hardinge conical mill, using either flint pebbles or steel balls as the grinding medium and operating at 28 r.p.m. The discharge from this mill or the Marcy mill may be sent to a Dorr classifier, the oversize being returned to the mill for regrinding.

(3) A 3½-ft. Huntington mill operating at the rate of 80 r.p.m. Screens are used to control the size of the product from the mill.

(4) A stamp mill provided with three 250-lb. stamps. The drop is 6 in. and rate 90 r.p.m. These stamps are used for crushing ores that contain free gold or silver. An amalgamation plate, 24 in. wide x 48 in. long, is also provided directly in front of the stamps.

All crushed material and the overflow from the Dorr classifier are pumped to the second floor of the mill building, where they are discharged into a mechanical classifier of the Dorr, Akins, or Esperanza type. The sands can be sent either to a three-spigot hydraulic classifier, which supplies a classified feed to the concentrating tables, or to a single Deister cone baffle classifier, which gives a table feed of any desired size.

Tables

The table equipment, shown in part in Fig. 3, includes two Wilfley tables with decks 3 ft., 4 in. x 7 ft., 6 in. long, one Deister-Overstrom finishing table, with deck 3 ft. wide x 7 ft. long, and one Overstrom roughing table of approximately the same area. The riffling on these tables can be changed and the speed of the table and length of stroke regulated.

Flotation Equipment

The flotation equipment consists of a Janney flotation machine patterned after the standard Janney machine and is of the combined mechanical and air type. This machine treats several tons of ore per day and does excellent work on small lots. The rate of feed is under perfect control and the amount of oils used is carefully regulated. By special arrangement the first or rougher concentrates can be stored and re-treated or cleaned in the same machine.

A flotation machine was furnished by the Arzinger Machinery Co., Nashville, Tenn., which has been successfully used in floating the graphite in the ores of the Alabama graphite fields and on the zinc ores in Tennessee.

A straight mechanical, two-compartment M. S. flotation machine with a variable speed motor completes the equipment.

When treating complex lead-zinc-iron ores it is often necessary to give middling products from the tables a slight roast in a furnace in order to make the iron magnetic. The furnace product is then treated in a three-magnet laboratory-size Campbell magnetic separator. Each pole is connected with a meter and rheostat regulating the fields so that the poles can be given different magnetic intensities. In the case of many chromium and manganese ores this magnetic separator can be used to separate magnetite, garnet and other ingredients from the chromite and manganese.

Considerable work has recently been done on the massive low-grade alunite deposits from Piute County, Utah. Experiments have been made with the idea of economically obtaining potash from the ores by a simple roasting-lixiviation process. The objects of the tests are as follows:

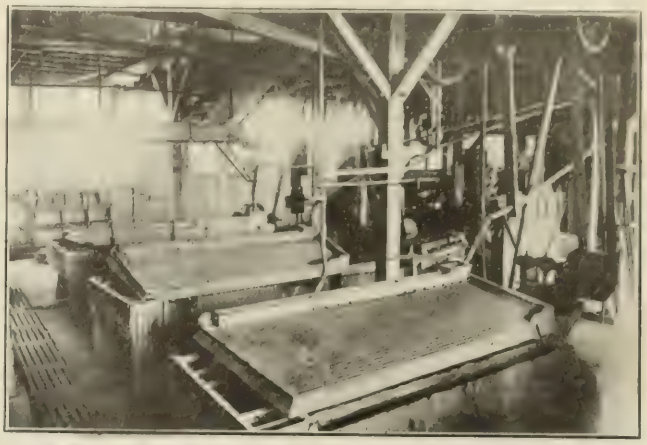


FIG. 3. PART OF ORE-DRESSING LABORATORIES

1. The roasting temperature best adapted to a high recovery of potash by subsequent lixiviation.

2. The size of crushed ore which on roasting at the most desirable temperature gives the best extraction-crushing economy.

3. Whether there is a loss of potash by volatilization during roasting operations.

Further tests on a large scale are now under way. These tests are to be carried on with the object in view of recovering the alumina as well as the potash.

Chloride Volatilization Process

The chloride volatilization process has recently been applied with considerable promise of success to the recovery of metal in oxidized ores and is one of the major problems being studied. The process, briefly stated, consists of the following steps:

First, crushing to a degree of fineness depending upon the character of the ore.

Second, mixing with chloridizing agents either alone or with other reagents. Sodium and calcium chlorides have been found to be effective chloridizers. Sulphur, either in the form of natural sulphur or as pyrite, has been found to aid in chloridizing, as has also lime, although the general effect of these reagents is yet to be worked out.

Third, furnacing to effect chloridization and the volatilization of the metal chlorides formed.

Fourth, recovery of the volatilized metal chlorides.

Fifth, treatment of volatilized chlorides to obtain the values in salable form, preferably with regeneration of the reagent.

Chloridization of the precious metals prior to subsequent lixiviation is an old practice. Volatilization of metals as they form into chlorides was a recognized source of loss and in practice was naturally to be avoided. Not until 1901 is there any record of an attempt to put this loss by volatilization to any gain. At this time, Messrs. Poole and Croasdale, using salt and sulphur, endeavored to volatilize a high percentage of all the valuable metals contained in the ore. Although not financially successful, due primarily to failure to collect the volatilized chlorides economically, their endeavor established the possibilities of this process.

The successful application of the Cottrell electric precipitator in the removal of solids from smelter gases was an important factor in the revival of the volatilization process and finally the feasibility of chloridizing and volatilizing the metals from ores by the use of a salt roast without the use of sulphur was established, at least for certain ores.

Crushing

The fineness to which ore must be crushed is dependent upon the character of the ore. Preferred practice with those ores which respond best to volatilization is to crush not finer than through 30-mesh. Such crushing involves the use of both crusher and rolls. Reagents must also be crushed to a fineness corresponding to that of the ore to give the best results.

Reagents

Two reagents have been successfully applied as chloridizing agents—sodium and calcium chloride. Extractions obtained with these two chloridizers vary with different ores and different metals, and while neither is uniformly better, common salt, being cheaper in western localities, will undoubtedly be used as the primary chloridizing agent. Present indications are that a slag consisting chiefly of calcium chloride will result from the reduction of the fume in most cases and will be re-used as a chloridizing reagent.

Besides the chloridizing agents, sulphur, pyrite and lime have been found to be beneficial with certain ores.

Reagents and ore are thoroughly mixed to insure intimate contact.

Furnace

Ore, after being mixed with the desired reagent, is fed into a horizontal cylindrical kiln similar to those used in cement mills, where the mixture is heated to effect chloridization and volatilization. On amounts of material of 100 lb. or over there is available a kiln 20 ft. long with an inside diameter of 13 in. for the last 15 ft. and 21 in. inside diameter for the first 5 ft. from the fire end, and also a 6-hearth Wedge roaster arranged for either muffle or direct firing. A reverberatory furnace is soon to be installed.

The cylindrical kiln is fired by an oil burner, the flame being directed into the open end of the kiln, as shown in Fig. 4. Ore is fed in by a worm feed so that it discharges into the kiln at a point about 3 ft. from the cold end, giving it a travel through the kiln of about 17 ft. The rate of revolution can be varied so that ore may be held in the kiln for periods of from one hour to two hours, one-half of this time being in the enlarged section where the maximum temperature is obtained.

Flue System and Cottrell Electrical Precipitation

The cold end of the kiln extends into a sheet iron cooling and settling chamber, where a large amount of the heavier solid particles drop out of the gases. From the settling chamber the gases pass through a short flue to a second settling and distribution chamber, where the greater part of the remaining dust particles are deposited without any great amount of the metal chloride fume. From the settling and distribution chamber the gases pass up through a flue and discharge by passing down through a small Cottrell precipitator. After passing through the precipitator the gases are to a large extent free from metallic chlorides and pass through an exhauster to the stack. No further attempt is made to clean the gases after they leave the Cottrell. At the present time this phase of the problem is receiving considerable attention.

The Cottrell precipitator at the Salt Lake City station is constructed in two units, each with a capacity of 1,500 cu.ft. of gas per minute. The units are 17½ ft. high x 4½ ft. square over all. Each unit receives the gases through a 15-in. pipe to the top chamber of the treater. The gases pass from the top chamber to the bottom chamber through twenty precipitating tubes; these are 6 in. in diameter and 8 ft. long. Gases are exhausted from the bottom chamber into the stack by an 18-in. fan. The units are exactly alike, and so arranged with slide dampers that either one or both of the treaters can be used at any time. The discharge electrodes are made of chromel wire.

The treater transformer is rated at 5 kva., 220-440/100,000 volts. The rectifier has a disk 36 in. in diameter and is driven by a 3-hp. synchronous motor at 1,800 r.p.m. The control of the voltage of the transformer is obtained by means of an auto-transformer which is arranged to supply power at any voltage between 55 and 440 by steps of 55 volts. A theater dimmer is used for the control between the auto-transformer voltages. By this arrangement any voltage from about 5,000 to 100,000 can be obtained from the secondary of the high-tension transformer.

Treatment of Fume

The fume, consisting of metal and sodium chlorides as collected in the treaters, must next be treated for the recovery of the contained metals. At present this part of the work is the least advanced of any, but is being taken up as one of the most important problems of the process. It is probable that the fume from each ore will in itself offer a distinct problem, although these

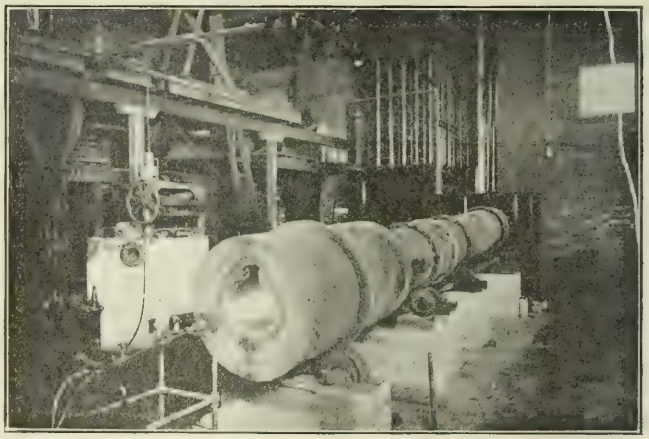


FIG. 4. VOLATILIZATION KILN

fumes will fall in a few general classes. Four general classes have already been met with as follows:

First, lead-silver-gold fumes; second, copper-silver-gold fumes; third, lead-copper-silver-gold fumes; fourth, very complex fumes, as for instance lead-zinc-copper-mercury-silver-gold fumes.

While no general statements as regards the treatment of the fume can be made, several solutions are suggested. First, it may be leached, with subsequent precipitation of the metal from the leach liquors; this method of treatment will probably be resorted to, partially at least, in treating the complex fumes; second,

metal may be directly reduced from the fume; this is accomplished by mixing the metal chlorides with lime and a reducing agent such as coke, and heating to a temperature above the melting point of the metal being reduced. The products formed in this case are bullion and a slag composed chiefly of calcium chloride. It seems probable that this method can be applied to such fumes as lead-silver-gold or copper-silver-gold combinations.

Ores Amenable to Volatilization

The volatilization process at the present time seems to have its greatest application to low-grade oxidized ores. The best results have been obtained with simple low-grade lead ores, copper ores, lead-silver ores and

FIG. 5. CHEMICAL LABORATORY

copper-silver ores. Considerable success has been met with also in the more complex oxidized ores carrying copper, lead, silver and zinc, although the last named is not volatilized with any very great degree of success. Little general success has been met with so far on the treatment of complex sulphide ores, although evidence indicates that it may be possible to treat this type of ore after the behavior of the simpler oxidized ores during volatilization is more generally known.

Oil Shale

Investigational work on oil shales has been carried on at the Salt Lake City station for over a year. The work thus far has been along two lines, (*a*) study of methods of assaying oil shales for commercially recoverable oil and ammonium sulphate, and (*b*) investigations of a retorting plant together with a study of the products produced by it from different shales of the Rocky Mountain country. Both these investigations are practically completed, and have given valuable information as to the nature of the products to be obtained from oil shales and as to the best methods of treating the shales themselves.

Messrs. Gavin and Karrich intend to produce sufficient oil from shales to make a study of the refining of the oils on a scale large enough to determine the commercial value of the refined products.

The Bureau of Mines at the Salt Lake station has accumulated a large amount of data pertaining to all phases of the oil-shale industry, both in order that the investigators for the Bureau could have easy access to the best literature and data on the subject and that the Bureau might be well equipped to answer inquiries and requests for information on the subject of oil shale.

In order to handle rapidly the large volume of analytical and chemical work necessary in making metallurgical tests, the Salt Lake City station is equipped with three laboratories: the main chemical laboratory, shown in Fig. 5, the fire assay laboratory and the fellowship laboratory. Together they form a laboratory system equipped with all modern appliances necessary for rapid and accurate work.

The microscopic examination and study of the physical characteristics of the complex ores has been one of the problems which has received considerable attention. Methods of preparation and study developed during the course of the investigation have resulted in the discovery of many mineral relations in complex sulphide ores, the knowledge of which has been of much value in determining the treatment to which the ore would be more amenable.

The U. S. Bureau of Mines in its co-operative work with the University of Utah maintains an excellently equipped microscopic laboratory in the metallurgical building, and this phase of investigation is applied to the problems in ore-dressing which constitute the work of the station.

Acknowledgment

The material for this description was kindly furnished by Thomas Varley, metallurgist in charge of the Bureau of Mines Station, supplemented by their Bulletin No. 11.

Foreign Trade of Australia for 1918-19 Shows Increase in Exports

Detailed figures of Australian imports and exports for the fiscal year ended June 30, 1919, as published at the end of the calendar year, show the value of imports to be £93,485,050, and the exports £106,805,985, an excess for exports of £13,320,935. A summary of the foreign trade for the four months of the new fiscal year, July-October, shows that the excess of exports was increasing, for with imports totalling £24,750,555, a reduction of £6,998,650 from the figures for the corresponding period of 1918, the exports for these four months increased about 40 per cent, or from £25,724,252 in 1918, to £46,726,503 in 1919. Almost half of the year's exports came under classification VI, "animal products, mainly unmanufactured, not foodstuffs." The amount for the fiscal year was £47,665,869, of which £42,766,775 represented wool, and £4,403,518 hides and skins. Meats were exported to the amount of £8,862,246.

Exportations of wheat totaled £11,334,665, and flour £5,818,785. In the four months July-October, 1919, exports of Class VI, defined above, were £18,476,285, animal foodstuffs £6,954,665, and vegetable foodstuffs £13,661,407. New South Wales was the largest exporter in these four months, with a total of £17,354,323, and Victoria ranked second with £15,192,284.

The largest items of import for the fiscal year were textiles, amounting to £25,956,450; wearing apparel, £3,812,453, of which hosiery comprised £2,098,897; tinned plates, £1,134,337; paper, £5,390,960; timber, £1,359,251; drugs and chemicals, £4,016,447; rubber manufactures, £1,164,317. In the four months of the new fiscal year importations of textiles and wearing apparel were less than half of those of the same months of 1918, while importations of machinery nearly doubled, an indication of the rapid growth of the movement to make Australia self-sufficient in the matter of clothing.

Photographing Etched Sections at Low Magnifications

By J. H. G. Monypenny
Chief Metallurgist, Brown, Bayleys Steel Works, Ltd.

THE advantage of being able to photograph sections of steel at low magnifications, using the same type of illumination as is used for higher magnifications, i.e., vertical illumination, has been apparent to those employed in metallurgical laboratories for a considerable time. Methods somewhat similar to those described in the short article by F. B. Foley in CHEMICAL & METALLURGICAL ENGINEERING, vol. 21, p. 140 (Aug. 1, 1919), have been in use in the writer's laboratory for a number of years. As these methods differ in certain details from that described in the article mentioned above, a description of them might be of interest.

For very low magnifications (up to about four diameters) the method employed is practically the same as that described by Foley. The lens used is a 5½-in. anastigmat and with the length of camera available in our laboratory, reproduction from natural size up to

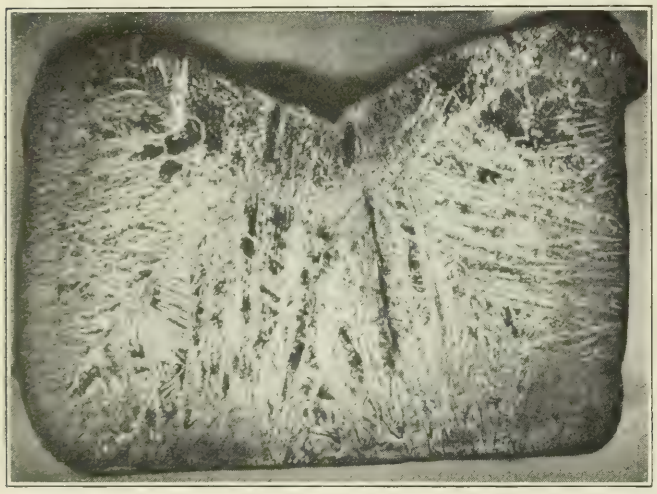


FIG. 1. LONG DENDRITES FROM CHILLED TEST-INGOT. ETCHED WITH COPPER REAGENT. × 3¼

four diameters may be obtained. Such magnifications are especially valuable with sections etched with one of the "copper" reagents (such as Stead's, Rosenhain's or Le Chatelier's). These require a low magnification to simulate macroscopic examination as a general rule. Fig. 1 (3¼ diameters) is an example of this. It represents a section from a small sample ingot taken for analytical purposes from an electric furnace, and shows the development of long "chill-crystals." Fig. 2 (from a file blank burned in forging) was also taken by this method and shows (2¾ diameters) the decarburization formed both on the skin and around the cracks.

When illuminating these large sections one should

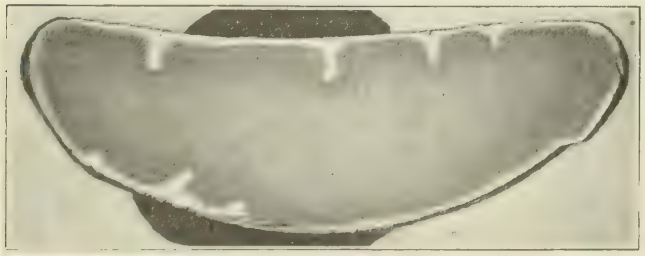


FIG. 2. FILE BLANK BURNED IN FORGING. ETCHED WITH COPPER REAGENT. × 2¾

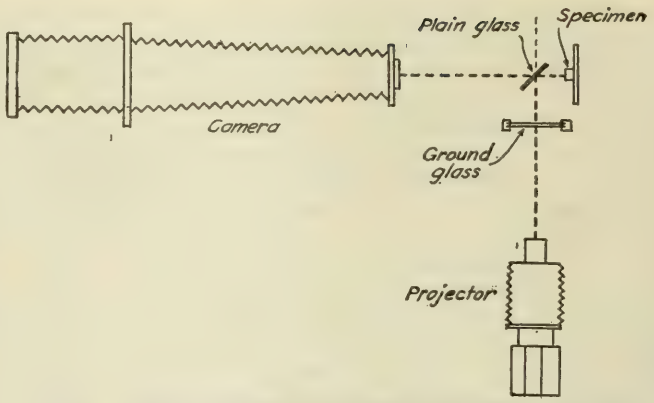


FIG. 3. ARRANGEMENT FOR PHOTOGRAPHY AT LOW MAGNIFICATIONS GIVEN IN FOLEY'S ARTICLE

endeavor to produce an evenly illuminated area, considerably larger than the section, on the ground glass (shown in the diagram, Fig. 3, from Foley's article) and the latter should be placed quite close up to the section.

For higher magnifications a 35-mm. projection lens (made by Zeiss) is employed by us, giving a magnification from nine to twenty-five diameters (with the minimum extension available on the camera a magnification of nine diameters is obtained—less could be obtained with a camera closing to a greater extent), and for these a somewhat different method of illumination is used.

If one is using an enlarging lantern or a projection lantern, then, in order to get satisfactory lighting, the condenser must be close to the negative or slide and must focus the illuminant on the projection lens, as is well known. The same principle is used for photographing sections and the arrangement of condensers is shown diagrammatically in Fig. 4. This sketch shows the 35-mm. lens *A* attached to the microscope tube and the section *B* on the stage. The microscope used is the large "works" model made by Watsons, London, which has a very wide tube—the inner draw tubes are removed for use with this lens. Condenser *D* forms a considerably enlarged image of the illuminant *C*, which now is a 500-cp. Pointolite lamp, a tungsten arc lamp made by the Edison Swan Co. and in the writer's

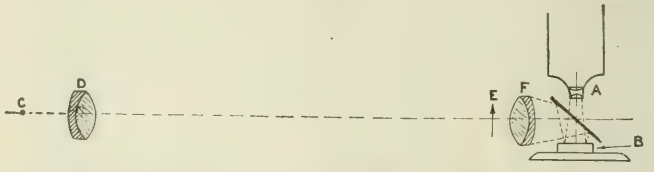


FIG. 4. MONYPENNY'S ARRANGEMENT FOR MAGNIFICATIONS OF 9 TO 25 DIAMETERS, USING 35-MM. ZEISS PROJECTION LENS

experience the best illuminant yet devised for photomicrography.[1] Such enlarged image is focused at *E*, close up to the second condenser *F*, and the latter in turn focuses the image, after reflection at the 45-deg. cover-glass reflector and the surface of the specimen, on the lens *A*, as indicated roughly by the dotted lines. The condensers used are 2⅛ in. diameter and 2⅝ in. focus, and it is possible to illuminate evenly a section about 1 in. diameter; this is more than required, as the field of the lens is only about ⅝ in. diameter. Figs. 5, 6 and 7 show some of the results obtained; I may add that most of these photographs were taken eight or ten years ago.

[1]See CHEM. & MET. ENG., vol. 22, p. 281 (Feb. 11, 1920).

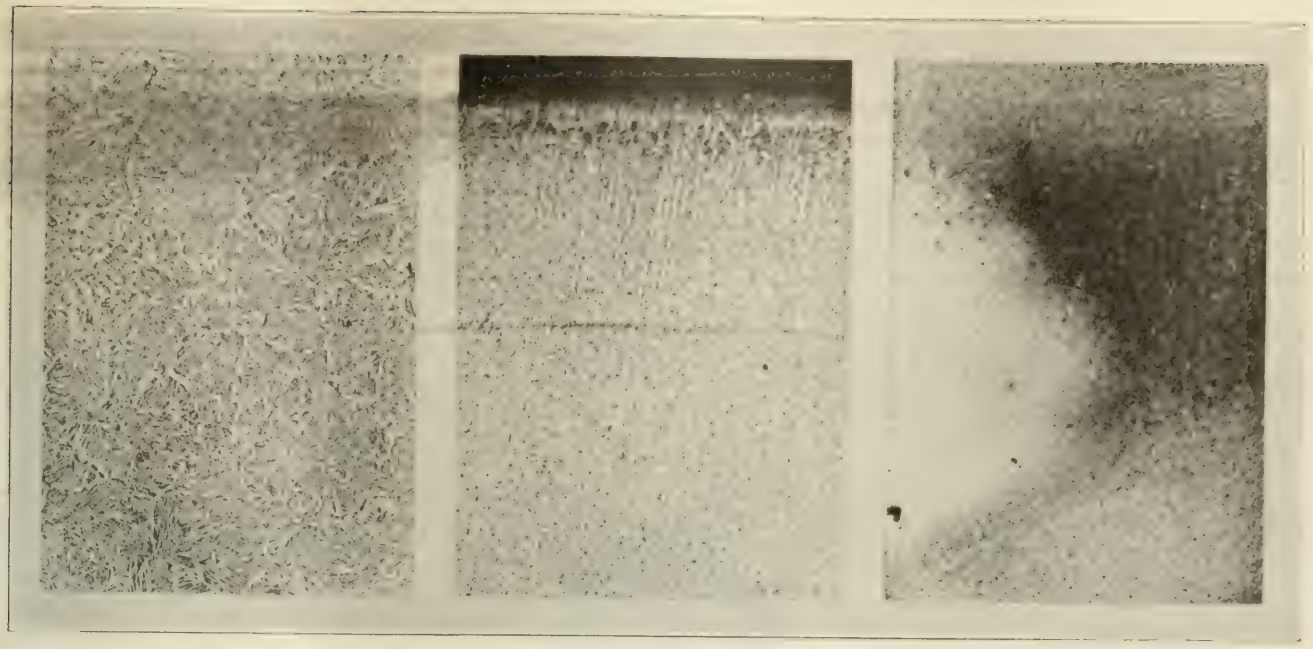


FIG. 5. OVERHEATED STEEL. × 10

FIG. 6. MILD STEEL BLOOM CUT BY OXY-ACETYLENE TORCH. × 10

FIG. 7. CARBON SEGREGATIONS AROUND AN UNSOUND SPOT. × 8

It is obvious that these low powers are of special value where either the structure is very coarse or where one wishes to show the variation of structure over a fairly large area. For example, Fig. 5, at ten diameters (originally exposed at twenty diameters), shows far better than a photograph at say 100 diameters the structure of the sample of overheated steel from which it was taken. Fig. 6 (at ten diameters reduced one-half from the original exposure) represents a section taken from a mild steel bloom cut by the oxy-acetylene blowpipe, and enables one to show in a single photograph the gradual change of structure produced. Fig. 7 (at eight diameters reduced one-half from original) illustrates another type of photograph for which the ordinary microscope objective would be quite useless; this shows the size of, and distribution of carbon in, an unsound segregated area. This actual example is rather unique, showing, as it does, high- and low-carbon areas in close proximity.

With regard to the proper exposure: Using a slow-process plate with the 35-mm. lens at twenty diameters, on a section similar to those shown in Figs. 5 to 7, two to four seconds would be required.

As mentioned above, the tube of the writer's microscope is very wide and comparatively short (2 in. diameter and 4⅜ in. long) and this enables one to use practically the full field of the 35-mm. lens; with a narrower tube, of course, part of the field would be cut off. In such cases one may do without the microscope and mount the lens on a small fitting (with either spiral or rackwork focusing) on the camera front. In one or two cases the writer has done this and has succeeded in obtaining a 6½-in. circle at nine diameters (i.e., a field of 0.72 in.). The definition in this case was not quite perfect around the edge, but it was sufficiently good for the purpose.

It may not be out of place to mention that when taking a photomicrograph without using an eyepiece it is necessary to avoid reflection from any metallic surface inside the microscope tube. The latter should be coated with a dead black varnish, but it is generally advisable to put in a lining of black cloth. Such a lining can easily be made by gumming a piece of black cloth of the required size on to a similar piece of fairly stiff paper, then rolling into a cylinder (cloth inside) which can be slid into the microscope tube.

For the 45-deg. reflector the writer uses a piece of thin microscope-cover glass 1⅝ x 1¼ in., mounted in a light metal frame which fits on the 35-mm. lens. The frame carrying the glass is pivoted, allowing the illumination to be adjusted to a nicety. The glasses may be obtained in various sizes up to 4¼ x 3¼ in., but as they are very brittle, it is advisable to use a thin lantern-slide glass for the lowest powers (i.e., from one to four diameters), which require a larger reflector.

Sheffield, England.

Wages in Japan

Commercial Attaché James F. Abbott, Tokyo, Japan, says that there is practically no regular employee now in Japan who does not get a bonus of from one to three and even five months' salary at New Year, this being a regular institution in Japan and applying to all government employees as well as to employees of private concerns. In many cases this bonus is paid twice a year, and important officials frequently receive a sum many times more than their annual salary. Another method of assisting their employees, adopted by some large factories, is to issue a rice stipend in addition to the regular salary. Some companies give board at the rate of 9 or 10 sen a day which actually costs the employer 25 to 35 sen. The employers prefer this method, as it is easier to reduce the labor outlay, should the cost of rice fall, than if the wages were increased.

Blending Casinghead Gasoline and Naphtha

A new edition has been prepared of the chart for blending casinghead gasoline and naphtha, computed by Clarence Netzen for the Bureau of Mines, Department of the Interior. This chart provides an easy method of determining the amount of naphtha to be used per gallon of casinghead gasoline to obtain a product of any required gravity. A copy of this chart will be sent on application to the Bureau of Mines, Washington, D. C.

Dr. F. G. Cottrell Succeeds Dr. Manning as Director, Bureau of Mines

THE resignation of Van H. Manning as director of the Bureau of Mines was not unexpected. It has been an open secret for several months that he would be selected as director of the research work of the American Petroleum Institute. Since it became known that Dr. Manning was about to resign there has been some agitation for the filling of the place with a mining engineer. Despite the very generally expressed preference for a mining engineer, the announcement that Dr. Frederick G. Cottrell, a chemist, had been recommended for the place brought forth no opposition. Dr. Cottrell's high professional standing and the fact that he has been in such close touch with the mining industry for so many years assure him of every confidence on the part of the mining industry. Dr. Cottrell was born in Oakland, Cal., Jan. 10, 1877. He attended school in Oakland and matriculated at the University of California in 1892. As a university student he gave especial attention to science, particularly chemistry. After graduation, in 1896, with the degree of Bachelor of Science, he was a Le Conte fellow at the university in 1896-7 and taught chemistry at the Oakland High School in 1897-1900. Then he went to Europe, where in 1901 and 1902 he studied at the University of Berlin and the University of Leipzig, receiving from the latter the degrees of Master of Arts and Doctor of Philosophy, 1902. On his return to this country, in 1902, he was appointed instructor in physical chemistry at the University of California, and in 1906 was appointed assistant professor, holding this position until 1911. While at the university Dr. Cottrell's chief contributions to science were researches relating to the electrical precipitation of fume and fine particles suspended in the gases of smelter, blast-furnace or cement works flues, and he finally evolved what is known as the Cottrell process for this purpose. This invention was first utilized at the Selby smelter in California for removing fumes from the waste gases of a sulphuric acid plant at the smelter, thereby abating a nuisance that threatened to necessitate shutting down the works. Subsequently this electrical precipitation process was installed at other smelters to remove fume and solid particles contained in the escaping gases, and it was also successfully used at cement plants, notably near Riverside, Cal., to prevent the dust from the calcining kilns from damaging nearby orange groves and vegetation.

DR. FREDERICK G. COTTRELL

Today the Cottrell process of fume and dust removal is in world-wide use, and is recovering materials heretofore wasted to the value of many thousands of dollars. One of the latest installations is at a large smelting plant in Japan; while the largest installation is at the Anaconda smelter, Anaconda, Mont. Dr. Cottrell in a desire to encourage scientific research turned over his extensive patent rights to a non-dividend-paying corporation, known as the Research Corporation, a body formed for that purpose. A fundamental requirement in the incorporation is that all net profits shall be devoted to the interests of scientific research.

In 1911 when Dr. J. A. Holmes, the first director of the Bureau of Mines, was serving as a member of commissions appointed by the Government to study alleged damages from smoke and fumes from the Selby and the Anaconda smelters, and when the Bureau of Mines was investigating at length the smelter-smoke problem, Dr. Cottrell, because of his scientific attainments and his special knowledge of metallurgical problems, was appointed chief physical chemist in the Bureau. In 1914 he was appointed chief chemist, in 1916 chief metallurgist, and in 1919 assistant director. Aside from his work on smelter smoke Dr. Cottrell has been deeply interested in and intimately connected with work on the separation and purification of gases by liquefication and fractional distillation. During the World War and subsequently the development of the Norton or Bureau of Mines process for the recovery of helium from natural gas has been his special care, and it was chiefly through his efforts that a plant for recovering helium on a large scale for military aëronautics has been erected near Petrolia, Tex. Dr. Cottrell is a member of the American Chemical Society, the Mining and Metallurgical Society of America, the American Electrochemical Society and the American Institute of Mining and Metallurgical Engineers. He was awarded the Perkin Medal by the New York Section of the Society of Chemical Industry in 1919 in recognition of his work on electrical precipitation.

Dr. Manning Deplores Inadequate Compensation

In his letter of resignation Dr. Manning says:

"In leaving the Government service there comes to me, as it has over and over again, the thought that although this Government spends each year many millions of dollars in useful scientific work for the benefit of the whole people, the monetary recognition of its scientific and technical servants is not sufficient to enable them to continue in the service for the people.

"With the marvelous expansion of the industry in this country and the growing necessity of science to industry, the scientific bureaus have been utterly unable to hold their assistants against the competition of industry which is taking their highly trained men at salaries the Government does not pay or even approach. I feel very deeply that there ought to be more adequate compensation for the scientific and technical men in the Government service so that none of them may be compelled to accept positions on the outside. Many of these scientific men are of fine type for Government work, care little for the commercial field, take an intense professional interest in their tasks and are of inestimable value to the Government."

Pre-War Legislation Affecting Nitrate Plants

Facts Concerning Political Activities in Congress—du Pont Co. Versus American Cyanamid Co.—Debate in the House and Senate—Passage of Measure as Section of National Defense Act—Selection of Site and Process—U. S. Nitrate Plant No. 1

By CHESTER H. JONES

A CAREFUL review of the *Congressional Record* covering the 64th and 65th Congresses beginning March 15, 1916, and of the more recent testimony delivered before the Graham House committee, 66th Congress, answers many of the questions which have arisen concerning the political motives behind the nitrate situation, and causes new queries to arise in the mind of the investigator. Some of these must for the time being remain unanswered.

Nitrogen fixation from the beginning was linked with the idea of water-power development, probably because cheap power was found to be essential to the success of the arc process in Europe. The cyanamide process also required a considerable quantity of power. It is a singular fact, however, that not a pound of nitrogen was fixed by water power in the United States during the war period. Indeed, plans were consummated to operate the large plant at Muscle Shoals entirely by steam power, and for this purpose the steam plants on the Warrior River (30,000 kw.) and the equipment at the cyanamide plant (60,000 kw.) were installed by the Government, together with an eighty-mile transmission line. The work on the Wilson dam was temporarily abandoned. It is now considered essential to complete the dam in order to make the process plant a commercial success.

In his recent testimony before the Graham House committee, Frank S. Washburn, president of the American Cyanamid Co., said that he was first interested in water-power development in the Southern district and therefore went abroad in 1907 to find an industry which would be a large consumer of power, thus building up the load on his proposed power plants. He returned with the cyanamide process for nitrogen fixation, but was forced to install his plant at Niagara Falls on the Canadian side because of political conditions unfavorable to the release of water-power sites in the United States.

Du Pont Proposals

The main controversy over nitrogen fixation opened in the Senate March 30, 1916, when Willard Saulsbury (Delaware) introduced bill S. 5,136 together with letters addressed to the Secretary of War and himself by Pierre S. du Pont, president of E. I. du Pont de Nemours & Co. These letters and bill contained a proposal whereby the du Pont company stood ready to negotiate a contract with the Government under which it would begin at once to construct a fixation plant in units of such magnitude as might be agreed upon by the Government, and the du Pont company would furnish the capital.

All the company asked was the release of water-power sites for the purpose. The bill provided "that at all times upon request of the Secretary of War the grantee shall deliver to the United States for military or naval purposes all or any part of the output of nitric acid at a price which shall include such profit as the Secretary of War shall determine to be reasonable, and his determination of the reasonableness of such profit shall be final."

An impartial study of the text of this bill and the accompanying letters discloses no ulterior motives such as were subsequently hinted at by political factions. The proposition seems clearly outlined and open. It was made by a reputable concern familiar with the Government methods of doing business.

Previous to the introduction of the above bill E. D. Smith (South Carolina) had introduced bill S. 4,971, which was at this time being considered by the Senate Committee on Agriculture. The committee had amended and was about ready to return it to the Senate. The Smith bill provided that the Government furnish the capital to build the necessary fixation plants. Upon the presentation of the du Pont bill, William S. Kenyon (Iowa) immediately recommended that the two bills be published side by side in the *Congressional Record*, and this was done.

Support of the Smith Bill

Oscar W. Underwood (Alabama) called attention to the fact that the du Pont company was a private corporation and spoke at great length against private ownership. He called attention to President Taft's veto of the Coosa River project, which had forced the American Cyanamid Co. to build in Canada some years previously. "Next to defending the country against a foreign enemy," he said, "the development of the agricultural interests is most important." He introduced clippings from the newspapers in which the du Pont company was criticized, and read into the *Record* an article by Frank S. Washburn, "one of the great engineers of this country." Mr. Washburn's paper appears on page 5,153 of the *Congressional Record*, 64th Congress. Mr. Underwood was the chief speaker for the advancement of the American Cyanamid Co.'s interests throughout the controversy, as evidenced by this and subsequent speeches.

Mr. Smith (South Carolina) urged that his bill be acted upon. He quoted Mr. Washburn, president of the American Cyanamid Co., as to the practicability of the cyanamide process, and said the Committee on Agriculture had interviewed Mr. Washburn and found he practically controlled the patents on manufacture by this method.

Opposition to the Smith Bill

Thomas W. Hardwick (Georgia) opposed Government ownership as outlined in the bill, calling the whole procedure "socialism." He continued in this attitude as a matter of principle in all his subsequent speeches.

Henry C. Lodge (Massachusetts) spoke in part as follows:

"The argument is not whether a corporation is back of a certain movement or not. I suppose a corporation is wicked in Pennsylvania or Delaware and good in Alabama. We should know who is behind these propositions.

"Frank S. Washburn is a patriot, no doubt, but it occurred to me we might find out what his business interests are. It appears in Moody's Manual that he is president of the American Cyanamid Co., which has been manufacturing this fertilizer for some years; that he is a director of the Alabama Traction, Light & Power Co., once president of the Muscle Shoals Hydro-electric Power Co., and other companies which control nearly all the water powers in Alabama.

"Mr. Washburn is associated with James B. Duke, tobacco manufacturer, and through Mr. Duke the American Cyanamid Co. controls the Ammo-Phos Co. of New York, the Amalgamated Phosphate Co. and the Virginia Chemical Co., which companies in turn practically control the fertilizer and cottonseed oil business of the territory east of the Mississippi and large water-power interests in North and South Carolina.[1]

"This development was proposed as early as January, 1909. Now I have given [these details] at somewhat tedious length because they all seem to be connected with Mr. Washburn, whose pamphlet has been sent to us to give the facts in the nitrogen case."

Mr. Kenyon (Iowa) suggested an investigation of the various processes for nitrogen fixation. He showed J. W. Worthington's political activities in Florence, Ala., on the Muscle Shoals development and his corporation connections with Mr. Washburn. The Engineers Corps had previously made an estimate of $18,500,000 for a dam at Muscle Shoals, exclusive of equipment. The Government had granted Mr. Washburn a monopoly through his patents, over 100 claims being allowed. On March 16 and 17 he had admitted before the Committee on Agriculture that he and Worthington had worked in the interest of the bill. "We might as well write Muscle Shoals in the bill and be done with it," said Mr. Kenyon.

Underwood Amendment

Mr. Underwood replied to these criticisms in a long speech (page 5,647, *Congressional Record*). He referred to Mr. Washburn as "a great hydro-electric engineer, a man of great ability," and asked for the support of the Smith bill. In a later speech, April 12, 1916, he offered an amendment authorizing and directing the Secretary of War to make contract with the owners for the use, rental, lease or purchase of a suitable air nitrogen process and further authorizing him to lease the plant for fertilizer manufacture in peace time.

Mr. Hardwick (Georgia) spoke at length, calling Mr. Underwood a "socialist," upon which the latter replied that his purpose was to make nitric acid and not fertilizer.

The debate was continued over a period of three days, during which time evidence was submitted on both sides by various Senators. Dr. Leo Baekeland's article on nitrogen was printed in the *Record*. The opposition led by Mr. Kenyon (Iowa) argued against the amendment.

Mr. Kenyon said: "The Underwood amendment if it is adopted will provide for the Government furnishing the money and building the plant, then leasing it to private parties. I cannot vote for this amendment nor the bill to which it is attached."

Mr. Lodge urged against placing so much power in Mr. Washburn's hands.

The amendment was finally rejected on vote.

Disposal of the Smith Bill

During the later discussions on the Smith bill it was shown that the constitutionality of such legislation might be in question on the ground of Government ownership in peace time. The bill was indefinitely postponed at the close of the 64th Congress, Third Session. This document was, however, so similar to the measure which finally passed that the discussion on the whole subject was not reopened on the later issue. The foregoing therefore represents the attitude of those concerned with nitrogen fixation in the Senate.

Debate in the Lower House

The controversy in the House of Representatives appears to have been opened March 17, 1916, when James Frear (Wisconsin) called attention to the clause in an Army bill which authorized the erection of nitric plants. He said: "Why was this slipped into the Army bill after it had been proposed in the Navy bill, authorizing the expenditure of $24,000,000 in Alabama Power Co. holdings? Apparently the Government is being used to finance this company's projects. It is a five-line section costing the Government over $4,000,000 per line. Why give $24,000,000 to Mr. Washburn's experiment?" He quoted L. L. Somers, C. W. Bennett, Joseph W. Richards and other experts who differed with Mr. Washburn's statements on the cyanamide process. He further found that 58 per cent of the American Cyanamid Co.'s assets were propaganda and patent rights, as shown by the 1914 report of the company as follows:

Total assets	$6,563,510
License, patents and patent rights	3,569,578
Founding and propaganda	230,589

Mr. Frear continued: "The Duke interests are reported to control the best phosphate deposits of the country and, connected with Washburn, make a promising fertilizer monopoly. This is the old Muscle Shoals project in a new garb. The Alabama Power Co. owns parcels of land along the river. This section should be stricken from the bill." Five exhibits were presented (page 4,324, *Congressional Record*) showing the Alabama Power Co. and Duke activities, in the newspaper clippings.

Nitrate Section in the National Defense Act

The important legislation in the House was contained in H.R. 12,766, Sec. 124, referring to the establishment of Government-owned nitrate plants. This section was essentially the same as the Smith bill in the Senate except it provided for the delegation of authority to the President instead of the Secretary of War. During the discussion Mr. Lenroot (Wisconsin) suggested that it be amended to give the power of its administration to the Secretary of War. Mr. Foster (Illinois) spoke in favor of Government-owned nitrate plants and was supported by Tribble (Georgia) and Sherley (Kentucky).

Mr. Ferris (Oklahoma) said on May 8, 1916: "Du Pont and other ammunition companies are meddling too much in the Government affairs. I am in favor of the Government-owned plant. The Senate amendment (Un-

[1] See p. 5,641 of the *Congressional Record*, 64th Congress, for details of all these interlocking interests in the fertilizer industry.

derwood amendment to Smith bill) will give all the surplus power to the American Cyanamid Co., and they in turn will sell it to the farmer at their own sweet price."

Mr. Miller (Delaware) defended the du Pont position. Other members of the House spoke in support of the nitrate provision, with Mr. Hulbert (New York), who demanded public hearings on the facts before the money was expended.

National Defense Bill Becomes a Law

The nitrate provision was finally carried through in Sec. 124, H.R. 12,766, National Defense, and became a law June 3, 1916, as recorded on page 215, vol. 39, part 1, Public Laws. Public 85. It reads as follows:

> Sec. 124. *Nitrate Supply.*—The President of the United States is hereby authorized and empowered to make, or cause to be made, such investigation as in his judgment is necessary to determine the best, cheapest and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products by water power or any other power as in his judgment is best and cheapest to use and is hereby authorized and empowered to designate for the exclusive use of the United States if in his judgment such means is best and cheapest, such site or sites, upon any navigable or non-navigable river or rivers or upon the public lands as in his opinion will be necessary for carrying out the purpose of this act; and it is further authorized to construct, maintain and operate, at or on any site or sites so designated, dams, locks, improvements to navigation, power houses and other plants and equipment or other means than water power as in his judgment is best and cheapest, necessary or convenient, for the generation of electrical or other power and for production of nitrates or other products needed for munitions of war and useful in the manufacture of fertilizers and other useful products.
>
> The President is authorized to lease, purchase or acquire, by condemnation, gift, grant or devise, such lands and rights of way as may be necessary for the construction and operation of such plants and to take from any lands of the United States or to purchase or acquire by condemnation materials, minerals and processes, patented or otherwise, necessary for the construction and operation of such plants and for the manufacture of such products.
>
> The products of such plants shall be used by the President for military and naval purposes to the extent that he may deem necessary, and any surplus which he shall determine is not required shall be sold and disposed of by him under such regulations as he may prescribe.
>
> The President is hereby authorized and empowered to employ such officers, agents or agencies as may be in his discretion necessary to enable him to carry out the purposes herein specified, and to authorize and require such officers, agents or agencies to perform any and all the duties imposed upon him by the provisions thereof.
>
> The sum of $20,000,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, available until expended, to enable the President of the United States to carry out the purposes herein provided for.
>
> The plant or plants provided for under this act shall be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital.
>
> In order to raise the moneys appropriated by this act and necessary to carry its provisions into effect, the Secretary of the Treasury, upon request of the President of the United States, may issue and sell, or use for such purpose or construction, hereinabove authorized, any of the bonds of the United States now available in the Treasury of the United States, under the act of Aug. 5, 1909, the act of Feb. 4, 1910, and the act of March 2, 1911, relating to the issue of bonds for the Panama Canal to a total amount not to exceed $20,000,000: *Provided*, that any Panama Canal bonds issued and sold or used under the provisions of this section may be made payable at such time after issue as the Secretary of the Treasury, in his discretion, may deem advisable, and fix instead of fifty years after date of issue as is said in the act of Aug. 5, 1909, not exceeding fifty years.

In spite of all the opposition, and with all the evidence presented which questioned the motives of its supporters, the nitrate measure became a law. Its passage through Congress was facilitated by the immediate necessity for national preparedness, by the fact that it was of Democratic origin and that the promoters held the control of the only process which was commercially successful in this country at that time. A complete review of all the legislation on the subject is available in the testimony of George Walter Johnson before the Graham House committee published in the hearings Serial 6, Part 50, Jan. 2, 1920, beginning on page 2,537.

Selection of Site

Newton Baker testified that shortly after the act was passed, with its provision for an investigation of sources of power and processes of manufacture, the President appointed the Secretary of the Interior, the Secretary of Agriculture and the Secretary of War as a delegation to go about through the South and see where a proper site could be found for the building of a plant for the production of nitrates in war time and fertilizer in peace time. This trip was made in March, 1917, in company with a party of nitrogen-fixation experts, including Colonel Wheeler and Dr. Charles L. Parsons. They visited points in Tennessee, Kentucky and West Virginia. They never visited Western points, but intended to do so.

Some time after the return from this trip the three Secretaries discussed the matter informally, and Mr. Baker talked it over with the Chief of Engineers and the Chief of Ordnance. The latter, supported by other members of the party, submitted the following recommendations:

> I think that the examinations made indicate the limit of choice to four localities, viz.: Chattanooga, Knoxville, Sheffield and North Birmingham, and after fully considering all the aspects of the matter, it is my opinion that the site at North Chattanooga, Tenn., having been adjudged first from the fertilizer standpoint and next from the compromise standpoint, is best fitted for the constructions now contemplated, and I recommend its adoption, and the purchase of a tract of 500 to 600 acres.
>
> William Crozier,
> Brigadier General, Chief of Ordnance, United States Army.

On the margin of that memorandum dated Aug. 6, 1917, is a postscript, or a sort of note:

> The original letter 471, 86/2020—Nitrogen, j/z. dated Sept. 20, 1917, a memorandum for the Secretary of War, signed by William Crozier, Brigadier General, Chief of Ordnance, United States Army, copy of which you already have been furnished; bears the following postscript in long-hand:
>
> "The President has selected Sheffield. So informed by Secretary of War.
> 9/28. W. C."

It is understood that the department heads indorsed this recommendation to the President, but he decided on the Sheffield, or Muscle Shoals, location in spite of such advice. The authority was vested in the President according to the provisions of the law, and he was evidently persuaded by advisers not members of the delegation which had been charged with recommending a proper site.

Selection of the Process

During the time that the site was under discussion, the committee of the National Academy of Science was

investigating the matter of processes, having made a trip to Europe for the purpose. Other commissions and individuals were carrying on similar inquiries.

Appointed by General Crozier to visit Europe in 1916, Dr. Charles L. Parsons studied processes in England, France, Italy and Greece and made an individual report which did not agree with the report made by the National Academy committee, in that he strongly favored the synthetic ammonia or modified Haber process of the General Chemical Co.

The Secretary of War then appointed a new committee called the Nitrate Supply Committee, and made Dr. Parsons a member. The personnel of this committee was as follows:

General William Crozier, Chief of Ordinance, U. S. Army; Admiral Ralph Earle, U. S. Navy; General William Black, Chief of Engineers, U. S. Army; F. W. Brown, U. S. Dept. of Agriculture; Dr. Leo H. Baekeland, Gano Dunn, Dr. Charles H. Herty, Dr. William F. Hillebrand, U. S. Bureau of Standards; Dr. Arthur A. Noyes, Dr. Charles L. Parsons, Dr. Willis R. Whitney.

This committee recommended, among other things, that the Government negotiate with the General Chemical Co. for the right to use the synthetic process for making ammonia, erect a plant to produce thirty tons of ammonia per day and an auxiliary plant to oxidize the ammonia to nitric acid.

U. S. Nitrate Plant No. 1

Contract was made with the General Chemical Co. as advisory engineer, on the modified Haber process, with the J. G. White Engineering Corporation as construction engineer to undertake the erection of the plant and with the Chemical Construction Co. to construct the special apparatus in the nitric acid plant. Thus the work on U. S. Nitrate Plant No. 1 at Sheffield, Ala., was finally started, during August, 1917.

Political Comment

On Sept. 14, 1917, Nicholas Longworth (Ohio) spoke in the House of Representatives concerning the report of the Nitrate Supply Committee mentioned above, quoting Dr. Herty as stating, "The country will receive supplies of fixed nitrogen far more quickly than possible under the methods which would require time in the development of water power." Mr. Longworth adds: "I was opposed to the $20,000,000 nitrate scheme because it involved only one plant. On report of Dr. Parsons, General Crozier and others it has been decided to indefinitely postpone making nitrogen by water power. This, thank goodness, sounds the death knell of the Muscle Shoals nitrate scheme. Its abettors and supporters have been knocking at the doors of Congress for some years."

Conclusion

It is not within the scope of this article to give more than a brief outline or series of sidelights from the history of the circumstances surrounding so wide a subject. Many inferences may be drawn from thorough research in the available archives to suit the taste of the individual explorer. No one can deny that with the present knowledge of the case at hand many humorous things are to be found in so reviewing.

It is the story of political intrigue, with the ever-present private interests in the near background; of sectional preference, with the needs of the nation often a secondary consideration, and differences of opinion held by scientists on a comparatively new subject. It may be gathered from the above paragraphs that Mr. Underwood is the gentleman from Alabama who helped do things for his state; that Mr. Longworth is from Ohio, not Alabama; that Mr. Washburn is in the fertilizer business; that Dr. Parsons is a strong advocate of the synthetic ammonia process; that the President ignored his official advisers, and many other pertinent facts which will make the readers of Chemical & Metallurgical Engineering better acquainted with the gentlemen who will have something to say when the pending bills for the operation of the Government plants are returned to Congress from the committees.

In the days of the war when these things were carried on, there was no question as to the earnest effort of the principals to accomplish those objects which would be of greatest benefit to the nation. Beneath it all lay a sound economic theme, and because the country needed nitrates in war and peace alike the deed was consummated. Because of patriotic fervor it was done quickly and successfully. The equipment stands idle today awaiting the action of Congress to start its operation in the service of agriculture.

Use of Cibucao Wood for Dye in Hongkong

The business of the import of "cibucao" wood from the Philippines and its manufacture into a stain or dye in Hongkong is in the control of a close combination of five Chinese firms in Hongkong, of which Yuet Loong Chan & Co., Hongkong, is the principal. The wood, called "Soo Mook" in Chinese, comes almost exclusively from Iloilo and vicinity in the Philippines. It is a red, fairly soft wood, and is cut and cured in short lengths and imported in bundles. It is bought and sold by the picul (133⅓ lb.), its price in Hongkong at the present time being about $2.10 local currency, or substantially the same in gold, per picul. The stain or dye manufactured from the wood is a red ink or paste used largely by the Chinese for inking the small "chops" or seals employed by them as the means of affixing their signatures to written instruments of a formal nature.

The color in the wood is extracted and used variously by the Chinese as an ink, a stain, dye, and paint color. The wood is boiled and the resulting water solution is further boiled down to a siruplike consistency. Whiting is then mixed with it for most purposes, the resulting paste being the preparation used as an ink for the native "chops." As a dye the stain is used for coloring cheap Chinese papers, notably the paper used in the manufacture of firecrackers, ceremonial papers of various sorts, and for the very cheapest sort of Chinese stationery. The whiting concentrate also is used as an adulterant for European red paints. The color liquor also is used at times for mixing with better quality of red dyes for coloring native cloths.

The whole process of extracting the dye is crude and wasteful, but the business is closely controlled by this syndicate, which is strong enough to regulate the volume of the manufacture and the price of the product. It is doubtful, therefore, whether it would be practicable to transfer the industry to the Philippines and have the dye or stain manufactured there for sale in China, although apparently there would be a considerable saving in freight and other expenses by so doing.

A Comparative Test Upon High-Speed Steels—II

Conditions Entering Into the Testing of a Tool for Cutting, Listed by Taylor, Are Discussed—Detailed Information is Given as to the Method of Eliminating Most of the Variables From a Comparative Test for the Efficiency of Several Brands of Commercial Tool Steel*

BY A. J. LANGHAMMER, M.E.†

AS EVERYONE knows, the Packard Motor Car Co. was the pioneer manufacturer of Liberty airplane motors for the United States Government during the war. In building Liberty "12" airplane motors, one of the most intricate problems was that of machining the steel cylinders. At the start of the manufacturing program, this unit was made of a solid billet, which practice fortunately was rendered obsolete by the most opportune invention of the Ford Motor Co. The Ford method permitted the making of these cylinders from steel tubing at greatly reduced initial cost and with an additional huge saving in labor (boring of billet) and tool costs. The material used was heat-treated mild carbon steel, subjected to rigid Government inspection for both composition and physical properties before it entered the machine shop. The result was, therefore, a product of unusual uniformity, thereby furnishing a material of exceptional merit for testing purposes. Since it was not only essential to get a product of highest quality machined to extremely low tolerance and limits but it was also vital to obtain a maximum production of airplane engines, a test was decided upon to determine the high-speed steel which would meet these difficult requirements. The following pages describe that test in detail.

Elements Entering Into the Cutting of Metal

Dr. F. W. Taylor in his "Art of Cutting Metals" gives twelve elements that affect the cutting speed of tools. To this must be added one more, the human element, thoroughly recognized by Dr. Taylor but emphasized by Prof. A. L. Jenkins, professor of mechanical engineering at the University of Cincinnati. As every test of cutting tools that is to be of any value must take full cognizance of these elements, they are listed below in abbreviated form:

1. Quality of metal to be cut.
2. Chemical composition of the tool steel and its heat treatment.
3. Thickness of shaving (feed per revolution).
4. Shape or contour of cutting edge of tool.
5. Type of coolant (water, oil) used.
6. Depth of cut.
7. Duration or length of cut.
8. Lip and clearance angles.
9. Elasticity of the work and of the tool, i.e., degree of chattering.
10. Diameter of work.
11. The changes of speed and feed possible in the machine tool.
12. The pulling and feeding power of the machine tool.
13. Human element.

To simplify the test and make the results more positive, as many elements as possible were made constant. Each variable as it affected our test in accordance with the above classifications will be discussed briefly.

Cutting Speed

In determining the proper cutting speed,[1] the depth of cut, feed, and the machine tool flexibilities had to be considered most carefully. The depth of cut was first determined (see discussion under that heading below) and then with the aid of special tools, not included in the test proper, several runs were made and a cutting

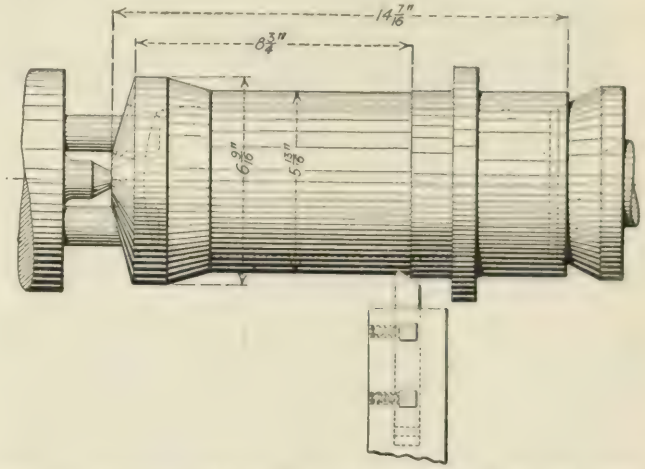


FIG. 1. SHOWING THE MATERIAL CUT AND SET-UP USED IN TESTS

speed of 35 ft. finally chosen. This value was used throughout the test in all runs and was maintained at a constant value, thereby eliminating the factor "cutting speed" as a variable.

Quality of Metal to Be Cut

The metal cut was the Liberty airplane motor cylinder, a mild carbon (0.40 to 0.50 per cent) heat-treated stock. Fig. 1 shows the cylinder in the rough before any machining operations have been performed. Every cylinder used in the test had to show a hardness between 217 to 255 Brinell (scleroscope 36 to 43) before it was accepted by Government inspectors. As there were thousands of cylinders to choose from, only those were actually selected for test purposes whose scleroscope range did not exceed these points. Each cylinder was also carefully inspected for out-of-round, eccentricity, variations in diameter, fins, and excessive scales or rust formations, any unsatisfactory specimen being summarily rejected. Attention is invited to these exceptional conditions by which the test was favored because such a desirable material would hardly be found avail-

*For Part I see CHEM. & MET. ENG., vol. 22, No. 18, May 5, 1920, p. 829.

†Industrial engineer, Thompson & Black, engineers and accountants, New York and Detroit.
Formerly mechanical engineer, Packard Motor Car Co.

[1] See "Art of Cutting Metals," F. W. Taylor.

TABLE II. COMPOSITION AND HEAT TREATMENTS OF TOOL STEELS TESTED

Brand	Chemical Composition * Carbon	Tungsten	Vanadium	Nickel	Chromium	Cobalt	Uranium	Heat Treatment: Preheating	Hardening	Quenching Medium	Drawing Temperature	Remarks on Heat Treatment
A	0.79	12.8	1.74	0.10	3.78	None	None	All tools slowly preheated to 1550-1600 F.	The temperature in the hardening furnace was maintained at practically 2300 F. The tools were withdrawn and quenched when the condition of sweating was satisfactory to the expert representing the steel company which produced the brand being hardened.	Oil	1050	Cyanide on tip of tools during hardening.
B	0.64	16.9	0.92	0.10	2.42	None	None			Lead at 1050 F.	1100	"B" tools withstood the high heat very well.
C	0.40	18.00	0.51	Tr.	3.53	None	0.11			Lead and kerosene.	1050	Tools 0 and 1 quenched in lead. Tools 2 and 3 quenched in kerosene
D	0.62	14.86	1.05	Tr.	3.59	None	0.10			Lead at 1050 F.	1100	One-half of tool immersed in lead. Relatively short heat.
E	0.49	17.35	0.23	Tr.	2.78	None	0.14			Lead	1100	
F†	0.67	19.70	0.99	0.21	3.78	None	None			Oil and lead	1100	Tools 0 and 1 quenched in lead. Tools 2 and 3 quenched in oil.
..	0.65	15.79	0.49	0.24	3.44	None	None					
G	0.62	18.26	0.75	Tr.	3.70	None	None			Oil	1050	
H	0.66	18.30	0.45	None	4.17	None	None			Lead at 1050 F.	1075	
J	0.68	18.12	0.48	Tr.	2.63	None	0.10			Oil and lead	1050	Tools 0 and 3 were immersed half way in oil; then they were placed on the floor and thus drawn.
K	0.59	13.34	0.95	Tr.	3.64	None	0.15			Oil	1075	
L	0.76	21.92	1.05	None	5.27	None	None			Lead at 1050 F.	1050	
M	0.69	16.95	0.75	0.18	3.09	None	None			Oil and kerosene	1100	Tool 2 quenched in oil. Tools 0, 1 and 3 quenched in kerosene. "M" tools withstood the high heat very well.
N	0.66	13.55	2.20	0.10	3.59	None	None			Oil	1050	
O	0.67	13.50	0.99	0.20	4.30	None	None			Oil and lead	1100	For tool 0 only. Tools 1, 2 and 3 were not drawn.
P	0.38	15.27	0.05	0.20	2.85	None	0.14			Lead	1100	Blistered on heating.
R	0.65	17.08	0.58	0.20	2.78	None	0.10			Oil and lead	1075	Tools 0 and 2 were quenched in lead. Tools 1 and 3 were quenched in oil.
13, 14‡	0.75	11.12	2.10	0.32	5.13	None	None				None	

The samples for chemical analysis were obtained from the same section of the bar of which the tools were made.

The temperature of the lead bath used in quenching was maintained at a temperature of 1050 F. The tools were immersed in the molten metal for about 3 min., and then allowed to cool in the air.

* Phosphorus and sulphur below 0.04 per cent in all cases.
† The second analysis under F gives that of a second bar obtained subsequently.
‡ This steel was not tested, but its microstructure is shown in Figs. 13 and 14.

able in ordinary practice. The factor of "quality of metal to be cut" was perforce a constant.

As a matter of record the metal being cut may be noted to be the so-called "Aircraft Standard Steel," or S.A.E. 1045, known to the trade as 0.45 carbon machine steel. The chemical compositon is

	Per Cent
Carbon	0.40 to 0.50 (0.45 desired)
Manganese	0.50 to 0.80 (0.65 desired)
Phosphorus	0.045 maximum
Sulphur	0.05 maximum

Ordinary heat treatment given the forgings consisted of a quenching in oil or water from 1,500 to 1,550 deg. F. (820 to 845 deg. C.) and a drawing at 1,150 to 1,200 deg. F. (620 to 650 deg. C.).

After such treatment the physical properties were:

Elastic limit (approximately)	67,000 lb. per sq.in.
Tensile strength (approximately)	98,000 lb. per sq.in.
Elongation	20 per cent
Reduction of area	56 per cent

Chemical Composition of the Tool Steel and Its Heat Treatment

In the first few columns of Table II are given the chemical composition of each set of tools of the separate brands, as determined by actual analysis. This composition supposedly represented the standard practice of the steel manufacturer. If the company made more than one grade of high-speed steel, the best or "superior" grade only was specified, as will be pointed out in more detail in the next paper. The heat treatment of each tool likewise is shown in Table II. "Chemical composition" therefore was a variable.

Thickness of Shaving

Experience has taught that the finer feeds are not adapted to test work because slight imperfections either in the cutting edge of the tool or in the material cut affect the tool in a manner more disastrous than a coarse feed. In shop practice, too, medium or heavy feeds are generally used and if the test conditions approach normal practice the results can be more easily interpreted by shop men. A feed of 0.054 in. was used in our "first run" and 0.090 in. in the "second run." (See discussion below under "Methods of Procedure.") As each value of feed was adhered to throughout the individual runs the "thickness of shaving" was a constant.

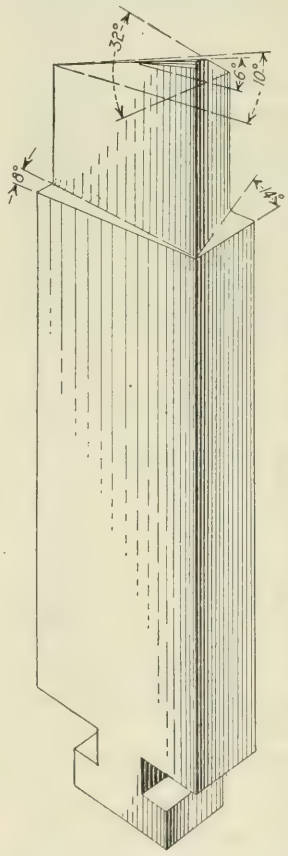


FIG. 2. LO-SWING LATHE TURNING TOOL

Shape or Contour of Cutting Edge of Tool

Fig. 2 shows the type of tool used in the test. Each individual tool was machined, rough ground and finish-ground. This particular design of tool is adaptable for a "Lo-Swing Lathe," because on such a machine the cut is generally started by "feeding in" the tool to the desired depth and then engaging the feed, rather than "setting" the tool to the desired depth before engaging the power feed. (See Fig. 1 for the illustration of this point.) Also on most work a "gang" of tools are used, some of which must cut right up to a shoulder or flange, necessitating the side cutting edge of the tool being parallel with the shank. All grinding was performed by an expert on a Taylor automatic tool grinder and every tool was inspected after the final operation.

A nose of $\frac{1}{16}$ in. radius or $\frac{1}{8}$ in. "rounding" was ground on all tools for the first run, while a $\frac{1}{8}$-in. radius or $\frac{1}{4}$-in. "rounding" was adopted during the second run. The radius was increased during the second run, because with the given designs of tool this procedure necessitated the minimum grinding and thereby reduced the chances of harming the tool during the grinding operation. As the stated values of the radii were uniform

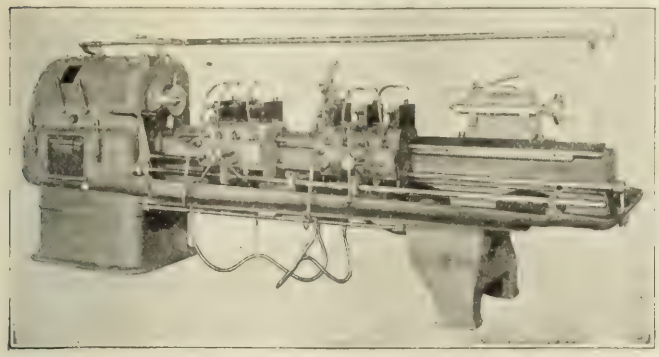


FIG. 3. TYPE OF MACHINE TOOL USED IN TESTS. EIGHT-INCH LO-SWING LATHE

for each run and the shape of the tool was rigidly inspected after grinding, the "shape or contour of cutting edge of the tool" was made constant.

Type of Coolant or Cutting Compound

The use of a coolant in itself introduces several variables (such as uniformity of material, pump trouble, misguidance of the cooling stream, etc.), adds considerably more work, and provides for possible inaccuracies. As it was desired to determine only the comparative life and not the maximum attainable, no coolant was used, thus making this factor, "type of coolant or cutting compound," zero.

Depth of Cut

Once either the feed or the depth of the cut has been decided upon, the other factor in conjunction with the cutting speed is determined by the time limit set for failure to occur, and by the power and flexibility of the machine tool employed. In this case the depth of cut was established first, because the material cut had to enter the regular production when the machine work was finished. This, then, limited the diameter to which the specimen could be reduced, and thereby automatically established the depth of cut, $\frac{3}{32}$ in. in this instance. The value of the depth of cut, like the feed, should in all cases approach the normal for ease of interpretation, and the figure stated checks very closely with the amount of stock removed in the average roughing operation on a simple drop forging. A snap or external limit gage that held the turned diameter to a variation of 0.005 in. was used to measure the depth of cut (the rough diameter of the material had been previously checked, as already described at length under "Quality of Metal to Be Cut"), so that the "depth of cut" was reduced to a constant.

Duration or Length of Cut

The duration of cut in a test on cutting tools is an item that requires very careful consideration. When too short a time limit is chosen, the results are questionable, if not valueless, because the heat generated at the working point of the tool is so great as to cause unjustifiable and wide variations in duration of cut. Too long a time is somewhat less objectionable, because it entails increased difficulties with respect to securing homogeneous material and possibly induces general inaccuracy. Therefore, for the first run, a duration of about 25 per cent less than the standard practice on that particular class of work was chosen. On the second run, however, a value which caused an average good tool (as determined by experiment with tools made up especially for this purpose) to fail within 20 min. was applied. Of course the time limit, other things being equal, depends on the cutting speed, feed, and depth of cut. As the depth of cut was predetermined due to the fact that the material used was a "production part" and the feeds and speeds of the machine tool used, an 8-in. Lo-Swing Lathe, Fig. 3, were limited, it was decided to change the feed only to vary our duration or length of cut. The element of "duration or length of cut" was perforce a variable.

Lip and Clearance Angles

At the beginning of the test the design of tool and all clearance angles were decided upon. The various clearances and slopes were as follows: 6 deg. clearance at the nose and 10 deg. clearance at the heel, 14 deg. side slope, no back slope, 32 deg. horizontal clearance, 8 deg. vertical clearance, 84 deg. lip angle and 90 deg. cutting angle. See Fig. 2 for a perspective representation of this tool and the values given. As these values were identical on each tool, the element of "lip and clearance angles" was of necessity a constant.

Elasticity of the Work and of the Tool, or Chattering

Chattering affects both the cutting-speed and finish of the work and is caused by incorrect design of cutting tool, incorrect method of clamping and driving the work, poor design and ill fits in the machine tool, synchronizing of the effects of defective elements and loose fittings in the machine and the set up, or a combination of these. By inspection of Fig. 2 it will be seen that the design of tool was such as would discourage chattering. In the same way Figs. 1 and 3 show an unusually rugged

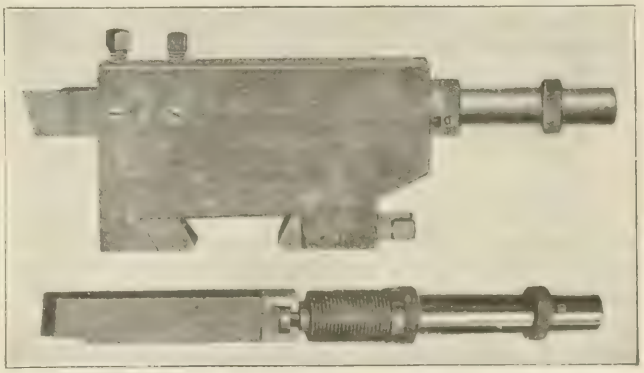


FIG. 4. DETAIL OF THE METHOD OF TOOL HOLDING, TOOL CLAMPING AND TOOL FEEDING

and positive drive with a good set up, so that chatter from this source was eliminated. Attention is invited to Fig. 4, which shows the particularly rugged tool block that was used. It is to be noticed that fully 80 per cent of the total length of the tool rests solidly on its base and that set screws are provided for securing absolute rigidity both horizontally and vertically. The choice of

machine tool provided a unit that was very adaptable to the work of the test, so that "chattering" as it affected the cut-speed was made a constant, approaching zero.

Diameter of Work

Under "Quality of Metal to Be Cut" it was pointed out above that all forgings were carefully inspected for variations in diameter. As a huge amount of stock was available, nothing but perfect specimens were accepted, so that the "diameter of work" was easily made a constant. This, too, was a feature that cannot easily be duplicated under ordinary conditions. Also the value of the diameter was such that it provided for easy interpretation in general shop practice.

Change of Speed and Feed Possible in the Machine Tool

In Fig. 3 is shown a half tone of the machine tool used in the test. The range of speeds and feeds are given in Table III.

TABLE III. CHARACTERISTICS OF MACHINE TOOLS USED

Spindle Speeds for 500 R.p.m. of Pulley	Feed per Revolution, Inches
25	0.166
45	0.120
75	0.090
120	0.054
200	0.040
325	0.030
	0.018
	0.013
	0.010

A belt- and not a motor-driven machine was used, so that the choice of feed and speed to secure failure of the tool within a given period was somewhat limited. By establishing the cut-speed and depth of cut at the onset, a proper feed was, however, readily determined so that the "change of speed and feed possible" was eliminated as a contending factor.

Pulling and Feeding Power of the Machine Tool

Inspection of Fig. 3 will show a lathe of rugged construction. The geared headstock is of good strength, and the heavy bed, carriage, and feed mechanism provide for rigid support and taking of heavy strains. As a matter of fact, the load applied in the test did not at any time approach the possible duty of the machine. The unit used was a new machine that had only been "limbered up" preparatory to the test. No variations were therefore introduced due to the "pulling and feeding power of the machine tool."

Human Element

It is generally conceded that in any undertaking the human element presents a very complex problem. This factor, therefore, received due attention and the personnel was made up not of one but of two operators who, in addition, were not only lathe hands but tool makers as well. Both men worked under constant supervision of a competent observer who was a technical graduate with years of practical experience. To further insure the accuracy of the test, other engineers checked the data and operations at frequent intervals so that the "human element" was made constant in so far as it was possible.

Variable Factors in the Tests

By a review of the above thirteen elements and the brief discussion of the manner in which they affected the test, it will be seen that only two—chemical composition of the tool, and duration or length of cut—remained variables. This condition, then, formed the basis of the test.

Duration of Test

Possibly it will occur to the reader to ask, "How long did it take to run this test?" To answer this the following data are submitted:

The time that elapsed from the date on which it was decided to run the test until the work was all completed and the data compiled was five months, in round figures. The actual number of cylinders turned with the test tools was 1,251 while another 150 were machined by special tools in determining the correct feed and duration of cut for the test proper. All told, then, 1,400 cylinders, or 1,690 ft. of 5¾-in. medium-carbon steel, were machined in this test.

(Part III will be published in our next issue.)

Belgian Penalties for Commercial Fraud

American manufacturers or exporters having trade disputes with Belgian importers should take note of the penal provisions of the Belgian code relating to obtaining money under false pretences. According to article 428 of the code, such false pretences connected with the sale of goods (*tromperie sur marchandises vendues*) are punishable by imprisonment of from one month to one year, or by fine of from 50 to 1,000 francs, or both. Fraudulent intent may arise from the furnishing of goods not of the quality or kind specified, or from deliberate failure to furnish specified quantities.

As *tromperie sur marchandises vendues* is a basis for criminal action, aggrieved Belgian importers have the right to cause the arrest of foreign vendors accused of such practices upon their arrival in Belgium. As there is no provision for release on bail pending trial in criminal cases, as in the United States, evidence of fradulent intent must be clearly shown by Belgian business men before a warrant is issued, however.

In a recent case a small and apparently irresponsible export house in New York had sold adulterated goods to several Belgian dealers. The importers had rejected the shipments when chemical analysis disclosed the adulteration and were attempting to secure reimbursement from the exporter. In the meantime one of the members of the exporting firm arrived in Brussels and was promptly threatened with summary arrest by his customers.

In this instance the export house claimed that the supplying manufacturer was responsible for the adulteration; it was also claimed that there was a misunderstanding regarding the nature and quantity of the goods, owing to ignorance of the French language. It was therefore impossible to establish prima facie fraud sufficient to justify imprisonment pending trial of the case. However, if the visitor to Belgium had been a manufacturer (not a forwarder) who had clearly furnished adulterated goods and received payment therefor, the result would no doubt have been more serious.

Polish Courts to Register American Firms

The Legation of Poland in Washington has received information from its government that courts in Poland have been instructed to register American firms without hindrance.

The Function of the Chemical Engineer in the Biscuit and Cracker Baking Industry

Application of Chemical and Industrial Engineering in the Baking Industry Is Now Recognized to Be a Really Great Step Toward Technical Improvements Leading to Uniformity of Products Manufactured and Efficiency of Plant Operation

BY O. C. F. LIPPERT
Chemical Engineer, the George H. Strietmann's Sons Co.

THE idea of having a chemical engineer associated with the organization of a biscuit and cracker bakery is a modern one. This is due to the fact that biscuit and cracker bakeries until recently have been rather successfully conducted by the "rule of thumb" methods.

The industry for the most part was made up of very small units in which it was possible for one or two men to successfully make and bake all the products by a sort of intuition, just as the housewife supplies the home with good bread and cake. That is, if she is asked to tell how she makes her products, she will somewhere in her instructions for making, or in her recipe, say: "I add so much of this or that until I get a certain taste," or else she will say: "I bake it until it gets such and such a color."

In a similar manner in the past and to some extent even today, the foremen of the various departments had and have that intuition which permits them to turn out a product which cannot be readily duplicated, even by their own assistants.

Chemical Engineering Work Needed to Obtain Uniformity in Manufactured Products

When one of these small units reaches a certain size, it becomes necessary that the products which the firm produces maintain a certain standard. Unfortunately it becomes impossible to maintain this standard when the responsible foreman is incapacitated. This is disastrous to the marketing and sale of the product and so the slogan of the sales department is "Uniformity." In the home or smaller concerns the problem would be met by waiting until the return of the party with the "gifted or inspired method of procedure." Where the units or plants are large, it is readily admitted that this is entirely impractical. Accordingly it becomes necessary to devise means and methods to bring about this uniformity. In this connection the services of a chemical engineer are most valuable, as his training, devoted to the study of materials and to methods of manufacture, fits him for undertaking work of this nature.

His work almost automatically divides itself into three main divisions which may be characterized as studies of (*a*) raw materials, (*b*) methods of manufacture, (*c*) finished products and industrial engineering.

Raw Materials

The problem of studying raw materials as used in the baking industry with reference to uniformity is complex. There is probably no industry which uses so many varieties of raw materials in so many combinations. Also, the raw materials are, for the most part, organic in nature and complex in structure, as the following list will show: Flour, butter, lard, shorteners, vanilla and flavoring extracts, eggs, milk, sugar and others. The inorganic raw materials, such as salt, sodium bicarbonate, do not present any difficulties. However, ammonium carbonate, the associate of sodium bicarbonate as to functioning, has presented rather interesting studies from time to time owing to its complex nature.

Methods of Manufacture

Topics in this group are:

1. The proper sequence of raw materials in mixing.
2. The physical condition of the raw materials before mixing.
3. The manner of mixing.
4. The conditioning or aging of the mix.
5. The treatment or preparation of the dough for the cutting machine.
6. The quantity of heat used.
7. The quality of heat used (including kind and temperature).
8. The method of baking (whether directly on the ovenpans, or on wire mesh pans, or on separate greased pans).
9. The subsequent cooling of the product.
10. The time elapsed from leaving oven until in container.

Not every problem required a study of all of the above topics, but all required taking into consideration at least the greater number of them.

Finished Products and Industrial Engineering

Concomitant with methods of manufacture, problems of industrial engineering are met with such as:

1. Time and motion studies of operations.
2. Stock arrangements.
3. Routing of materials (both raw and finished).
4. Costs and production.
5. Mechanical problems of equipment.

Typical Analyses Needed in the Baking Industry

In order to give some idea as to the nature of the raw materials studies, the following is presented.

The main raw material used in the baking industry is flour, which is supplied in sacks of 98 lb. and 140 lb. (usually the latter). It is stored on platforms or trucks, twenty-one sacks to a platform in layers of three sacks each. The problem of getting representative samples and keeping track of the various lots as received and analyzed was rather annoying, as it was of little importance to the stores department workmen to keep supplies according to lots. It was met by tagging each platform with a serial number and using the well-known butter or lard "trier" or "thief." It was found that the

trier gave a conical sample extending from the outside of the sack to the inside or center. In this way, the sample contained flour which had been subjected to atmospheric conditions as well as flour which had been protected from same. By taking samples from several sacks in proportion to the size of the lot of flour and mixing these sack samples, a very representative lot sample was obtained.

The next problem was, What kind of analysis should the flour be subjected to, consistent with time, cost and results?

The following analyses are typical of flour as used in the baking industry and as submitted by wheat and flour-testing laboratories:

	Straight Per Cent	Patent Per Cent	Patent Per Cent
Moisture	12.50	11.18	11.70
Fat or oil	1.12	0.98	1.35
Ash	0.564	0.508	0.488
Absorption	57.00	56.00	56.55
Color	100.00	104.00	101.00
Gluten (dry)	8.38	9.49	10.36
Protein (5.7 × N)	9.22	10.28	11.55
Quality of gluten	100.00	94.70	101.50

Sometimes the additional information of loaf value (expressed in per cent) is given.

Critical Study of the Analyses for Use in the Cracker-Baking Industry

A critical study of the analyses for use in the cracker-baking industry as to the importance of the individual items, consistent with time, cost and results, led to the following conclusions:

1. That the moisture, gluten, absorption, protein and ash determinations were worth the time and cost.
2. That the fat determination was not worth the time and cost.
3. That the loaf value was not directly applicable in the cracker and cake industry and hence not worth the time consumed in obtaining it.
4. That the color and quality of gluten determinations were of some value.
5. That some supplemental test or determination would have to be made which would give the same information to the cracker baker about the quality of gluten that the loaf value does to the bread baker.
6. That this test must be carried out in conjunction with some of the other tests.

The bread baker bakes one kind of product—that is, he bakes different kinds of bread—but he is not using his flour in as many different formulas nor is he using it with as many kinds of ingredients.

Importance of Determining the Value of Gluten and the Method of Its Determination

The problem narrowed down to determining the value of gluten as gluten alone and the effect of heat on the gluten, i.e., of determining what was afterward called the expansion test.

At the present time no method is known by which proteins or gluten may be isolated by chemical methods. However, the physical method, of washing out the starchy part of flour, is very applicable, especially so since it can be carried out with rapidity. Furthermore, the absorption value can be previously determined and subsequently the appearance and elasticity of the gluten noted and examined on the same sample.

The method of procedure for obtaining the absorption value and washing out of the starchy material is as follows: 33.33 g. of flour is weighed into a beaker and 15 c.c. of cooled distilled water is added from a burette. It must be remembered in connection with the washing out of the starch that the temperature of the water is of importance, i.e., must be kept cool. Then ½ c.c. of water at a time is added until a dough of proper consistency is formed. The number of c.c. of water used multiplied by 3 equals the absorption of the flour for water.

Enough water is now added to cover the dough and same set aside for 1 hr., after which it is washed out over a screen of bolting cloth, using cooled (in summer cold) water, until free from starchy material. Care must be exercised not to have the water flowing too fast, as it tends to divide the gluten into small particles which are hard to incorporate with the main portion. Care must also be taken not to extend the washing-out process over too long a period of time, as this causes the gluten to adhere to the fingers. Any loose or small pieces of gluten which have been caught on the bolting cloth screen can be gathered by using the main ball as a swab. The screen is made by fastening silk bolting cloth (125 mesh to the lineal inch) into the largest size obtainable embroidery frame. The gluten thus gathered into one ball is put in a beaker using fresh cooled water and allowed to stand for an hour, after which it is observed as to its elasticity and quality, which are determined by physical examination.

Glutens of excellent quality will have a light or creamy color, will remain solid and will be elastic. There is, however, a difference in the elasticity of excellent quality gluten. Some stretch very readily without breaking, while others offer more resistance. This aids in a preliminary way in determining the use of a flour, i.e., whether it is adapted for crackers or cakes.

Method of Determining the Heat Action on Gluten

The following method was developed in determining the heat action on gluten and has been termed the "expansion test": The moisture from the isolated gluten is removed by pressing the gluten between the palms of the hands and the fleshy part of the thumb. Care must be taken to have the hands cool (which is usually accomplished by allowing water to run over the wrists). The hands must be frequently dried during this operation. The gluten is then rolled into a ball and transferred to a clean, previously weighed, zinc plate about 2 in. square, which is then placed in an electrically heated oven or furnace, where a temperature of 158 to 160 deg. C. is maintained for 18 min. At this temperature and for this time the best expansion of the gluten is obtained. It is then transferred to a drying oven maintained at 100 deg. C. for a period of 16 hr. (usually over night), then weighed and dried to a constant weight at hourly intervals. It has been found that all the moisture has been expelled in the 16-hr. period when the test is conducted as above.

The measuring of the expansion is accomplished as follows: The gluten ball is carefully removed from the zinc plate (zinc plates are used because the adhesion of gluten to zinc is less than in the case of other metals or glass) and placed in a 2½-in. cubical measuring box with sliding lid. Seeds of fair size (such as hemp) are added (from a graduated cylinder filled with the seed and whose cubical contents equal that of the box) until the box is filled. The seeds remaining in the cylinder give the cubical contents of the volume occupied by the gluten ball. The volume thus obtained, divided by the number of grams of dried gluten, equals the expan-

sion per gram of gluten, which when multiplied by the per cent of protein obtained by chemical methods equals the total expansion volume of the gluten in terms of c.c. per 100 g. of flour.

Tabulated and Plotted Results of Flour Analyses

A statistical study is then made every season (usually about August, when the new flour comes in) of the expansion factor with reference to the protein, gluten (by washing-out method) and the ash determinations. Table I gives the information in tabular form, supplemented by curves and comments thereon, of a typical season.

The curve sheets show clearly the variations encountered in flour analysis. Fig. 1 illustrates the variation met with in protein content and gluten value. Fig. 2 combines the data as given in Fig. 1 with the ash value, which is the index as to how the wheat was milled to produce the flour.

A high-grade flour most generally has a low ash value. A 40 per cent patent means that only 40 per cent of the wheat was used (i.e., the best part), while a 60 per cent patent would be milled from 60 per cent of the wheat and hence would contain more mineral matter, with a resulting higher ash content. It has been observed, however, that flour obtained from wheat grown on the

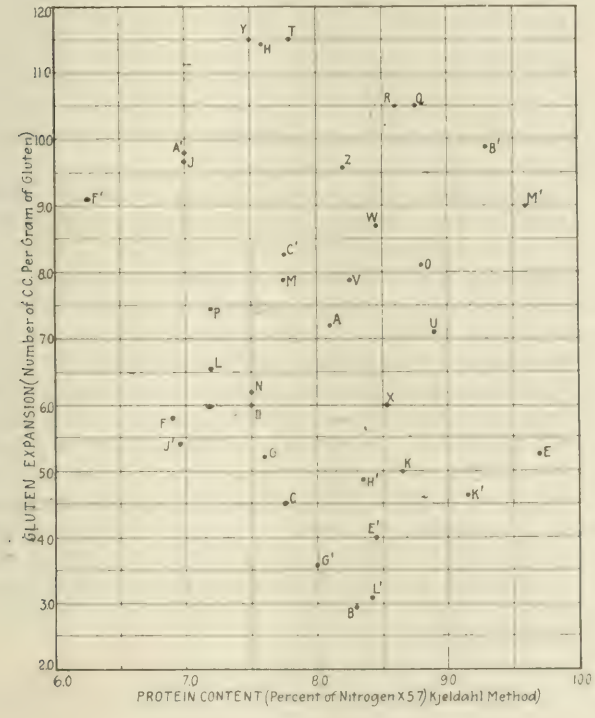


FIG. 1.

Pacific Coast has a high ash value due to the soil in which the wheat is grown.

The total gluten expansion value gives with one figure the combined quality and quantity value of the gluten. Having worked out, at the beginning of the season, charts similar to those given, it is a rather easy matter on subsequent analyses for the same season to determine just where a flour belongs and what it can best be used for, crackers or cakes, and also what kind of cakes.

The absorption value tells how much water to use in your mixes and the moisture determination tells how much water you are paying for.

In a similar manner, standard specifications were

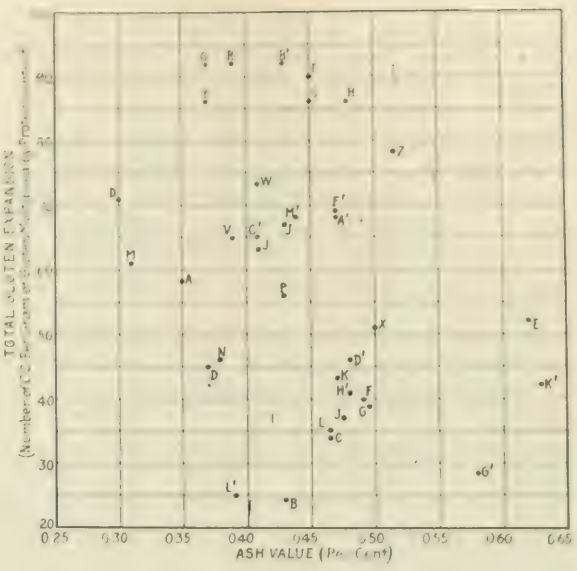


FIG. 2

worked out for other raw materials. Chief among these were:

1. Butter, lard and shorteners; in which it was found advisable to make melting point, refractometric, moisture, ash (including salt), casein determinations; obtaining fat by difference. Special attention must always be paid to color, taste and odor.

2. Milk products and milk powder; make ash, moisture, fat (Babcock method—Leach) determinations.

3. Molasses, syrups, sugar; make moisture, invert sugar and sucrose determinations.

4. Flavoring extracts; make specific gravity determinations and observe taste.

5. Baking powders; make acidity tests and determine starchy material.

TABLE I.

Lot Symbol	Protein in Per Cent (5.7 × N)	Gluten in Per Cent	Gluten Expansion in c.c.	Gluten Expansion per g. of Gluten (calc.)	Total Expansion per 100 g. of Flour (calc.)	Ash Value Per Cent
A	8.07	9.30	22.3	7.20	58.20	0.35
B	8.32	10.65	10.8	2.95	24.60	0.43
C	7.73	9.45	14.1	4.48	34.60	0.47
D	7.51	9.15	15.0	6.00	45.80	0.37
E	9.69	11.10	19.5	5.27	51.60	0.62
F	6.90	7.65	14.8	5.80	40.00	0.49
G	7.60	7.95	13.8	5.22	39.60	0.39
H	7.55	8.40	32.0	11.40	86.00	0.48
J	7.00	7.35	23.5	9.60	67.00	0.43
K	8.66	9.75	16.2	5.00	43.30	0.47
L	7.19	8.70	19.0	6.56	47.20	0.35
M	7.74	9.30	24.5	7.90	61.20	0.31
N	7.50	7.00	14.5	6.18	46.40	0.38
O	8.79	8.15	22.0	8.08	71.00	0.30
P	7.20	6.77	16.8	7.45	53.60	0.43
Q	8.74	10.80	37.7	10.45	91.50	0.37
R	8.59	10.50	36.6	10.45	91.50	0.39
S	8.50	10.20	30.0	10.20	86.80	0.45
T	7.80	9.90	38.0	11.50	89.60	0.45
U	8.90	9.15	21.6	7.10	63.20	0.51
V	8.27	9.00	23.8	7.86	65.00	0.39
W	8.46	10.05	29.0	8.70	73.50	0.41
X	8.55	10.50	21.0	6.00	51.30	0.50
Y	7.51	9.75	37.5	11.50	86.40	0.37
Z	8.18	10.35	33.0	9.56	78.40	0.52
A'	6.96	8.40	26.3	9.80	68.00	0.47
B'	9.29	10.50	34.7	9.90	92.10	0.43
C'	7.75	8.40	20.9	8.22	63.60	0.41
D'	10.46	11.40	17.0	4.40	46.00	0.38
E'	8.41	10.05	15.0	4.50	37.80	0.50
F'	6.25	6.90	25.3	11.00	68.80	0.47
G'	7.92	9.00	10.6	3.56	28.20	0.38
H'	8.34	8.40	13.6	4.85	40.50	0.48
J'	6.98	7.65	13.7	5.36	37.40	0.48
K'	9.17	10.55	16.3	4.64	42.60	0.63
L'	8.41	9.36	28.5	5.04	25.60	0.39
M'	7.59	10.50	31.5	9.00	68.20	0.44

The most striking example of the methods of manufacture studies was "Ammonium Carbonate Versus Ammonium Bicarbonate." Merck's 1907 Index gives the following information about the two salts:

Ammonium Bicarbonate—Large, transparent crystals, soluble in water and alcohol. Decompose at 60 deg. C.

Ammonium Carbonate—Mixture of ammonium bicarbonate and ammonium carbamate. Crystals, white, effloresce in air, stringent ammonia odor, sharp saline taste, soluble in five parts water at 15 deg. C. Decomposed by hot water.

Analyzing the samples for ammonia content, it was found that the commercial products as furnished to the baking trade gave the following figures: Ammonium bicarbonate, 20.86 to 21.05 per cent. Ammonium carbonate varied from 22.50 to 25.60 per cent.

It will be readily seen that the ammonium carbonate does not aid in producing uniformity of product, as it is itself quite variable in constitution. It is true that as to ammonia content it is stronger and hence would be more economical, as its function is to produce volumes of ammonia gas. An attempt was made to get the same baking results by using ammonium bicarbonate in sufficient quantities to equal the ammonia content of ammonium carbonate. The results, however, did not equal those ordinarily obtained. It was then decided to investigate the manner of mixing and also the baking. This investigation showed that certain kinds of cakes must have a leavening agent which is capable of acting quickly upon the application of heat. This was found to be true of ammonium carbonate, as it is more unstable than ammonium bicarbonate.

Test of Acidity in Sponges Used in the Baking Industry

Another example of this type of studies is "Acidity in Sponges in the Making of Crackers."

By "sponge" in the baking of crackers is meant that portion of the raw materials which is mixed in advance with the fermenting agent. This sponge is allowed to stand for a long time, becoming acid due to the fermentation. This acidity is neutralized with sodium bicarbonate when the remainder of the raw materials are added to make the dough, which in turn goes through a fermenting period of short duration. Experience has shown that when all other figures or factors are constant, there has been developed an empirical relationship between the temperature of the sponge just before mixing and the amount of soda to be added. When other variables enter into the mixing conditions, erratic temperatures are obtained. To take these variables into consideration, the following chemical method was developed. The sponge is sampled and exactly 20 g. weighed out into a white enameled dish and distilled water added to dissolve the sponge thoroughly. Standard alkali is run in from a burette to neutralize the acidity, using phenolphthalein as an indicator. The burette is so graduated as to read per cents directly. A table furnished to the workman performing this test tells how much soda to add. This table was prepared in the laboratory making acidity determinations on the sponge and also on the finished products resulting therefrom. In this way any erratic temperatures are subjected to chemical checking.

The finished product and industrial engineering studies were more closely correlated than in the two preceding groups and accordingly do not offer isolated examples.

In the cracker industry we have the following factors entering into production and costs: In the making of approximately two hundred different kinds of finished products, sixty different materials are used. These products are made on ten different ovens or machines. Each product has its own die or cutter for cutting out the cake. Each dough has its ideal speed at which the cutter will work effectively. There is also an ideal time for baking and a certain number of operators are required for each product. The finished cakes will average so many to a pound, depending upon the cake. Similarly, there is an average weight for each packing container (large can, small can, wood boxes, barrels, drums and cartons), and there is a certain speed of packing, depending upon the size and nature of the product.

All of the above factors vary from day to day, and as a result the determination of standards representing ideal operating conditions was an extremely difficult task.

The standard method adopted by which to measure production and cost standards in the cracker baking industry requires a knowledge of the following:

1. Determine the number of cakes cut out with every stamp of the cutter.
2. Determine the ideal speed (ideal referring to speed at which the resultant product is best obtained) at which to operate the cutter, i.e., cuts per minute.
3. Determine the average number of cakes per lb.
4. Determine the minimum number of operators who can effectively turn out the product.

The above applies to manufacturing departments as contrasted to packing departments.

In the packing departments, it was necessary to set up an individual standard for each product in each and every kind of packing container.

Since the goods are sold on a pound basis, it is evident that the cost standard must include pounds in its expression or terms. Furthermore all production and cost standards involve time. If the machine cost variance is great and the machines are operated by the same number of operators, then the machine hour basis is most applicable. In the cracker-baking industry the variance is found in operators and not in the cost of the machines. Hence the most applicable and accurate production standard is expressed as pounds produced per operative hour or the pounds produced per person per hour. For cost work, it takes a more convenient form, its reciprocal, or part of an operative hour required to produce 100 lb.

In the course of a day there is manufactured approximately fifteen different styles of goods, each with a different rate of production as follows:

Product A	100 lb. per person per hour
Product B	174 lb. per person per hour
Product C	102 lb. per person per hour
Product D	170 lb. per person per hour
Product E	147 lb. per person per hour

The respective cost standards are:

Product A	1.000 operative hr. to produce 100 lb.
Product B	0.575 operative hr. to produce 100 lb.
Product C	0.980 operative hr. to produce 100 lb.
Product D	0.590 operative hr. to produce 100 lb.
Product E	0.680 operative hr. to produce 100 lb.

The production rate of "lb. per operative hr." is computed according to the following equation:

$$\textit{Pounds per operative hour} = \frac{\textit{Cakes per cut} \times \textit{cuts per min.} \times \textit{operating min. per hr.}}{\textit{Number of operators} \times \textit{cakes per lb.}}$$

It was necessary, in installing a system of this design, first to explain thoroughly to department heads just how the reports were to be made out—that is, to distinguish between direct help (working on the particular machine) and indirect help (foreman, mixers and others who are intermittently working on several varieties of goods at one time), to take accurate speeds and keep accurate time, so that the data represented true and actual conditions; secondly, to explain to the cost department assistants how to interpret correctly the data submitted and compute the production rates as well as to detect inconsistencies. For a certain period of time it was necessary to make computations of standards daily on each and every run in order to check up intentional carelessness on the part of some in assembling the data; after which it was possible to fix a certain standard rate of production. By dividing this standard rate of production for any given variety into the total pounds produced in any day, it is possible to obtain the time equivalent in operative hours of direct help of work produced. Dividing this time equivalent by the actual time spent by the operatives on the particular run, the efficiency of the run is obtained.

Standards Representative of Operating Conditions

If the efficiency thus obtained is abnormally low, then it is due to one of two conditions: (1) abnormal operating conditions (necessitating a change of standard), or else (2) indifference on the part of the operatives to maintain the production standard as set. In the case of abnormally high efficiencies, the standard is set too low, or else the data as submitted do not represent true conditions. In this way the standards receive constant checking and represent actual or operating conditions.

In the packing department it often occurs that several kinds of packages are being packed at one time off of one run, and therefore the best method to set standards was found to be by making time and motion studies for each and every piece and container. This requires careful and keen observation and unprejudiced conclusions. In a few instances it was found that group studies could be made.

Time and motion studies in the cracker industry on packing operations are quite different from studies in the machine shops, due to so many variables and also due the fact that the operators are girls unfamiliar with time and motion study work; hence it was most difficult to have them understand just what was wanted.

Factors in Time and Motion Studies

The following are the observations which must be made in connection with time and motion studies of packing operations in the cracker-baking industry:

1. How are crackers brought to the packers?
   (On conveyors or on trays in stacks.)
2. How are packing containers supplied to the packers?
3. Do packers pack from conveyors?
4. Movement of conveyors—intermittent or regular?
5. Kind of product—cracker or cake?
6. Size of product?
7. Shape of product?
8. Thickness of product?
9. Do products stick to conveying pans?
10. Are stackers required?
11. Time to pack each individual layer.
12. Time to face front of containers.
13. Number of crackers or cakes per row.
14. Number of rows per layer.
15. Number of layers per container.

Determination of Plant Efficiency

Having determined the standards, the efficiency is determined as follows: The weight of goods packed in style I container is divided by the standard (for that particular container), giving the time equivalent for style I; similarly style II is treated, etc. Then the time equivalents expressed in operative hours of work produced of all the styles of containers for one variety of product are added and the sum is divided by the total number of operative hours of direct help, giving the efficiency. It is more difficult to detect errors in setting standards in the packing operations, as the effect of any single standard is masked in arriving at the efficiency per cent.

The time equivalents or standard operative hours of work produced for all varieties in a department are totaled for a given period of time (usually a month). These totals are then divided into the departmental labor charge (includes both direct and indirect help for the same period of time), giving the operating labor cost per operative hour. Similarly, the same totals are divided into the departmental burden, giving the burden cost per operative hour.

In calculating the cost of labor and burden on any piece or variety of goods, the cost unit (part of an operative hour required to produce 100 lb.) is multiplied by the rate per operative hour, giving the cost per 100 lb.

Conclusion

The difficulties in installing a system of this kind are the usual ones met with in installing any new industrial engineering system, namely,

1. Convincing every one concerned as to the importance of co-operation.
2. Designing suitable forms, reports and cards.
3. Interpreting and straightening out details which cannot be covered by a set of general instructions.

It must be remembered that owing to seasonal variations in the raw materials, factory methods are constantly changing, and accordingly the members of the cost department must always be on the alert to detect any irregularities.

This system has been in operation for two years and has been developed to such an extent that standard costs as calculated are proved against the actual departmental costs with only a very small percentage of variance. In this way it is possible to ascertain just what goods are creating and what ones are not creating departmental profits and also to anticipate new production costs very accurately.

In connection with the time studies on packing operations, a piece rates schedule was set up which increased production without increasing costs. This schedule is closely co-ordinated and consistent with the cost standards as set.

Summarizing the results of this investigation it has been shown that some of the functions of the chemical engineer in the cracker and biscuit baking industry are:

(*a*) Setting up standard specifications for purchase and control, checking of raw materials used.

(*b*) Investigating methods of manufacture and giving technical assistance.

(*c*) Solving industrial engineering problems.

Cincinnati, Ohio.

Legal Notes

By Wellington Gustin

Judgment for Refusal to Ship Phosphate Upheld

The judgment of the Clinton Oil & Manufacturing Co. of Clinton, S. C., against J. H. Carpenter, president of the Tennessee Fertilizer Co. of Nashville, has been affirmed in the Supreme Court of South Carolina. The action was for damages for failure to deliver acid phosphate under a contract, the material part being in these words:

"J. H. Carpenter agrees that he will sell to the other parties to this contract . . . acid phosphate during the two seasons, May 1, 1916, to May 1, 1917, and May 1, 1917, to May 1, 1918, at the price of $8.50 per ton f.o.b. cars at the plant of Carolina Phosphate Co., near Greenville, the fertilizers to be paid for on May 1, 1917, and May 1, 1918, respectively."

The present case grows out of the transaction for the fiscal year May 1, 1916, to May 1, 1917, the amount of acid phosphate agreed to be sold being 1,000 tons. Of this amount 160 tons was delivered and defendant refused to deliver the balance of 840 tons.

The persons involved in the whole transaction are the Tennessee company, represented by Carpenter, its president; Sparrow, its secretary at Nashville; Todd, the local agent and manager of the Carolina Phosphate Co. at Greenville and an agency of the Tennessee company; Bryson, the head of two corporations organized under the laws of South Carolina, the Woodruff Oil & Fertilizer Co. at Woodruff, S. C., and the Clinton Oil & Manufacturing Co. at Clinton, S. C.

Holdings of the Court

Looking at the contract, the Supreme Court said the phosphate was to be delivered to the Clinton company before May 1, 1917, as it was the end of the fiscal year, and payment was then due. Therefore, if the plaintiff did not call for an execution of the contract by asking delivery to it before May 1 of the 1,000 tons, the plaintiff has been done no wrong.

The contract does not prescribe by what formality, in time or in agency, the buyer should call for delivery of the acid, said the court; it does not prescribe that the call for delivery shall be intermittent, or that it shall be in writing. The seller's witness testified that it was the custom of the trade in carrying out a contract of this kind to ship from time to time during the season, and not all at one time; the custom being to give orders from time to time with shipping instructions. There were six of such orders filled for plaintiff during the latter half of January, 1917, aggregating 160 tons, and all shipped to Woodruff.

Contention of Defendant

Now, the seller contended that he was instructed by buyer Feb. 1 not to make any further shipments until "we write you again," and that the buyer made no further call for shipment until April 30, when it telegraphed: "If compelled to have shipping instructions, ship balance Woodruff Clinton acid to Spartanburg." His consequent contention was that this instruction, though within the letter of the contract, came too late for him to comply with the contract, and it was therefore inoperative.

Further testimony showed that the Tennessee Fertilizer Co. wrote the buyer, plaintiff, on March 19, and inquired to ascertain "the total amount of acid phosphate which you will take during the current season, ending May 1, 1917," to which letter the buyer replied on March 21, that it "expected to take the amount the contract calls for." The court said that with this reply before him there was no warrant for defendant to have been misled by the buyer's letter of Feb. 1. Mr. Bryson testified that the seller frequently had been requested, in person and by phone message, to ship out the balance of the contract. But Todd testified he never recognized verbal orders coming to him over the phone, though he admitted he suspended shipments upon request by phone to do so.

The question of whether the buyer had ordered shipment of balance of goods in time for shipment before expiration of period the court held for the jury to decide, as was also the question of whether seller waived his right to have buyer's orders for shipment in time to ship goods before expiration of the period.

And it said that when one party to a contract notifies the other party that he elects to breach the contract, the other party need not make tender to sell, since tender would be an idle performance.

Again, the damages to a buyer for failure of the seller to deliver goods were measured by the market value of the goods at time and place of delivery, or, if not ascertainable at place of delivery, at nearest market place plus cost of shipment to place of delivery. But buyer's ability to have made a profit by resale to others may not be recovered as damages.

Held Guilty of Contempt for Refusal to Testify

William A. Rushworth has been held guilty of contempt in the Circuit Court for Cook County, Illinois, for failure to testify and to produce certain documents in the matter of the Imperial Trust Co. of Canada, Ltd., vs. W. Howard Jackson, the case now pending in the Supreme Court of Ontario, Canada. A commissioner has been appointed to take evidence of several witnesses in Chicago, including George M. Reynolds, president of the Continental & Commercial National Bank, Armour & Co., Stuart G. Shepard, Central Trust Co. of Illinois, Sheridan Trust Co., Colonel R. R. McCormick and a number of manufacturing companies. Responding to a subpœna, Rushworth appeared, but refused to testify or produce desired documents.

Counsel for Rushworth said he would refuse to obey the court's order on the ground that it was without jurisdiction and authority to enter such order, and that the Illinois statute permitting the taking of the evidence is contrary to Section 9, Article II of the Constitution of Illinois. An appeal from the court's order was allowed to the Supreme Court of Illinois.

The order of the court was for Rushworth to appear before the commissioner and answer questions as to:

"An agreement between William A. Rushworth and the Tennessee Copper Co., as regards the sale or purchase of toluol and sulphuric acid.

"A certain contract for the supply of toluol to the Canadian Explosives Co. by the Tennessee Copper Co.

"A certain copy of a tender for toluol to the Imperial Munitions Board for 15,000 gal. of toluol monthly on behalf of the Tennessee Copper Co. made through William A. Rushworth."

The Hot-Process Water Softener

A Study of the Rate of Sedimentation of Lime and Magnesia Precipitates During Softening at Low and High Temperatures—Plant Equipment: Reagent Proportioner, Tanks and Filter

By GEORGE H. GIBSON

THE hot-process softener, in its present form, is a recent development. By taking advantage of the fact that chemical reactions are more rapid and complete in hot water than in cold water, more efficient removal of scale- and sludge-forming substances are obtained. The apparatus performs the functions of the open feed-water heater usually found in steam-boiler plants, in addition to those of a softener, and less space, lighter foundations, less housing, less piping and fewer fittings are required than for a cold-process softener plus an independent heater. There are several reasons why scale-forming matter is more completely removed from hot water than from cold water.

Effect of Heat Upon Reactions

Chemical reactions are enormously accelerated by heat. This is a well-known and generally recognized fact, and was used in the household for ages before it assumed the dignity of a law of chemistry. Everyone knows that dishes and clothes are washed more rapidly and thoroughly in hot water than in cold water. Paper pulp is causticized in hot water, etc. The exact law connecting temperature and rapidity of chemical reaction has never been determined accurately, some chemists stating that the speed of reaction doubles for each 10 deg. C. added to the temperature, and others that chemical reactions are speeded up approx-

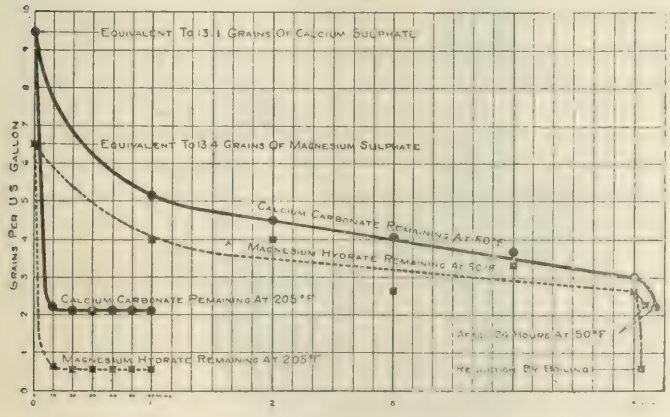

Equivalent To 13.1 Grains Of Calcium Sulphate
Equivalent To 13.4 Grains Of Magnesium Sulphate
Calcium Carbonate Remaining At 50°F
Magnesium Hydrate Remaining At 50°F
Calcium Carbonate Remaining At 205°F
Magnesium Hydrate Remaining At 205°F
Grains Per U S Gallon

FIG. 1. RATE OF SEDIMENTATION AT 50 AND 205 DEG. F.

imately as the twentieth power of the absolute temperature. Those formulas are not in agreement, but everyone concedes that there is a tremendous increase in speed of reaction with rise in temperature.

Some years ago experiments were made in the chemical laboratory of the Harrison Safety Boiler Works to determine the effect of temperature upon the reactions which take place between softening reagents and scale-forming matter in boiler-feed water. The results are shown graphically in Fig. 1.

It will be seen that the reduction in hardness, that is, in content of calcium and magnesium salts, is much greater at the end of 10 min. in water at 210 deg. F. than at the end of 5 hr. in water at 50 deg. F.; in fact, 24-hr. treatment in cold water does not bring the scale forming matter down as much as does 10-min. treatment in hot water. Subsequent heating to the boiling point of the sample which has stood at 50 deg. F. for 5 hr. reduces the magnesium hydrate to less than 1 grain per gal., but the same result is obtained in hot water in 10 min. In performing these experiments, only sufficient softening chemical was added to combine with the scale-forming substances. In practice a slight excess is used, which reduces the hardness to lower figures.

Factors of Rate of Sedimentation

The precipitates resulting from the transformation of scale-forming substances also settle more rapidly and completely from hot water than from cold water. Solid particles suspended in water settle to the bottom if their density is greater than that of the water or rise to the top if their density is less than that of the water. The force acting upon the particles is its weight less the weight of water displaced, and the force by which it is resisted depends upon the extent of its surface and the viscosity of the fluid in which the particle is suspended, multiplied by the velocity of fall. A maximum velocity is reached at which the retarding force is just equal to the accelerating force.

Viscosity is the resistance which a fluid offers to shearing. The coefficient of viscosity may be defined as equal to the tangential force required to slide a unit surface at unit velocity a unit distance from another surface with the fluid between.

Obviously, a large particle will settle more rapidly than a small particle because it contains a greater mass, and hence is acted upon by a greater force, in proportion to its surface. Considering a spherical particle whose density is greater than that of water, the maximum velocity with which it falls is given by Stokes' formula

$$V = \frac{2}{9} \frac{D - d}{N} gr^2,$$

in which V is the velocity, D the density of the particle, d the density of the water, g the acceleration of gravity, r the radius of the particle and N the coefficient of viscosity.

In a water softener the precipitated particles are of various sizes and possibly of different densities, but any given particle will fall through water at a rate depending upon the viscosity, and it is therefore of interest to note how the viscosity of water changes with temperature as shown in Table I, by Thorpe & Rodger.

TABLE I.

Temp., Deg. F.	Coefficient of Viscosity	Temp., Deg. F.	Coefficient of Viscosity
32	0.01778	140	0.00468
50	0.01303	158	0.00406
68	0.01002	186	0.00356
86	0.00798	194	0.00316
104	0.00654	212	0.00283
122	0.00548		

At the freezing point the viscosity of water is over six times as great as at the boiling point, while as between water at 68 deg. F. and water at 212 deg. F., the increase in velocity of fall will be about four times.

Now consider how this applies in a water softener. Suppose we have a large tank full of absolutely quiet water. A particle of any given size will descend four times as far in an hour in hot water as it will in cold water.

Next, suppose we have a continuous softener in which the water is constantly flowing through the sedimentation tank. The rate of flow can be four times as great in a hot-process water softener as in a cold-process softener without carrying particles of a given size to the pump supply pipe; or, to put it in still another way, with a given rate of flow through the settling chamber, much smaller particles can be separated out in the hot-process softener than in the cold-process softener. The further fact that the particles formed in a hot-process softener are larger than those formed in a cold-process softener renders the advantage of the hot process still greater, since the velocity of fall increases as the square of the radius of the particle.

It is therefore plain why the preliminary heating of the water, a feature which is peculiar to the hot-process softener, gives more complete chemical reactions and more thorough removal of the resulting precipitates.

Report on Hot-Process Test Run

The completeness with which scale-forming matter is removed from water treated in a hot-process softener may be shown by the analyses of water (Table II) before and after treatment in a commercial installation. In considering these results, it should be borne in mind that a grain is 1/7,000 of a pound, or 1/58,415 of the weight of a gallon of water. The small amount of solids remaining in the treated water from a hot-process softener does not form scale in the boiler, but gathers a sludge, which is easily blown out.

The chemical reagents must be fed to a softener accurately in proportion to the amount of water and to the impurities in the water, so that the treated water may not deposit scale on the one hand, or contain an excess of unused reagents on the other. For proportioning the reagents to the raw-water supply various mechanical arrangements have been devised.

Methods of Proportioning Softener and Water

In some softeners, the raw water flowing to the softener turns a waterwheel or operates a tilting bucket which in turn operates dippers by which the reagents are ladled out to be mixed with the raw water. Such appliances, widely used with cold-process softeners, are usually located above the reaction chamber of the softener, involving the lifting or hoisting of the reagents 15 or 20 ft. or more above the ground level.

In other softeners, a certain portion of the water, divided from the main supply by means of orifices or weirs, flows through chambers containing the reagents. In one such proportioner, the water, in flowing through the reagent tank, becomes saturated. This method is faulty, however, since solubility varies greatly with temperature.

In another form the water displaces the reagent from a tank, at the same time diluting that which remains in the tank. Elaborate means for adjusting the orifices progressively as the reagents become more and more dilute are therefore required.

None of these methods is well adapted for feeding chemicals to a hot-process softener, which should be designed for operation under a few pounds back pressure, since it is necessary to carry a few pounds back pressure upon the exhaust steam in order to insure a temperature of at least 205 deg. F. of the treated water at all times. With the methods just mentioned, it is necessary that the chemical feeding equipment be inclosed within the steam space or else that the chemical and raw water, after being proportioned, be pumped into the softener against the back pressure. If the waterwheel, or the tilting bucket, is inclosed so that the reagents can flow by gravity directly to the reaction

TABLE II. ANALYSES OF WATER BEFORE AND AFTER SOFTENING

	Grains per U. S. Gallon Before Softening	After Softening
Calcium sulphate	13.00	None
Calcium carbonate	12.30	0.36
Magnesium carbonate	5.36	0.94
Silica	0.82	0.35
Iron and aluminum oxides	Trace	Trace
Total incrusting solids	31.48	1.65
Organic and volatile	6.32	2.98
Sodium carbonate	.....	4.80
Sodium sulphate	0.64	12.60
Sodium chloride	2.28	1.92
Total non-incrusting solids	9.24	22.30
Free carbonic acid	2.45	.....

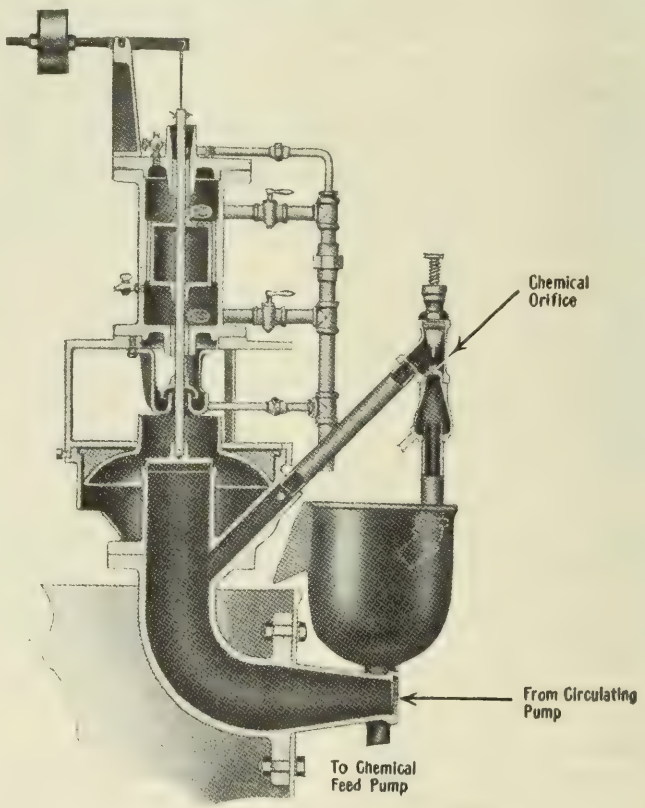


FIG. 2. CHEMICAL PROPORTIONER

chamber, steam finds its way into the chemical tank, where it condenses, diluting the reagents and rendering the feed inaccurate. The divided flow method involves an additional pumping of both the raw water and the reagent, and is therefore complicated and expensive.

In still another arrangement the raw water is passed through a hydraulic motor, of the reciprocating or of the rotary form, which drives a small chemical pump. This method is defective because it is practically impossible to prevent slippage past the valves and packings of such motors and pumps, which renders the proportioning inaccurate.

The chemical proportioner used in the Sorge Cochrane Hot-Process Softener to regulate the feed of chemicals in proportion to the flow of raw water is a true flow proportioner. The chemical to be fed to the softener is forced through an orifice by a pressure just equal to the differential pressure set up by the flow of the raw water through an orifice in the supply pipe.

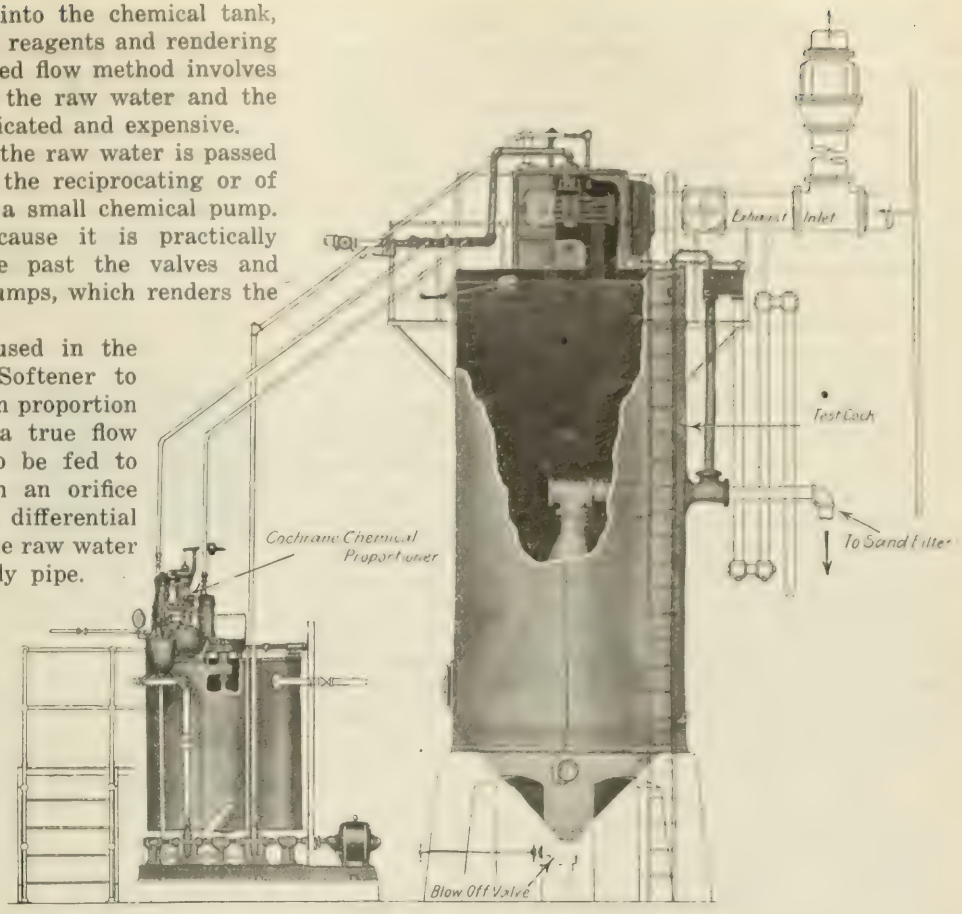


FIG. 3. HOT-PROCESS WATER SOFTENER INSTALLATION

Operation of the Softener

To understand how the device works, refer to Fig. 2. Between two flanges in the pipe through which the raw water flows to the heater at the top of the softener is placed a thin orifice disk. From the two sides of this orifice, small pipes lead to the opposite ends of a cylinder containing a piston. The piston is thus acted upon by the differential pressure due to the flow of water through the orifice. The vertical piston rod extends through water glands at each end of the cylinder. On the lower end of the rod is a valve disk, which closes over an opening through which a fluid mixture of the reagents is constantly being forced by a centrifugal circulating pump. The weight of the piston, rod and valve disk is counterbalanced. The differential pressure acting upon the piston pushes the disk down upon and tends to close the opening, while a pressure builds up underneath just sufficient to balance the differential pressure. The pressure of the chemical solution is therefore directly controlled by the differential pressure resulting from the flow of water through the orifice in the raw-water pipe. Through a simple pipe connection, this pressure acts directly at the chemical orifice, insuring an effective pressure on this orifice at all times equal to the differential pressure on the raw-water orifice. Most of the chemical solution supplied by the circulating pump flows out from under the disk and through a strainer and hence back into the chemical solution tank. The proportioned chemical flows through the chemical orifice into a funnel, from which it is taken by a chemical feed pump, lifted to the softener and forced in against any back pressure that may exist in the latter. The back pressure in the softener thus does not affect the proportioning. As the chemical, before escaping through the small orifice, is not in contact with air, no incrustation occurs therein, but to provide for dislodging any obstruction, a cleaning needle is so arranged that it can at any time be forced through the orifice by the pressure of the hand.

Besides being accurate, this arrangement has other advantages: Only one chemical solution tank is required, which is at the ground level, where it can be charged without hoisting of chemicals or inspected without climbing a ladder. The motor which drives the circulating pump also drives agitating paddles in the tank. Milk of lime can thus be kept in suspension and fed as well as purely fluid reagents. The large saturator tanks necessary where lime water is used are eliminated and the difficulty due to the fact that lime water varies in strength according to temperature is avoided. Solutions of caustic soda or sodium carbonate, lime water, milk of lime, or any mixtures, are all handled equally well and fed accurately.

The accuracy with which the solution is fed is well within 2 per cent, which is closer than attendants will measure out chemicals into the chemical tank. Representative test results are shown in the following table:

Rate of Flow of Raw Water Gal. per Hr.	Rate of Flow of Chemical Gal. per Hr.	Chemical per Gal. of Water	Variation Per Cent
1740	134.6	0.0773	0.28
1590	122.2	0.0769	0.22
1410	108.4	0.0769	0.22
1160	88.8	0.0766	0.71
710	54.6	0.0769	0.22
411	31.8	0.0773	0.28
290	22.4	0.0773	0.28
290	22.5	0.0775	0.52
184	14.3	0.0771	0.05

The chemical treatment is controlled by drawing a sample of the treated water from time to time and titrating with standardized solutions, the whole operation requiring about 10 min. By locating the titration readings thus obtained upon a chart for correct chemical treatment, the operator sees at a glance what change, if any, is required in the amount of the chemicals.

The apparatus, as may be seen in Fig. 3, is simple and compact. The open heater, with an oil separator attached for purifying the exhaust steam used for heating the water, is mounted directly over the reaction and sedimentation chamber. The water is heated to steam temperature by spraying it over trays, which also serves to release oxygen and other dissolved gases. It is then mixed with the reagent and fal's directly into the sedimentation tank. There is no constricted piping between heater and tank to become choked with scale. In fact, the water does not pass through piping from the time when it is first heated until it has been through the sedimentation chamber, even the overflow receiving only settled water.

The precipitated matter deposits in the conical bottom of the sedimentation chamber, from which it can be quickly washed by the opening of a single valve. In order to eliminate convection currents the hot water and the softening are delivered at the top and travel slowly to the bottom, from which the clarified water is drawn off by an inverted funnel. The precipitates formed when the water is first mixed with the chemical fall through the water below, securing a screening effect and gathering together the smaller particles. All precipitates are carried to the conical bottom of the tank, from which they are readily blown out by opening a sludge valve at the lower end or apex of the cone.

Filters

The removal of scale-forming matter at high temperature by sedimentation is so effective that for many waters and plant conditions it is entirely practicable to dispense with filters. Many softeners are accordingly installed without filters and are successfully protecting the boilers from scale and corrosion, even though the softened water contains a slight amount of suspended matter. Other conditions demand the use of filters, for which a low-pressure sand filter is placed between the sedimentation tank and the boiler-feed pumps or meter, the water flowing through the filter by gravity. These filters deliver a crystal-clear water which contains no solids except those in solution and no mud-forming properties except the amount which is below the exceedingly low limit of solubility of calcium and magnesium monocarbonates, silica, etc., at the boiling point. This water will leave no troublesome deposit in the feed lines, pumps or meters, and is particularly suitable for boilers operated at high ratings.

The filter is essentially a bed of fine sand resting upon a bed of gravel. Embedded in the gravel layer are strainer heads or valves. The strainer valves are of a self-cleaning type, having a movable head or disk which rests upon the stationary part of the valve in such a way as to leave small openings or ports around the edge. In back washing, the water is admitted through the strainers in a reverse direction and lifts the disks or heads, increasing the openings of the ports to double the normal size, with the result that any particles of sand or other substances which may have lodged in the port during the filtering operation are released and carried out by the wash water.

The strainers may be screwed into a collecting and wash-water distributing manifold, as illustrated in Fig. 4, or into a diaphragm.

Embedded in the gravel layer is an air-distribution system consisting of a main pipe with laterals, the latter perforated on the under side to permit the escape of air throughout the gravel layer. The air is used for loosening up the filter bed preliminary to back washing, the proper rate of air admission being controlled by an orifice in the pipe connection.

The filter chamber is connected to the softener through valves at the top or inlet and to the boiler-feed pump from the bottom or outlet chamber. There is also a valved bypass from the softener directly to the boiler-feed pump suction. The inlet and outlet of the filter are connected through hand-operated gate valves to a waste pipe, to which a relief valve at the inlet

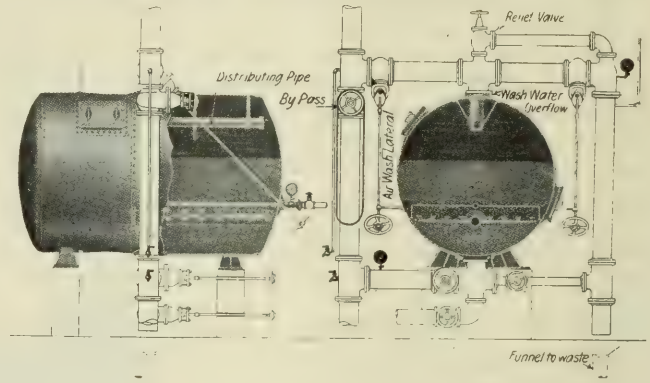


FIG. 4. HORIZONTAL SAND FILTER

also discharges. Finally, there is a connection to the outlet opening from a water supply, for back washing. A pressure gage is provided to show when the filter needs washing. Back washing is done at intervals, several times daily, the frequency depending upon the character of water. In some installations more than one filter is installed, so that it is not necessary to feed unfiltered water to the boilers while washing.

Canada's Special Overseas Trade Commission

The Canadian Trade Mission in England has been discontinued and in its stead there has been constituted the special trade commission to be known as the overseas branch associated with the trade commission office in the United Kingdom.

The duty of the overseas branch will be to make sales or purchases, or negotiate contracts for individuals or corporations. The aim will be:

1. To provide a convenient commercial meeting place for Canadians visiting London for business purposes, where they will be made welcome and can find men ready and willing to give them advice and information.

2. To have at hand full and permanent information as to conditions of trade, openings for business, demands for Canadian supplies, and possible contracts; to facilitate conferences with business firms, manage introductions to business houses and in every legitimate way aid Canadians to extend trade.

3. Conversely, the overseas branch will be a Canadian bureau of business information as to Canadian products where persons desirous of doing business with Canadians may find ready answers, careful directions, and sound, reliable counsel.

4. To give uniform and reasonable publicity to Canadian resources and productions and opportunities.

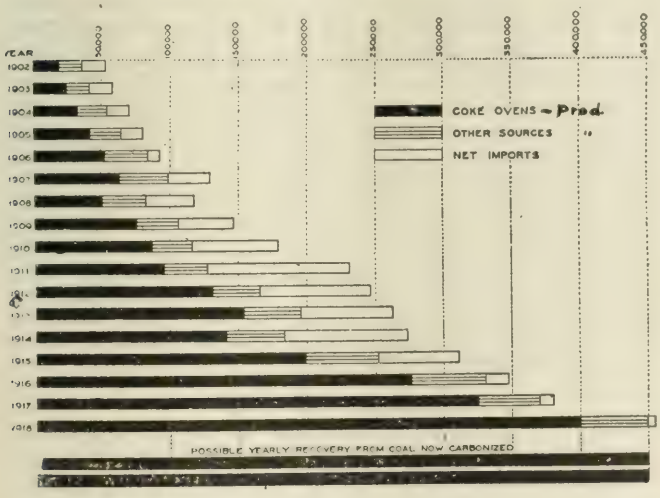
5. To establish a wideawake and efficient commercial liaison office between Canadian producers and world buyers in London, and to that end the overseas commercial branch in London will keep in close touch with the commercial intelligence branch of the Department of Trade and Commerce.

Synopsis of Recent Chemical & Metallurgical Literature

The Utilization of Coal Tar.—A comprehensive description of the operations of The Barrett Co., by PHILIP P. SHARPLES, will be found in *Gas Age*, March 10, 1920, p. 205. After outlining the scientific blending of various tars for roofing, road-building and road-preserving purposes, the author discusses the distillation of coal tar for the production of the raw materials used in the dye and other synthetic organic industries. When the maximum amounts of these materials are recovered by distillation, there remains in the retort a hard pitch. Of this, the author says:

"Before the war it was possible to export the excess of pitch for use abroad in making fuel briquets from the soft and friable European coals. Since the scarcity of shipping closed this outlet, stocks of pitch have accumulated to an incredible extent. Truly acres of pitch surround some of the plants, and The Barrett Co. has learned to its sorrow what the English tar distiller calls 'the burden of pitch.'

"A profitable tonnage use for hard varieties of pitch is still to be found, and until found, this handicap of



AMMONIUM SULPHATE PRODUCTION, CONSUMPTION AND IMPORTS

pitch will always overshadow the profitable production of coal-tar oils. Up to date our coals have been too good to require briquetting.

"Certain small uses have been developed for carefully prepared grades. Hard pitches are used in core compounds, in the manufacture of electrodes and in making clay pigeons. All the large uses of pitch, like roofing, paving and waterproofing, call for the softer grades with many of the oils left in."

At first, gas-house tar was the only tar available. Later, water-gas tar gave promise of becoming the dominant factor, but the adoption of the coke oven by the steel industry has given the lead to coke-oven tar. During 1918, about 263,000,000 gal. of coke-oven tar was produced, while the production of all other tars (including water-gas tar) was 161,000,000 gal. Gas-house tar production is nearly stationary, while coke-oven tar production is growing by leaps and bounds with the substitution of byproduct for beehive ovens. Whether this flood of tar can all be distilled and absorbed in the growing market for coal-tar materials, or whether its value as fuel will divert some of it to that field, is a problem of the future.

In the capacity of sales agents for many of the byproduct coke plants, The Barrett Co. is interested in the use of ammonium sulphate as a fertilizer. The accompanying chart shows the production, consumption and imports of ammonium sulphate from 1902 to 1918.

The double line at the bottom of the chart represents the amount of ammonium sulphate which would be produced at the present time from the amount of coal carbonized, were it not for the loss of ammonia caused by the use of beehive ovens.

Preparation of Methyl Chloride and Methyl Bromide From Dimethyl Sulphate.—In a note presented at the March 8 meeting of the French Academy of Sciences, CH. BOULIN and L. J. SIMON describe their work on the preparation of methyl chloride and methyl bromide (*Comptes Rendus*, vol. 170, No. 10, pp. 595-597). Methyl chloride is prepared preferably by the action of 16 deg. Bé. hydrochloric acid or less advantageously of sodium chloride on dimethyl sulphate according to the equations

$$SO_2(OCH_3)_2 + HCl = SO_2(OH)(OCH_3) + CH_3Cl$$

$$SO_2(OCH_3)_2 + NaCl + Aq = SO_2(ONa)(OCH_3) + CH_3Cl + Aq$$

When using hydrochloric acid the best operating temperature is 50 deg. C. The methyl chloride obtained contains only a few thousandths of methyl oxide, and the efficiency is 90 per cent. When using sodium chloride it is necessary to first bring the solution to 60 to 65 deg. C., at which temperature the reaction starts, and then cool down to 50 deg. C. The efficiency is about 90 per cent.

For the preparation of methyl bromide they use a concentrated solution of an alkaline bromide slightly acidulated with sulphuric acid and operate at a temperature of 30 to 35 deg. C. The efficiency is 90 per cent on the basis of the dimethyl sulphate used and practically quantitative on the basis of the bromine in the bromide used.

The Production of Tin in Australia.—In most tin-mining countries the bulk of the metal is obtained from alluvial workings, and although the tin from such deposits is by no means exhausted, such is the case with most of the easily worked deposits. Economic considerations prevent the utilization of the unworked deposits, and, on the whole, the day of alluvial tin mining is on the wane. Practically all the tin mined in Bolivia, and all mined in Cornwall, comes from lode mines, but this type of mining is unpopular in Australia. There are various reasons for this, such as a large proportion of failures of lode operations due to such causes as unfavorable location, bad management, unsuitable treatment plants and inadequate scale of operations. However, with the gradual elimination of alluvial deposits as producers and the increasing demand for tin, lode tin mining will probably receive greater attention in the future. This, according to J. B. LEWIS, who writes on the subject in *Chemical Engineering and Mining Review* (Australia), is satisfactory as far as Australia is concerned, for there are a large number of occur-

rences of tin in all the states, those in Tasmania being probably the richest and largest in extent, while in Victoria there are also extensive deposits.

There are difficulties to be overcome in dealing with these large deposits, for as a rule they are of low grade and to be profitable should be worked on a large scale, In the northeast of Tasmania are several lode tin fields, those at the Blue Tier and Aroca being the most extensive. Practically the only metal in the ore is tin, other minerals such as wolframite, molybdenite and ores of copper being found in very small quantities and in few places. At one mine over a period of about ten years the average recovery was 3.42 lb. of tin oxide per ton, which indicates that the original ore contained about 4¼ per cent of tin oxide. Near the west coast of Tasmania there is a belt of country where there are found large low-grade deposits of tin, copper, silver-lead and zinc ores, the Mt. Lyell copper mine and the Mt. Bischoff tin mine being well known.

It seems probable that an increasing amount of tin may be expected from Australia when the large low-grade deposits receive the attention they deserve.

Recent Chemical & Metallurgical Patents

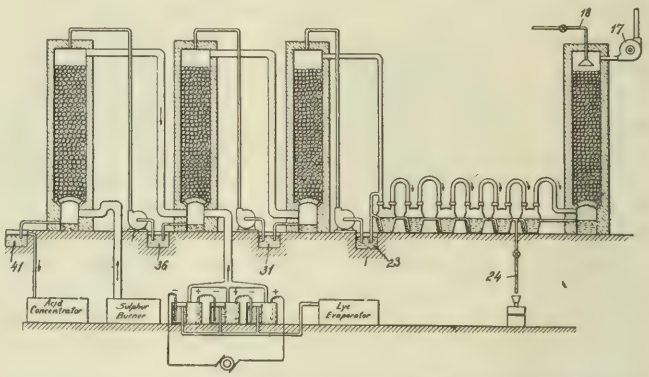
Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Use of Sodium Bisulphate in the Manufacture of Ammonium Sulphate.—When sodium bisulphate is used in place of sulphuric acid in the ammonia saturators, a double salt, $Na_2SO_4\ (NH_4)_2\ SO_4 4H_2O$, is formed. GERHARD N. VIS of Paris, France, describes a cyclic process of fractional crystallization for the separation of sodium and ammonium sulphates from the double salt. By heating the double salt and ammonium sulphate with water in the proper proportions, all of the ammonium sulphate goes into solution, while part of the sodium sulphate is dehydrated and remains undissolved. This is filtered off and the mother liquor cooled to 62 deg. C., when ammonium sulphate separates with a small amount of Na_2SO_4, which may be removed by washing with saturated $(NH_4)_2SO_4$ solution. The final mother liquor is treated with more double salt and $(NH_4)_2SO_4$ to restore the original composition of the solution and the cycle repeated. Attention is directed to the fact that 100 parts of H_2O saturated with $(NH_4)_2SO_4$ at 110 deg. C. dissolve 42.2 parts of Na_2SO_4 and the separation of the double salt from the solution only commences at about 60 deg. F. Further, the solubility of $(NH_4)_2SO_4$ in 100 parts of water saturated with Na_2SO_4 decreases nearly regularly from 102 to 75 parts when the temperature is reduced from 110 to 50 deg. C. (1,332,419; March 2, 1920.)

Simultaneous Production of Sulphuric and Hydrochloric Acids.—HENRI TOBLER of Hackensack, N. J., has adapted the following reaction to large scale production:

$$SO_2 + Cl_2 + 2H_2O = H_2SO_4 + 2HCl$$

As shown in the accompanying illustration, the apparatus consists essentially of three absorption towers similar in construction to Glover towers in series with a number of hydrochloric acid tourills and a fourth Glover tower. Sulphur dioxide is produced in a sulphur burner and delivered to the first tower, where a portion of the heat is utilized in concentrating and completing the removal of hydrochloric from the sulphuric acid formed later in the process. Passing to the second tower, the gas is mixed with chlorine from electrolytic cells. The reaction is completed in the third tower and the gases are drawn through the tourills and fourth tower by a suction fan, 17. A cold-water spray admitted at 18 serves to absorb the last portions of hydrochloric acid gas. Substantially pure hydrochloric acid is drawn



TOBLER APPARATUS FOR SIMULTANEOUS PRODUCTION OF SULPHURIC AND HYDROCHLORIC ACIDS

off through pipe 24, while the mixture of HCl and H_2SO_4 is pumped to the tops of the first three towers in succession. The mixed acid in sump 23 has a gravity of about 23 deg. Bé. After passing through the third tower, the liquid in sump 31 is about 36 deg. Bé. The proportion of H_2SO_4 increases steadily in the liquid, sump 36 containing 50 deg. Bé. acid and sump 41, 60 deg. Bé. H_2SO_4 containing practically no HCl. This acid is removed for further concentration to 66 deg. Bé. The products of this plant are HCl, H_2SO_4 and NaOH. The latter compound is obtained as a byproduct from the electrolytic cells which furnish chlorine for the process. (1,332,581; assigned to American Bromine Co., of Maywood, N. J.; March 2, 1920.)

Australian Patents

Complete specifications of Australian patents may be obtained from the Government Printer, Melbourne, one shilling each.

Preserving India Rubber.—To prevent the oxidation of rubber goods, the enzymes are destroyed by the application of a 10 per cent solution of ammonia containing about 0.3 per cent of a saponaceous substance such as sodium oleate, laurate and cresylic acid, carbolic acid or other antiseptic substance which will not precipitate the soapy material. The solution is applied to the latex, or to flexible rubber goods by immersion or by repeated superficial application. (Aust. Pat. 3,364; F. E. STOWE, New South Wales. Feb. 10, 1920.)

Extracting Copper.—To precipitate copper from a cuprous solution the latter is passed through a series of tanks arranged in terraced fashion and connected by launders. The tanks contain charcoal placed on perforated plates. The precipitated copper is separated from the charcoal by washing. The tanks may be divided into compartments by vertical partitions over and under which the solution passes from the inlet to the outlet launder. (Aust. Pat. 9,254; J. H. FLEMING, New Zealand. Dec. 23, 1919.)

Current Events
in the Chemical and Metallurgical Industries

Reorganization of Research in Applied Chemistry at M. I. T.

At a recent dinner tendered to nineteen members of the Research Laboratory of Applied Chemistry staff, Dr. William H. Walker made public his resignation as director of this laboratory. He was compelled to do this because of the pressure of duties in connection with his position as director of the Division of Industrial Co-operation and Research.

Coincident with the above announcement was the appointment of Prof. Robert E. Wilson, formerly assistant director, to the position of director. In view of the enlarged scope of laboratory work, two assistant directors were also appointed, Dr. C. S. Venable—in charge of organic problems, and Dr. L. W. Parsons—in charge of inorganic problems.

Prof. R. E. Wilson, who is taking the position left vacant by Dr. Walker's resignation, was graduated from the University of Wooster, Ohio, in 1914 and from Course X at the Institute in 1916. From that time until the present he has had broad experience in research work. During the spring and summer of 1915 he worked in the Research Laboratory of Physical Chemistry, and the following year was engaged in research for the General Electric Co. at Schenectady. He returned to the Institute as research associate in applied chemistry in the fall of 1916, but left in the spring of 1917 to act in the capacity of consulting chemical engineer in the Bureau of Mines. Under the direction of Prof. W. K. Lewis, he organized the first research laboratory for poison gas work.

When this work was expanded and moved from Pittsburgh to Washington, he was placed in charge of the smoke and absorbent units and was commissioned Captain and later Major in the Chemical Warfare Service. Upon completing his army work a year ago, he refused several important industrial research positions to take up his work at the Institute.

Dr. C. S. Venable was graduated from the University of North Carolina and received a Master's degree in 1911. He received his Ph.D. in organic chemistry from the Institute in 1917. As a Captain in the Chemical Warfare Service, he had responsible charge of much research and development work on toxic gases. He joined the Research Laboratory in April, 1919.

Dr. L. W. Parsons is a graduate of Course V, chemistry, in the class of 1913, and served as assistant in analytical chemistry for one year. From 1914 to 1916 he served as a teaching fellow at Harvard, and a year later received his Ph.D. from that institution. He served throughout most of the war as a Captain in the Chemical Warfare Service, aiding in the directing of research work on absorbents. He returned to the Institute as research associate in March, 1919.

The Research Laboratory was first organized in 1907 by Dr. Walker and under his direction has successfully solved a large number of industrial problems, as well as publishing twenty papers of general scientific interest. During the period of the war, the laboratory was closed, but was re-opened about a year ago. Starting then with seven members, the laboratory has grown rapidly until it now numbers fifteen full time workers, and several part time workers. The laboratory is now conducting a wide number of problems for such concerns as the Goodyear Tire & Rubber Co., Vacuum Oil Co., the National Electrolytic Co. and the National Tube Co.

Fixed Nitrogen Corporation Bill

With Senator Gronna's announcement on the floor of the Senate of views unmistakably in favor of the fixed nitrogen corporation bill, it is apparent that the measure soon will be reported favorably by the Senate Committee on Agriculture. Based largely on the assumption that Senator Gronna was not particularly friendly to the bill, some of those opposing the measure hoped that no prompt report on the bill would be forthcoming.

The determined way in which the Senate rejected the amendment to the fortifications appropriation bill, which would have curtailed expenditures at Muscle Shoals, is an indication of an overwhelming sentiment in favor of operating the plant and continuing the work.

Senator Underwood in an extended speech declared that "there are certain great interests in this country that have made up their minds to kill this plant." He declared that Senator Smoot, who was urging the amendment, had been misled on the proposition. Resentment was shown because the suggestion which resulted in the amendment came from Representative Graham. The Senate oftentimes does not take kindly to such suggestions from members of the House. In addition, in this case, many members of the Senate have no high opinions of the soundness of many of the conclusions which have been drawn by the Graham committee.

Dye Bill Before Senate

Consideration of the dyestuff bill began in the Senate May 1. Senator Frelinghuysen addressed the Senate at length, urging the passage of the bill, which he places second in importance to the Army and Navy bills, providing for the national defense. It is anticipated that extended debate will result before the measure can be passed.

Société de Chimie Industrielle

A meeting of the New York section of the Société de Chimie Industrielle will be held in Rumford Hall, 50 East 41st St., on Friday evening, May 14, beginning promptly at 8:30 o'clock. An informal dinner will be held at 6.30 P. M. Visitors are invited.

The program will be as follows:

"Commercial Relations Between France and the United States," the Hon. Maurice Casenave, chairman French High Commission to the United States; "Condition of Chemical Industry in the United States Before the War," Joseph H. Choate, general counsel of the Chemical Foundation, Inc.; election of officers, general business, social gathering and reception.

Aid for Austrian Engineers

There have been referred to Engineering Council by some of its member societies several appeals for aid to Austrian engineers. Consquently, at its meeting April 29, Council voted to instruct its secretary to prepare an appeal and transmit it to the member societies with request for publication.

A letter from the Austrian Society of Engineers in Private Practice is representative of the appeals for food:

> Fellow Craftsmen:—Austria is hungry! The supply of foodstuffs available is less than half enough. Hunger has lowered the standard of our work and has so undermined us physically that we can do nothing toward improving ourselves. We turn to America as the only state which can help us in our distress; the only nation in the world that can keep us from starving.
>
> There are 1,000 members of our organization in Austria in the various branches of engineers, such as electrical, mechanical, civil, mining, architectural and chemical. Approximately half of our members are wholly without employment, but even those who have work receive only on an average 1,500 kronen a month, a little more than $5.
>
> Through the American Relief Administration a means is provided for furnishing us with food. Americans can buy food drafts at any bank in America and send them to us by registered mail. On presentation of these drafts in Austria, the American Relief Administration Warehouse will deliver to us stipulated quantities and kinds of American food shipped to Austria for that purpose.
>
> You are our professional brothers—and we ask you to stand by us in our hour of need. We appeal to you, fellow craftsmen across the sea, to send us food drafts lest we starve!
>
> For further information apply to the American Relief Administration, 115 Broadway, New York, or to your own or the nearest bank.

There are also appeals for technical literature, such as books and back numbers of technical magazines issued since the middle of 1914.

Purple Dye From Shellfish

On the Pacific coast of Costa Rica, especially in the region about Cocos Bay, there abounds a kind of shellfish called the "nacascol," from which a fine purple color is obtained. So far no way has been found for preserving this dye, and the industry has remained in the hands of the few old people who take the trouble to dye a few ounces of thread every summer. The process is very simple. On picking up the shell from the beach or detaching it from a boulder, the gatherer blows her breath into it, whereupon a few drops of a greenish liquor ooze out. This liquor is collected in a clamshell, and after a sufficient quantity has been collected the thread is passed through it, soon after assuming, on exposure to the sunlight, a beautiful purple color, which is absolutely fast after it has turned purple. It is thought possible that the dye turns fast only on exposure to the air and that the liquor could be preserved by keeping the air away from it. There is little doubt that this industry of dyeing thread could be extended to much greater proportions if an extensive demand at good prices could be found for the dyestuff.

Fire in National Lead Co.'s Plant

On Sunday, May 2, fire broke out in the plant of the National Lead Co. on Staten Island. Some of the corroding stacks were burned and part of a small mill. The loss is estimated at between $50,000 and $75,000, fully covered by insurance.

Fellowships at the University of Utah

Seven teaching fellowships have been provided in the department of chemistry by the University of Utah for the academic year starting the fall of 1920. Dr. W. D. Bonner, in charge, has outlined an attractive series of investigations upon oil shales and other Utah raw materials.

American Cotton Seed and Cottonseed Products

Preliminary figures issued by the Bureau of Census show that 3,894,408 tons of cotton seed was received at the mills in the United States during the period from Aug. 1, 1919, to March 31, 1920, as compared with 4,051,797 tons during the corresponding period of 1919. These figures do not include 23,725 tons and 40,438 tons on hand Aug. 1, nor 151,650 tons and 113,869 tons reshipped or destroyed for 1920 and 1919, respectively. The amount of cotton seed crushed during the eight-month period was 3.704,978 tons in 1920, and 3.785,626 tons in 1919.

Imports of cottonseed products for the eight months ended March 31, 1920, amounted to 16,672,391 lb., and to 11,194,336 lb. during the corresponding period of the preceding year. Exports during this period consisted of 106,676,290 lb. of oil, 226,281 tons of cake and meal and 33,978 running bales of linters in 1920, as compared with 106,403,221 lb. of oil, 87,503 tons of cake and meal and 64,095 running bales of linters in 1919.

New Protection Against Deadly Gases

A new means of detecting the presence of carbon monoxide, which is the cause of many deaths in mines, has been perfected by Prof. C. R. Hoover. The device was invented by him in his chemical laboratory at Wesleyan University, Middletown, Conn. It is a delicate instrument which records not only the presence of the monoxide but also the quantity of it in the air. It consists of a small glass tube filled with a mixture of an iodine salt, pumice stone and fuming sulphuric acid. When impure air is admitted to the tube the contents turn green, the depth of the color indicating the percentage of CO.

The detector can be lowered by a string into shafts and then withdrawn for examination before anyone is permitted to enter. It is of special value in the iron and steel industries, in gas manufacture, for fire departments and in mine rescue work.

Mexican Directory of Domestic and Foreign Industries

The Mexican Confederation of Industrial Chambers has decided to publish a registry of foreign industries, having already in advanced preparation a registry of Mexican industries, and will furnish to foreign manufacturers and capitalists, without charge, information requested by them, unless, to obtain such information, it should be necessary to employ experts. It is requested that chambers of commerce, manufacturers' associations and similar organizations in the United States communicate directly with the Mexican organization, sending such data as will serve to co-operate in bringing the commercial and industrial interests of the two nations into mutually advantageous relations. The name of the Mexican body is Confederacion de Camaras Industriales de los Estados Mexicanos, Apartado 28, Mexico, D. F.

Carborundum Refractories to Be Made at Perth Amboy

The Carborundum Co., of Niagara Falls, N. Y., has acquired from the Alien Property Custodian the plant formerly owned and operated by the Didier-March Co. at Perth Amboy, N. J. The plant will be taken over at once and converted to the manufacture of a complete line of refractories.

The principal business of the Didier-March Co. was the manufacture of special refractory clay products, and practically all of its equipment will be utilized. The plant is located on a site of twenty-four acres fronting on the Raritan River and is well provided with wharfing facilities and railroad connections. It consists of a modern clay-working plant with a capacity of over one hundred tons per day and covers a floor space of about 300,000 sq.ft. The buildings are of substantial brick, steel and concrete construction, and there are also included office buildings, laboratories and ample housing facilities for employees. In addition to this property, the company acquires sixty acres of high-grade fire-clay lands at Bonhamton and a clay-excavating plant in operation.

The plant will be used exclusively for the manufacture of carborundum refractories. These are made in four regular grades, in addition to which special mixes are utilized in the production of saggers. These grades are known as Carbofrax "A," "B" and "C," and Refrax. All of the standard shapes in which fire-clay or silica brick are made can be produced in any of the grades, in addition to which practically any special shape, including tile, muffles and saggers, can be made in any of the three Carbofrax grades only.

Refractories made in any of the three Carbofrax grades are composed of over 90 per cent silicon carbide to which small percentages of highly refractory materials are added to facilitate binding. High refractibility is, therefore, maintained due to the fact that silicon carbide cannot be melted, and is decomposed into silicon vapor and graphite only above 4,000 deg. F.

In addition to the regular line of made-up refractories, the new plant at Perth Amboy will produce a complete line of high-grade refractory cements. It has not been found possible to produce a refractory cement which will cover all conditions, consequently ten special cements have been developed and these have been found to cover a great variety of requirements.

Large Canadian Chemical Company Organized

Chemical Products, Ltd., has secured the Trenton, Ont., plant of British Chemicals, Ltd., which was operated during the war for the production of acids and explosives. The new company is prepared to manufacture 75,000 tons of acid phosphate per year, and expects to engage in the production of acids, both sulphuric and nitric.

The plant has been re-arranged into four units where the following operations will be undertaken in a very large way in charge of A. H. C. Heitman:

Plant 1. Production of sulphuric acid and acid phosphate; production of nitric acid for general purposes.

Plant 2. Refined nitrate of soda, magnesium sulphate.

Plant 3. Salicylates and derivatives.

Plant 4. Ammonia and coke-oven byproducts.

Tennessee Copper & Chemical Corporation's Deficit

The largest lead chamber sulphuric acid plant in the world is located at Copper Hill, Tenn., and is operated by the Tennessee Copper & Chemical Corporation. It was erected to abate the nuisance caused by the great quantities of SO_2 produced during the smelting of the low-grade sulphide ores. It has a capacity of about 350,000 tons of 60 deg. acid per year.[1]

A deficit was returned for the last fiscal year, due largely to the fact that the acid makers were working under a 10-yr. contract with the International Agricultural Corporation for the entire output. An agreement which was attractive at the outset is evidently not so profitable at present. Fortunately for the Tennessee corporation, but unfortunately for the Agricultural company this contract expires on Dec. 31, 1920. It is understood that the Tennessee Copper & Chemical Corporation has already made tentative future arrangements with several fertilizer companies in which higher prices for 50 per cent of its acid will be obtained. This will leave a quantity of acid which can either be sold in the open market or utilized by the corporation itself in the manufacture of acid phosphate, which field it has recently entered.

The Southern Agricultural Corporation, a new company owned and controlled by the Tennessee Copper & Chemical Corporation, has been formed for the manufacture of fertilizer, and a new 100,000-ton plant is being erected at Atlanta, Ga. A phosphate rock property near Bartow, Fla., has also been acquired recently.

St. Louis Coke & Chemical Co.

A new plant being constructed in St. Louis for the St. Louis Coke & Chemical Co. occupies about 220 acres and will be served by ten miles of trackage facilities. On the site is being erected a 500-ton blast furnace which will be used for the manufacture of pig iron. The metal will not be cast into pigs, but will be conveyed in molten form in ladle cars to the plant of the National Stamping & Enameling Co., which adjoins the property.

Iron ore will be brought in by car and barge from the Minnesota districts and approximately 2,000 tons of Illinois coal will be carbonized daily. There will be eighty of the Robert type of ovens for the manufacture of coke. These ovens are 13 in. wide, 14 ft. high and 42 ft. long. The various carbonization products will be divided as follows: 1,400 tons of coke, 20,000 gal. of tar, 10,000,000 cu.ft. of gas, 6,000 gal. of motor fuel and 6,000 lb. of ammonium sulphate. All the byproducts with the exception of the ammonium sulphate will be utilized by the company.

Du Pont Company to Manufacture Artificial Silk

The du Pont company and the Comptoir des Textiles Artificiels, of Paris, France, have entered into an agreement whereby a new company will be formed in America for the manufacture of artificial silk. Announcement is made that the du Pont Fibersilk Co., with a capitalization of $4,000,000, has been organized.

The Comptoir des Textiles Artificiels controls practically all of the largest artificial silk plants in Europe.

It is anticipated that the plant will be in full operation within a year.

[1] For description of this plant see CHEMICAL & METALLURGICAL ENGINEERING, vol. 13, p. 194, Sept. 25, 1915.

Annual Reports of Metallurgical Companies

New Cornelia Copper Co.

Market conditions were unsatisfactory throughout the year 1919 and the company was unable to market a large quantity of copper, notwithstanding a considerable curtailment of production. This adversely affected the income account and increased the amount of copper on hand. The operating costs, however, were satisfactory. At the plant at Ajo 29,640,211 lb. of electrolytic copper was produced and 6,368,952 lb. shipped as cement copper. Sales of copper during the year amounted to about 30,000,000 lb., of which but 23,000,000 lb. was delivered.

The leaching and the electrolytic plants have worked satisfactorily. The hard lead anodes after thirty months service show very little corrosion. The leaching system has also worked satisfactorily. An inspection of the lead linings of the leaching tanks and the pumps shows that there has been no appreciable wear or deterioration on these installations. A six-compartment settling tank which will have capacity to take care of the slimes of the neutral solution before going to the sulphur dioxide reduction towers and the reduced iron solution after passing the towers is being installed. This will permit of the use for leaching of a tank that has been used as a settling tank and prevent the plugging of the reduction towers with slimes.

A 500-ton flotation mill was completed and put in operation late in August and 14,024 tons of sulphide ore was treated in the mill. This ore ran 1.275 per cent sulphide copper and 0.038 per cent oxide copper. A tailing was produced carrying 0.203 per cent sulphide and 0.028 per cent oxide copper, which represents a total recovery of 83.61 per cent. The ratio of concentration was 14.767 to 1.

Calumet & Arizona Mining Co.

The report of the Calumet and Arizona Mining Co., for the year ended Dec. 31, 1919, shows a production of 50,000,000 and sales amounting to 47,000,000 lb. of copper and a net income of $524,416 after charging off $1,381,948 to ore depletion. The year opened with a heavy balance of unsold copper in the hands of producers, which necessitated a curtailment in production. The last quarter of the year showed improvement in the demand for copper, and record sales were made in December for 1920 delivery. The average daily wages paid at the mines increased from $5.37 to $5.52.

During 1919 the smelter at Douglas treated 701,450 dry tons of ore, compared with 850,894 dry tons in 1918; the production for 1919 was about 56 per cent capacity, the decrease being largely in the blast-furnace department. Reduction in the blast-furnace department was made on account of the lower operating cost of the reverberatories, the decreased amount of oxide ore received and the gradual changing of all ores to a more desirable reverberatory charge. The roaster plant operated at full capacity the entire year.

On account of the curtailment of operations of the New Cornelia Copper Co., which consumes the largest portion of the acid produced by the acid plant, this plant was operated at about two-thirds capacity, producing 48,600 tons of 60 deg. Bé. acid compared with 67,100 tons in 1918.

On account of the deterioration of the tile lining inside the stack of the roaster department, it was necessary to remove the top 120 ft. of steel and all of the tile lining and to replace the old steel with new and completely reline the stack with acid-proof high-silica brick. When this is completed the roaster department will be in good condition. During the shut-down of the acid plant the towers of the acid plant were cleaned, putting this plant in good operating condition.

Judge Mining & Smelting Co.

Labor conditions in the Park City district and the unsatisfactory conditions of the zinc market during 1919 adversely affected the operations of the Judge Mining & Smelting Co. During the first part of the year there was an acute shortage of labor, and as a consequence it was impossible to obtain proper efficiency from the men obtainable. Agitation fostered by the Industrial Workers of the World resulted in a complete stoppage of operations for two months. Since the first of the present year, however, conditions have improved, better prices have been obtained for zinc and the surplus zinc on hand has begun to move.

For 1919 the metal content of all ores sold was: Silver, 410,307 oz.; lead, 6,989,908 lb.; copper, 276,926 lb.; gold, 462 oz.; zinc, 262,760 lb.

The electrolytic zinc plant operated for the first four months of 1919, when operations ceased because of the labor strike. Advantage was taken of the shut-down to carry on experimental work for the purpose of increasing the recovery of metal and to develop a process for the recovery of byproducts. The experimental work has been completed and the necessary changes in the plant have been made. Operation of the zinc plant was resumed in January, 1920, and zinc is now being produced of 99.95 per cent purity.

American Smelting & Refining Co.

The reconstruction period of 1919 adversely affected the business of smelting and refining of metals in the following important respects: (1) The reduction of mine production and a proportionate curtailment of operations of the smelters and refineries, which increased the cost of operation per ton treated. This made necessary the reduction of forces and readjustment of methods. (2) The cessation of demand for metals locked up the company's liquid capital and increased greatly the metal carried in stock. (3) The company's policy of accepting long-time contracts, many of which were entered into in the early stages of or prior to the war, became burdensome due to the increased cost of labor, fuels and supplies and because of the decreased efficiency of labor and higher freight rates. Average wages per 8-hr. day increased from $3.96 to $4.34.

The situation made necessary drastic measures to decrease expenditures. These were taken early in the year, and the beneficial results are shown in the net earnings, which for the first six months of 1919 were $2,149,159.66 and for the last six months of 1919 were $3,446,424.91.

The rising price of silver turned attention particularly to Mexico, and efforts were made to develop maximum output. Production was interrupted by the Villa activity in the late spring. All smelters in Mexico were in operation at the close of the year.

In order to increase ore production a substantial interest was purchased in the Premier mine, in British Columbia, and other options have been taken on several properties in that country. Over 90 per cent of the

Sabines Coal Co. has been acquired during the year. This property is located about one hundred miles from the Mexican border, and development will enable the Mexican smelters to be supplied with a satisfactory quality of coke at a lower cost.

A comparison showing the receipts from sale of metals and the metal production for the years 1918 and 1919 is given below.

RECEIPTS

From Sales of Metals:	1919	1918
Gold	$44,777,926.70	$40,624,998.17
Silver	64,105,415.60	54,547,364.28
Lead	21,573,831.43	34,955,070.42
Copper	81,281,842.45	208,840,411.45
Zinc	2,797,444.95	4,544,170.26
Tin	8,537,899.83	14,635,931.77
Other metals	2,032,790.26	1,912,540.40
Total	$225,107,151.22	$360,060,486.75

METAL PRODUCTS

	1919	1918
Ounces of gold produced	2,191,041	1,994,015
Ounces of silver produced	78,200,298	72,572,506
Ounces of platinum and palladium produced	1,824	1,516
Tons lead produced	208,439	260,192
Pounds copper produced	705,676,000	868,540,000
Pounds spelter produced	33,375,301	41,238,000
Pounds nickel produced	662,637	626,085
Pounds tin produced	15,340,000	19,868,000
Pounds sulphuric acid produced	40,362,000	87,338,000
Pounds arsenic produced	9,359,541	7,837,063
Pounds copper sulphate produced	3,675,499	5,164,000
Pounds byproduct metal produced	884,438	1,870,662

The company paid $6,681,242.25 in dividends, a decrease of $921,421.50 from 1918, practically all of this being on the common stock.

Portland Gold Mining Co.

The effect of the diminished purchasing power of gold is reflected in the annual report of the Portland Gold Mining Co. Operations during 1919 resulted in profits from mining and milling of $224,000, which, together with revenue from other sources, brought the net income to $234,636. Depreciation of mine and mill equipment was charged off to the extent of $174,666 and mine depletion to $146,313, resulting in a net loss to surplus of $92,817. Dividends of $240,000 were paid in 1919, the surplus for Jan. 1, 1920, being $819,531, a decrease of $332,817 from Jan. 1, 1919. Adverse conditions brought about by the war are still in effect in the Cripple Creek district.

Before the war ore of a value of $2 a ton was treated with greater profit than $3 ore yields at the present time, notwithstanding the many economies instituted during the war period.

Mount Morgan Gold Mining Co., Ltd.

The Mount Morgan Gold Mining Co., Ltd., of Queensland, Australia, for the six months ended Nov. 30, 1919, smelted 90,475 tons of ore and concentrate, recovered 2,749 tons of copper and 41,191 oz. of gold, and showed a surplus over expenditures of £43,333. Production of the mines was reduced about 40,000 tons below normal due to an epidemic of influenza and to a stoppage of operation brought about by the seamen's strike. Experimental work on leaching Mount Morgan ore in a unit treating one ton of calcines per 24 hr. gave satisfactory indications as to the recovery of copper, but gold extractions have not been so completely and satisfactorily demonstrated. With a view of obtaining more complete data a 10-ton unit is now being installed. This unit will, in addition to leaching copper from the calcines, also treat the residues for gold by chlorination.

Scarcity of German Dyes

In January, a committee from the British Color Users' Association of Manchester was sent to Germany to investigate the dyestuff situation and to report upon the available stocks now held in that country. This committee, after carefully examining the situation in Germany and after holding a number of conferences with leading German color manufacturers, has issued its report, in which it first states that it found the stocks of dyestuffs available in Germany to be very small indeed. It ascertained that very little, if any, manufacturing of dyestuffs was being carried on, owing principally to the shortage of raw materials and fuel, although conditions were slightly better in the sector at present under British occupation, where manufacturers were succeeding in turning out small quantities of dyes. It found that in some parts of Germany numerous foreign buyers had been trying to purchase any surplus stocks that might be had after the necessary 50 per cent had been set aside for the purposes of the Reparation Commission, but with no great success.

This British commission decided on a policy of buying on commercial lines on behalf of the whole body of color users, and bought for immediate export to Great Britain 140 tons of German dyestuffs for the approximate sum of £191,720 ($933,000 at normal exchange for the pound sterling) for the lot. Of course, the committee would have been better pleased if it could have secured a much larger quantity, but it found this to be impossible. The committee, however, entered into tentative negotiations with sundry manufacturers, and hopes, by reason of these, to receive larger and more varied shipments of dyes from Germany in the near future. Catalogues of all dyes already purchased are being prepared for the use of British consumers, and the committee has stated that, in its opinion, the best means whereby an adequate supply of dyes can be obtained will be by an organized plan for the purchase of all possible supplies wherever obtainable. Only by some concerted and well-organized effort can the British dye users expect to obtain in the future such stocks of European dyes as will enable them to meet all their requirements.

Finer Colors Lacking in British Dyes

There seems a definite fear among the color-using trades of the United Kingdom lest the British dye industry concentrate on the production of the commoner kinds of dyes to the neglect of the finer qualities and a wide range of varieties.

It is claimed that hundreds of dyes made in Germany are not being manufactured in Britain, and while all these are not essential dyes, they indicate that there is a far wider range of production in the German dye industry. British color users complain that the dye industry in Britain is a virtual monopoly, and is not paying sufficient attention to the requirements of the color-using trades, particularly in the matter of fine dyes.

It is fully admitted that many chemicals, never before manufactured, are being produced in Britain, but many more remain to be dealt with, as all the synthetic chemicals, whether dyes, drugs, etc., are associated in manufacture. This view receives some support from the recent Board of Trade order prohibiting export from the United Kingdom of all coal-tar products which form the basis of dyes and most chemicals.

Notice to Engineering Societies

On June 3 and 4, 1920, there will be a meeting at Washington of the Joint Conference Committee of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers to consider plans for organizing a national engineering organization.

The Joint Conference Committee has twice convened, the first meeting on Aug. 13, 14 and 15 and the second Sept. 15, 16 and 17 in 1919. The results of these meetings were published in a report, which was favorably acted upon by the governing boards of the several societies, and resolutions were adopted directing the committee to call a meeting of the engineering organizations of the United States for an organizing conference and to establish the proposed organization.

Any engineering society or organization not a branch of a national engineering society is eligible for membership in the organizing conference. Full information as to credentials may be had from the committee by addressing it at 29 West 39th St., New York.

India's 1919-20 Cotton Crop

The Indian Department of Statistics has issued its final memorandum on the acreage and yield of the 1919-20 cotton crop.

The total area reported is 23,063,000 acres—about 10 per cent more than the revised total for 1918-19. The estimated yield is 5,845,000 bales of 400 lb. each—47 per cent more than in the preceding year. Of the total yield Oomras represent 48 per cent, Bengal-Sind 23 per cent, Dholleras 9 per cent, Coompta-Dharwars and Broach 5 per cent each, Tinnevellys, Salems, and Cambodias 4 per cent, and Northerns and Westerns 3 per cent.

American Purchase of Bolivian Petroleum Deposits

A large tract of petroleum land held by Chilean capital is said to have been acquired by an American in Chile for £750,000. The center of the deposits is in the vicinity of Santa Cruz. It has been announced by the new petroleum interests that a petition will be submitted to the Bolivian Government for a concession to construct a railway line from Santa Cruz to Formosa, in northern Argentina, the construction to be facilitated by grants of government lands.

Must Label Wood Alcohol Products Poison

As a further means of protecting the general public against the dangers in the use of wood alcohol, the laws of the State of Massachusetts have been so amended that such articles as bay rum, toilet water, cosmetics, and drugs containing wood alcohol, must be labeled "Poison, for external use only." It is expected that this example will be followed by other states.

Freight Rates on Vegetable Oils

A proposition is before the Transcontinental Freight Bureau to restrict to the direct lines the application of rates on vegetable oils from the Pacific Coast to eastern destinations. At the present time these rates apply via practically all routes and transit privileges and are authorized in southwestern states, which will be greatly restricted if the proposition carries.

Book Reviews

MICROSCOPIC DETERMINATION OF ORE MINERALS. By *W. Myron Davy* and *C. Mason Farnham.* Thumb-indexed; cloth, 6 x 9; pp. 154, illus. New York: McGraw-Hill Book Co., 1920. Price, $2.50.

Although the compound microscope has been extensively utilized for opaque mineral classification since the appearance of William Campbell's epoch-marking paper in 1906, Joseph Murdoch's "Microscopical Determination of the Opaque Minerals," published in 1916, has been the only comprehensive manual or textbook available on the subject.

It is to be expected that a new branch of science will at first develop rather rapidly, that new ideas will be adopted, and that new methods will be originated. That this has been true of "Mineragraphy," the name adopted by Messrs. Davy and Farnham to designate the subject on which they have written, is unquestionable; and these authors have described in their "Microscopic Determination of Ore Minerals" the new technique and criteria that have been found most useful in several laboratories.

The book is not a rehash or an adaptation of Murdoch's work, but differs therefrom in many important particulars. For instance, the determinative tables in the new book are based primarily on micro-chemical tests instead of upon color, the basis of Murdoch's tables. Davy and Farnham use only six chemical reagents, while Murdoch used seventeen; and the new book gives some data on streaks and cleavages which are not mentioned in Murdoch's work. Davy and Farnham also give in detail simple methods for testing the electrical conductivity and the electro-potential of minerals in polished sections, and describe the use of electrolysis to etch and bring out the structure of such minerals. Finally, they have included a section on standard blowpipe and inorganic qualitative chemical tests.

Investigators familiar with Murdoch's book and who use the new work may miss a few features that they have found useful; but careful study of the new book indicates that its authors have simplified the subject, and have endeavored to eliminate the personal equation.

Although determinative tables and the necessary preliminary explanations fill most of the volume, one chapter is devoted to a very lucid explanation of the technique of polishing and examining specimens, while another treats of the photo-micrography of polished sections.

The most evident weakness of the book is the inadequacy and even incorrectness of the non-microscopic data offered. It is doubtless very difficult to decide where to draw the line, so the almost complete lack of crystallographic information may perhaps be condoned. It is not so easy, however, to overlook actual errors, such, for example, as the statements that the streak of pyrite is greenish to brownish-black (instead of just black), that of enargite is sometimes grayish (instead of black), and that of sphalerite is "pale (what?) to colorless." The experienced mineralogist will also be surprised to find the cleavage of alabandite described as *perfect* cubic, this being the same term applied, and properly so, to galena. He will further search in vain, for instance, for mention of the red streak often shown by tennantite, or the greenish streak on glazed paper or porcelain so characteristic of molybdenite. Finally, he may wonder why orpiment, realgar and many other translucent or transparent minerals of non-metallic luster are described, while vanadinite, pyromorphite, wulfenite, scheelite, monazite and other important ore minerals are omitted.

It is undeniable, however, that the defects or inconsistencies criticized detract little from the usefulness of the book as a guide to the *microscopic* classification of most ore minerals, and that, considered as a whole, the volume is admirably adapted to its purpose. It forms a welcome addition to the literature of "mineragraphy" or mineralography" (Murdoch), and should be owned and used by everyone interested in this fascinating and useful science.

G. M. Butler.

Personal

WILLIAM C. DOWD has resigned as chemist of the American Smelting & Refining Co., Pueblo, Col., to accept the position of chief chemist of the Austin plant of the American Radiator Co., Buffalo, N. Y.

Dr. H. N. HOLMES of Oberlin gave a series of three lectures before the California Section of the American Chemical Society. The first lecture, on "Emulsions," was given at the Chemistry Building, Stanford University, April 22; the second, on "Gels," on April 23 at the University of California. On the evening of April 24 Dr. Holmes lectured on "The Industrial Application of Colloid Chemistry" at the Chamber of Commerce rooms, San Francisco.

DAVID F. HOUSTON, Secretary of the Treasury, before the Chicago Chamber of Commerce, on April 23, discussed the nation's problems and the duty of Americans.

J. F. JOHNSON, formerly with the Procter & Gamble Co., Ivorydale, Ohio, is now chief chemist of the Lever Bros. Co., Cambridge, Mass.

THOMAS J. KEENAN, secretary of the T.A.P.P.I., has resigned as editor of *Paper* and is now located at Room 1102, 18 East 41st St., New York City.

ALEXANDER M. MACMILLAN, one of the head chemists in the Customs Inland Revenue Laboratory, Ottawa, Canada, has resigned, to enter a manufacturing concern.

Prof. E. G. MAHIN, of Purdue University, presented a paper on "Non-Metallic Inclusions in Steel" before the Indiana Section of the American Chemical Society on May 8.

Dr. VAN H. MANNING recently tendered his resignation as director of the Bureau of Mines, effective June 1, and is to become director of research with the recently organized American Petroleum Institute. Dr. F. G. COTTRELL succeeds him as director.

HARRY H. MERRICK was elected president of the Mississippi Valley Association in St. Louis, April 21.

Dr. F. S. MORTIMER, secretary of the Iowa Section of the American Chemical Society, has accepted a position on the staff of the National Aniline & Chemical Co., Buffalo, N. Y.

Prof. W. A. NOYES, of the University of Illinois, Urbana, Ill., addressed the meeting of the Chemical Society of Washington, D. C., on April 28. His subject was "Foundations of Chemical Development."

L. B. SHIPLEY, formerly chemist and technical representative in matters pertaining to coal-tar heavy oils for The Barrett Co., has accepted a similar position with Bernuth Lembcke Co., Inc., New York City.

LEON R. WHITCOMB has resigned as chemical engineer with Hill & Ferguson, New York City, to accept a position with the Refinite Co., Omaha, Neb.

Obituary

SAMUEL T. MORGAN, president of the Virginia-Carolina Chemical Co., who was well known in the fertilizer field, died at his home in Richmond, Va., on April 16.

I. FRANK STONE, formerly president of the National Aniline & Chemical Co. and one of the leading manufacturing chemists of the country, died in New York City, May 5, in his fifty-fourth year. Mr. Stone was born in Chicago and when only twenty-one years old founded there the firm of I. F. Stone, that later was changed to Stone & Ware and moved to New York City in 1897. Three years later he became head of the Schoelkopf, Hartford & Hanna Co., and in 1906 assumed the presidency of the National Aniline & Chemical Co. This last concern did much to further American chemistry after German products were cut off.

Current Market Reports

The Non-Ferrous Metal Market

New York, May 10, 1920.—The metal market has been in an unsatisfactory state for the last week, owing largely to difficulties of shipment. Tin dropped about five points. Silver continues to decline.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent.	32@33
Antimony, wholesale lots	11.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	56.25
Lead, New York, spot	9.37½@9.50
Lead, E. St. Louis, spot	9.00 @9.12
Zinc, spot, New York	8.62½
Zinc, spot, E. St. Louis	8.25

OTHER METALS		
Silver	oz.	$1.05
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	2.70@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	110@115
Iridium	oz.	300.00
Palladium	oz.	105@115
Mercury	75 lb.	85.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper sheets, cold rolled (over 14 oz.)	31.50
Copper bottoms	38.00
Copper rods	23.00
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless high brass tubing	30.50

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	21.75@22.75
Aluminum, sheet scrap	21.25@22.50
Copper, heavy machinery comp.	13.50@14.00
Copper, heavy and wire	13.50@13.75
Copper, light and bottoms	12.25@12.75
Copper, heavy cut and crucible	14.75@15.00
Brass, heavy	7.50@8.00
Brass, light	7.00@7.50
No. 1 clean brass turnings	8.25@8.50
No. 1 comp. turnings	10.25@10.75
Lead, tea	5.25@5.40
Lead, heavy	7.00@7.25
Zinc, scrap	4.25@4.50

The Iron and Steel Market

Pittsburgh, Pa., May 7, 1920.

There has been a further and very material increase in the railroad movement as affects the iron and steel industry, but the rail strike is by no means broken. The roads have made gains, through the return of a few more of the strikers, through receiving more help from volunteers and through means multiplying for getting around the difficulty, which is chiefly that of operating the yards. The Pittsburgh & Lake Erie is conspicuous by still being able to handle scarcely any freight, while even the passenger service on that line is very meager. The effect is felt particularly in the Youngstown district, but the two other lines in that territory, the Pennsylvania and the Baltimore & Ohio, are doing better, and the district is producing at least 50 per cent as much pig iron and steel as normally. As for the Pittsburgh district, it is doing probably 90 per cent or better.

An estimate can now be made that the production of pig iron in April in the country as a whole, some districts being affected by the rail strike and some not, was at about 17 per cent lower rate than production in March. Assuming capacity at 45,000,000 gross tons per annum, March production was at 90 per cent and April production at 75 per cent, but production had been increasing, and had it not been for the rail strike April would probably have shown a gain over March. Production of steel ingots probably

declined in much the same manner as production of pig iron. The pig iron production rate now is probably about 85 per cent of capacity.

Steel Shipments Heavier

There has been a slight decrease in the embargoes, permits are granted somewhat more freely, and there are somewhat better car supplies on the whole. Considerably more has been done in the past week than in the previous week by way of moving solid trainloads of finished steel, either direct to a large consumer or to classification yards, particularly in the West, that are free to operate and can distribute single cars to various consumers. The total movement of finished steel from mills has materially increased, and in a few cases the shipments have been exceeding the current production. In general, however, steel continues to pile up in mill warehouses and yards. It can readily be seen that the distribution of steel is inequitable, some consumers being entirely shut off, and it is quite probable that some consumers, with lines of communication open, are receiving more steel than they really need.

It seems to be a fair analysis that when the rail strike is ended, as presumably it will be some time, steel will be found to be more plentiful than it was before the strike started, through consumption having been more restricted than production, and this, of course, will have a bearing upon the market in general and upon prices in particular. The market is now extremely dull. Buyers are indisposed to make forward commitments, and as to prompt deliveries, they are more likely to get deliveries on orders already placed than on orders that might be placed at this time.

Prices Easier

There have been some declines in the premiums asked for very early deliveries, in from three to six weeks, bars being available at about 3.50c., as against 4c. a few weeks ago, and plates at 3.75c., against 4c. to 4.50c. For the farther forward deliveries, in from two to four months, there are no definite price declines, although some exceptional sales have been made at special prices, but there is some softening in the market.

It is now not an uncommon view in iron and steel trade circles that industry in general is marked for an early readjustment in activity and prices, and there are not a few who welcome the change. While the experience may be uncomfortable, good results are expected. Steel producers recognize that steel demand suffers from the fact that the cost of putting steel into employment is very high, both from the high prices ruling for other commodities used in conjunction with steel, and from wages being extremely high in proportion to the service rendered, and as steel prices, except for the fancy premium prices for very early deliveries, are quite moderate compared with many other commodities, the steel industry may gain more than it loses by there being a general industrial readjustment.

The Chemical and Allied Industrial Markets

New York, May 7, 1920.

The two questions uppermost in every market at the present time and for six weeks past are: (1) Are materials obtainable at any price? and (2) At what price? There is no need to enlarge upon the difficulties of shipment. Everybody in every industry is personally acquainted with the freight tie-up.

Acetic acid, 28 per cent, is to had at prices ranging from \$3.50@\$4.50 per cwt., depending upon quantity desired, as against \$2.75@\$3.50 of pre-strike listing, while 56 per cent is firmly fixed at \$6@\$7.50 per cwt. The sensational rise on *barium chloride* which started about two months back shows no signs of breaking and producers are unable to meet the situation by accepting contracts; small quantities of this material on the spot market are quoted at \$140@\$150 per ton. *Barium sulphate*, blanc fixe, dry, is in practically the same position, with 4½@6c. prevailing, against 3@5c. per lb. of the previous report, while blanc fixe, pulp, is practically off the market, current prices ranging from \$60@\$80, as compared with \$30@\$50 per ton of a few weeks ago. *Chlorine gas* can be had in 100-lb. liquid cylinders at 9@10½c. per lb., an advance of 2c. on the pound, which has been caused by curtailment of production and the scarcity of containers. Inquiries on *bleaching powder* and *soda ash* have fallen off considerably, which points to the conclusion that buyers, both foreign and domestic, realize that the present shortage has depleted the market of everything but small quantities and are unwilling to commit themselves on the prevailing premium prices. Producers have withdrawn quotations on *glauber's salt*, as the freight tie-up has very seriously affected this item. Nominal quotations ranging from \$1.50@\$2 per cwt. have been heard for small quantities of spot material. *Caustic potash* is again falling behind and it is reported that manufacturers are sold out for months ahead. Whatever material has been available during the week sold at 30@35c. per lb.

Coal-Tar Products

Inasmuch as many of the items are unobtainable and those that are available may be had only in small quantities, it will be sufficient to state a few of the prices which are not wholly nominal. Among these are *aniline oil*, which remains at former levels of 34@45c. per lb. and *aniline salts*, at 46@50c. per lb. One large producer who is the controlling factor in the *phthalic anhydride* market steadily maintains this item at 65@75c. per lb., while *toluol* is still listed at 28@30c. on contract, with considerable quantities of this material on hand.

Naval Stores

As noted last week, the prices listed in the naval stores market are those to become effective upon arrival of material in this market. This applies particularly to all grades of *rosin*, of which shipments are expected to arrive from the South soon. Savannah is being held up by a combination of labor troubles and the difficulties in coastwise shipping.

Vegetable Oils

Linseed oil has shown considerable weakness during the week. No activity has been manifested on the part of buyers, and as a result all grades have dropped. Current quotations are: *Linseed raw*, car lots, \$1.72; *raw*, tank cars, \$1.67; *boiled*, tank cars, \$1.75 per gal.

Ores and Semi-Finished Products

Fluorspar—We are advised that 700 tons of gravel fluorspar have been sold for \$25 per net ton, f.o.b. mines southern Illinois, with no analysis guaranty, contracts reading "Fairview Washed Gravel Fluorspar." Also, 1,250 tons were sold at the same price and same shipping point with an average guaranty of 85 per cent calcium fluoride and not over 6 per cent silica, while a small tonnage was sold at the same point, with no analysis guaranty, packed in barrels, at \$37.50 per ton. Producers in this territory are not desirous of accepting contracts for acid grades of fluorspar and have refused to make any quotations on these grades. During the past few weeks the demand has become more active, but a good many of the fluorspar companies are pretty well sold. It is asserted that they are holding a certain portion of their tonnage for an expected increase in price.

Vanadium Ore—Prices of vanadium ores are usually based on the vanadium content, and at present range from \$1 to \$3 per lb. of contained vanadium. The variation depends not only on the percentage of vanadium but also on the presence of lead, copper, arsenic, molybdenum, uranium, etc., which may be difficult of separation.

Ferro-Alloys

Ferromanganese is well sustained at former levels, \$200 being asked for last half delivery, and \$230@\$250 per ton for prompt. Continuous labor difficulties dating back to early December, 1919, combined with excessively heavy demand, are responsible for present rise, which occurred in rather consistent jumps of \$10 a week, from \$115 to the the present high mark at \$250.

Spiegeleisen came up \$10 during the week, from \$63@\$65 to the current price of \$73@\$75 per gross ton.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.65 $0 75
Acetone	lb.	$0.19 -$0 20	21 - .22
Acid, acetic, 28 per cent	cwt.	3.50 - 4.00	4 25 - 4 50
Acetic, 56 per cent	cwt.	6.50 - 7.00	8 75 - 9 00
Acetic, glacial, 99½ per cent, carboy	cwt.	15.50 -16.00	16.50 - 17 50
Boric, crystals	lb.	.14½- .15½	.15½- .16½
Boric, powder	lb.	.14½- 15	.15 - .16
Citric	lb.	.85 - .86	1.17 - 1.18
Hydrochloric (nominal)	lb.	.07 - .08	.09 - 10
Hydrofluoric, 52 per cent	lb.	.12 - .12½	.13½- .14
Lactic, 44 per cent tech	lb.	.11 - 11½	.12 - .16
Lactic, 22 per cent tech	lb.	.04½- .05½	.06 - .07
Molybdic, C. P.	lb.	4.00 - 4.50	4.50 - 5.00
Nitric, 40 deg.	lb.	.06 - 07	.07½ - .08½
Nitric, 42 deg.	lb.	.07½ 08	.08½ - .09½
Oxalic, crystals	lb.	.55 - .57	.58 - .59
Phosphoric, Ortho, 50 per cent solution	lb.	.22 - 23	24 - 25
Picric	lb.	.30 - .35	.40 - .50
Pyrogallic, resublimed	lb.	2.50 - 2.55	2.60 - 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 -18.00	-
Sulphuric, 60 deg., drums	ton	- -	- -
Sulphuric, 66 deg., tank cars	ton	22.00 -25.00	- -
Sulphuric, 66 deg., drums	ton	35 00 -40.00	- -
Sulphuric, 66 deg., carboys	ton	36.00 -40 00	- -
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 -30.00	32.00 - -
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 -30.00	34.00 - -
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 -35 00	40.00 - -
Tannic, U. S. P.	lb.	1.50 - 1.60	1.65 - 1.70
Tannic (tech.)	lb.	- -	.60 - .90
Tartaric, crystals	lb.	- -	.75 - .80
Tungstic, per lb. of WO	lb.	- -	1.20 - 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 - 5.50	6.00 - 7.00
Alcohol, Methyl (nominal)	gal.	2.50 - 3.50	- -
Alcohol, denatured, 188 proof (nominal)	gal.	- -	1.00 - 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	- -	.98 - 1.02
Alum, ammonia lump	lb.	.04½- .05	.05½- .06
Alum, potash lump	lb.	.07½- .08¾	.09 - .09½
Alum, chrome lump	lb.	.17 - .18	.19 - .20
Aluminum sulphate, commercial (nominal)	lb.	.01½- .02	.02½- .03½
Aluminum sulphate, iron free	lb.	.02½- .03	.03½- .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾- .10¾	.11 - .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 - .35	.35 - .40
Ammonium carbonate, powder	lb.	.16 - .16½	.17 - .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 - .16½	.17 - .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 - .13½	.14 - .14½
Ammonium nitrate	lb.	.08¾- .12	- -
Ammonium sulphate	lb.	.07 - .08	.08½- -
Amylacetate	gal.	- -	3.65 - 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	- -	.13½- .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 - .24	- -
Barium chloride (nominal)	ton	150.00–160.00	165.00 -175.00
Barium dioxide (peroxide)	lb.	.21 - .23	.24 - .25
Barium nitrate	lb.	.10 - .11	.11 - .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½- .05	.05½- .06
Bleaching powder (see calcium hypochlorite)		- -	- -
Blue vitriol (see copper sulphate)		- -	- -
Borax (see sodium borate)		- -	- -
Brimstone (see sulphur, roll)		- -	- -
Bromine	lb.	.85 - .90	- -
Calcium acetate	cwt.	2.00 - 2.05	2.10 - -
Calcium carbide	lb.	.04¼- .04½	.04¾- .05½
Calcium chloride, fused, lump	ton	23.00 -25.00	30.00 - 40.00
Calcium chloride, granulated	lb.	.01½- .01½	.02 - .02½
Calcium hypochlorite(bleaching powder)	cwt.	4.00 - 4.25	4.35 - 5.00
Calcium peroxide	lb.	- -	1 50 - 1.70
Calcium phosphate, monobasic	lb.	- -	.75 - .80
Calcium sulphate, pure	lb.	- -	.25 - .30
Carbon bisulphide	lb.	.07 - .08	.09 - .10
Carbon tetrachloride, drums	lb.	.11 - .11½	.12 - .15½
Carbonyl chloride (phosgene)	lb.	- -	.80 - 1.05
Caustic potash (see potassium hydroxide)		- -	- -
Caustic soda (see sodium hydroxide)		- -	- -
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 - .09½	.10 - .10½
Chloroform	lb.	.30 - .35	.36 - .38
Cobalt oxide	lb.	- -	2.00 - 2 05
Copperas (see iron sulphate)		- -	- -
Copper carbonate, green precipitate	lb.	.27 - .28	.29 - .31
Copper cyanide	lb.	- -	.65 - .70
Copper sulphate, crystals	lb.	.08¼- .09	.09 - .09½
Cream of tartar (see potassium bitartrate)		- -	- -
Epsom salt (see magnesium sulphate)		- -	- -
Formaldehyde, 40 per cent (nominal)	lb.	.38 - .40	.60 - .80
Glauber's salt (see sodium sulphate)		- -	- -
Glycerine	lb.	- -	.24½- 26
Iodine, resublimed	lb.	4.30 - 4.35	4.40 - 4 45
Iron oxide, red	lb.	- -	.03 - .20
Iron sulphate (copperas)	cwt.	1.50 - 1 75	1.80 - 2 00
Lead acetate, normal	lb.	.14 - .14½	.15 - 18
Lead arsenate (paste)	lb.	11 - 12	.13 - 17
Lead nitrate, crystals	lb.	- -	.90 - 1 00
Litharge	lb.	.14 - 15	15½ - 16
Lithium carbonate	lb.	- -	1 50 - -
Magnesium carbonate, technical	lb.	.12 - .14	.15 - 16
Magnesium sulphate, U. S. P.	100 lb.	3.50 - 3.55	3.60 - 4 25
Magnesium sulphate, commercial	100 lb.	- -	3 25 - 3 60
Nickel salt, double	lb.	.14 - -	15 - -
Nickel salt, single	lb.	.16 - .17	.17½ - -
Phosgene (see carbonyl chloride)		- -	- -
Phosphorus, red	lb.	.50 - 55	.60 - 65
Phosphorus, yellow	lb.	- -	.35 - 37
Potassium bichromate	lb.	.36 - 37	.40 - .46
Potassium bitartrate (cream of Tartar)	lb.	.53 - 56	.57 - .58
Potassium bromide, granular	lb.	- -	.85 - 90
Potassium carbonate, U. S. P.	lb.	- -	.85 - 88
Potassium carbonate, crude	lb.	.21 - .25	.26 - 28
Potassium chlorate, crystals	lb.	.14 - .16	.21 - -
Potassium hydroxide (caustic potash)	lb.	.28 - .29	.30 - 35
Potassium iodide	lb.	- -	3.35 - 3 60
Potassium nitrate	lb.	.19 - -	.21 - -
Potassium permanganate	lb.	- -	.65 - .95
Potassium prussiate, red	lb.	$0 90 - $1 00	$1.05 - -
Potassium prussiate, yellow	lb.	.32 - .36	.38 - .90 41
Potassium sulphate (powdered)	ton	$225 00 - 240 00	- -
Rochelle salts (see sodium potassium tartrate)		- -	- -
Salammoniac (see ammonium chloride)		- -	- -
Saltpeter (see sodium nitrate)		- -	- -
Salt cake	ton	28 00 -32.00	-
Silver cyanide (nominal)	oz.	- -	1 25 -
Silver nitrate (nominal)	oz.	- -	74 - 76
Soda ash, light	100 lb.	- -	3 50 - 3 60
Soda ash, dense	100 lb.	- -	3 55 - 3 65
Sodium acetate	lb.	.08½ .09	.09½ - .10
Sodium bicarbonate	100 lb.	2 25 - 2 60	2 75 - 3 00
Sodium bichromate	lb.	.39 - .41	.42 - .45
Sodium bisulphate (nitre cake)	ton	7 00 - 7 50	8 00 - 10 00
Sodium bisulphate Powered	lb.	.06 - .06½	.07 - .07
Sodium borate (borax)	lb.	.09 - .10	.10½ - -
Sodium carbonate (sal soda)	100 lb.	1 60 - 1 80	1 80 - 2 00
Sodium chlorate	lb.	- -	.12 - .14
Sodium cyanide, 96-98 per cent	lb.	.24 - .25	.26 - .27
Sodium fluoride	lb.	.18 - -	.19 - .20
Sodium hydroxide (caustic soda)	100 lb.	4 50- 5 50	7.00 - 7 50
Sodium hyposulphite	lb.	- -	.03 - .04
Sodium molybdate	lb.	2.50 - -	3 25½ - -
Sodium nitrate	100 lb.	3 00 - 3 25	3 75 - 4 00
Sodium nitrite	lb.	.22 .24	.24 - .25
Sodium peroxide, powdered	lb.	.32 .35	.35 - .40
Sodium phosphate, dibasic	lb.	.03½ .04½	.04½ - .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 .40	.40 - .41
Sodium prussiate, yellow	lb.	.23 - .2	.30 - .40
Sodium silicate, solution (40 deg.)	lb.	.01½ .02	.02 - .0[illegible]
Sodium silicate, solution (60 deg.)	lb.	.02½- .03	.04 - .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.50 - 1.70	1.75 - 2 00
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.09 - 10	.10½- .11
Sodium sulphite, crystals	lb.	.03½ - -	.04 - .06
Strontium nitrate, crystals	lb.	.23 - 24	.25 - 26
Sulphur chloride	lb.	.05½- -	.06 - -
Sulphur, crude	ton	22.00 - -	- -
Sulphur dioxide, liquid, cylinders	lb.	.09 - -	.10 - .12
Sulphur (sublimed), flour	100 lb.	3.35 - -	3.40 - 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 - -	3 30 - 3.40
Tin bichloride (stannous)	lb.	42½- -	.46 - .50
Tin oxide	lb.	.60 - .63	.65 - -
Zinc carbonate, precipitate	lb.	.16 - 18	.19 - .20
Zinc chloride, gran.	lb.	.13 - -	.13½- .15
Zinc cyanide	lb.	.49 - -	.50 - .60
Zinc dust	lb.	.12¼- .12½	.13 - .15
Zinc oxide, U. S. P.	lb.	.18 - .19	.20 - .21
Zinc sulphate	lb.	.03½- .03¾	.04 - .04½

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1 10 —	$1 25
Alpha naphthol, refined	lb.	1 40 —	1 60
Alpha naphthylamine	lb.	.50 —	.60
Aniline oil, drums extra	lb.	.34 —	.45
Aniline salts	lb.	.46 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1 00
Benzaldehyde (f.f.c.)	lb.	2 00 —	2 10
Benzidine, base	lb.	1.35 —	1 40
Benzidine, sulphate	lb.	1 20 —	1 25
Benzoic acid, U.S.P.	lb.	.90 —	1 10
Benzoate of soda, U.S.P.	lb.	.80 —	1 00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	.50 —	.65
Beta naphthol, sublimed (nominal)	lb.	.70 —	.90
Beta naphthol, tech (nominal)	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2 25 —	2 40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1 10 —	1 20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 —	1 05
Cresylic acid, 50%, first quality, drums	gal.	.65 —	.75
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	1.40 —	1 50
Dimethylaniline (nominal)	lb.	—	1 80
Dinitrobenzol	lb.	.30 —	.37
Dinitrochlorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.40 —	.45
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25% tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.55 —	.65
H-acid (non inad)	lb.	2 25 —	2 50
Metaphenylenediamine	lb.	1 15 —	1 80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1 70 —	1 85
Naphthaline, crushed, in bbls (250 lb.)	lb.	.15 —	-
Naphthaline, flake	lb.	.15 —	.17
Naphthaline, balls	lb.	.16 —	.18
Naphthionic acid, crude	lb.	.75 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitrotoluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3 25 —	4 25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.85 —	1 25
Ortho-nitro-toluol	lb.	.35 —	.40
Ortho-toluidine	lb.	.35 —	.45
Para-amidophenol, base	lb.	2 50 —	3 50
Para-amidophenol, HCl	lb.	2 50 —	3 25
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	1 70 —	1 90
Para-nitro-toluol	lb.	1 15 —	1 [illegible]
Paraphenylenediamine	lb.	2 00 —	3 [illegible]
Paratoluidine	lb.	2 00 —	2 [illegible]
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., in drums (about 240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2 [illegible] —	2 [illegible]
Resorcin, crystal	lb.	4 75 —	4 [illegible]
Resorcin, pure	lb.	6 [illegible] —	6 [illegible]
Salicylic acid, tech., in bbls (110 lb.)	lb.	.50 —	.52
Salicylic acid, U. S. P.	lb.	.55 —	.61
Salol	lb.	.90 —	1 00

Solvent naphtha, water-white, in drums, 100 gal.	gal.	$0.25	—	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36	—	$0.39
Beeswax, refined, light	lb.	.40	—	.41
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1. (nominal)	lb.	.80	—	.88
Carnauba, No. 2, regular (nominal)	lb.	.60	—	.70
Carnauba, No. 3, North Country (nominal)	lb.	.45	—	.46
Japan	lb.	.21	—	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.....	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.09¾
Paraffine waxes, refined, 118-120 m.p.	lb.	.....	—	.11¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.....	—	.13½
Paraffine waxes, refined, 133-135 m.p.	lb.	.14	—	.15
Paraffine waxes, refined, 135-137 m.p.	lb.	.16	—	.16½
Stearic acid, single pressed	lb.	.26	—	.27
Stearic acid, double pressed	lb.	.32	—	.29
Stearic acid, triple pressed	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine taroil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

*Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$16.95	—	$18.75
Rosin E-I	280 lb.	18.75	—	19.00
Rosin K-N	280 lb.	19.00	—	21.00
Rosin W. G.-W. W.	280 lb.	20.50	—	21.50
Wood rosin, bbl.	280 lb.	15.50	—	18.50
Spirits of turpentine	gal.	.....	—	2.50
Wood turpentine, steam dist.	gal.	2.35	—	2.40
Wood turpentine, dest. dist.	gal.	.....	—	2.00
Pine tar pitch, bbl.	200 lb.	8.40	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.92	—	.95
Rosin oil, second run	gal.	.94	—	.97
Rosin oil, third run	gal.	1.00	—	1.05
Rosin oil, fourth run	gal.	1.10	—	1.15

* (See New York market letter)

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½	—	$0.42
Upriver coarse	lb.	.29	—	.32
Upriver caucho ball	lb.	.30½	—	.33
Plantation—First latex crepe	lb.	.44	—	.45
Ribbed smoked sheets	lb.	.44½	—	....
Brown crepe, thin, clean	lb.	.42	—	....
Amber crepe No. 1	lb.	.40½	—	.41½

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0 18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.23
China wood oil, in bbls.	lb.	.24	—	.24½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.18½	—	.19½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.20	—	.21
Corn oil, crude, in bbls.	lb.	.17½	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15¼	—	.16
Cottonseed oil, summer yellow	lb.	.18½	—	.19
Cottonseed oil, winter yellow	lb.	.21	—	.23
Linseed oil, raw, car lots	gal.	1.72	—	.....
Linseed oil, raw, tank cars	gal.	1.67	—	....
Linseed oil, boiled, car lots	gal.	1.75	—	....
Olive oil, commercial	gal.	2.75	—	3.00
Palm, Lagos	lb.	.15½	—	.16½
Palm, bright red	lb.	.14½	—	.17½
Palm, Niger	lb.	.14	—	.17½
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.23
Peanut oil, refined, in bbls.	lb.	.23	—	.26
Rapeseed oil, refined in bbls.	gal.	1.62	—	1.64
Rapeseed oil, blown, in bbls.	gal.	1.68	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14	—	.14½

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.34	—	1.36

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00	—	$40.00
Barytes, off color	ton	20.00	—	25.00
Barytes, crude	ton	10.00	—	12.00
Blanc fixe, dry	lb.	.05½	—	.06½
Blanc fixe, pulp	ton	60.00	—	80.00
Casein	lb.	.15	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50	—	18.00
Fuller's earth, domestic, powdered	ton	25.00	—	30.00
Fuller's earth, imported, powdered	ton	35.00	—	40.00
Graphite, crucible, 85% carbon content	lb.	.....	—	.07½
Graphite, crucible, 86% carbon content	lb.	.....	—	.08
Graphite, crucible, 87% carbon content	lb.	.....	—	.08½
Graphite, crucible, 88% carbon content	lb.	.....	—	.09
Graphite, crucible, 89% carbon content	lb.	.....	—	.09½
Graphite, crucible, 90% carbon content	lb.	.....	—	.10
Graphite, crucible, 91% carbon content	lb.	.....	—	.10½
Graphite, crucible, 92% carbon content	lb.	.....	—	.11
Graphite, crucible, plus 92%	lb.	.....	—	.12½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, orange, fine, nominal	lb.	1.50	—	....
Shellac, orange, superfine	lb.	1.60	—	1.65
Shellac, A. C. garnet	lb.	1.30	—	1.35
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	20.00	—	30.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21	—	.22
Ferro-manganese, 70-80% Mn	gross ton	200.00	—	250.00
Spiegeleisen, 16-20% Mn	gross ton	73.00	—	75.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25	—	2.75
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	200.00
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90	—	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70	—	$0.85
Chrome ore, 48% and over	† unit	....	—	....
Coke, foundry, f.o.b. ovens	net ton	12.00	—	14.00
Coke, furnace, f.o.b. ovens	net ton	11.00	—	12.00
Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00	—	30.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, Mex.	net ton	30.00	—	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00	—	65.00
Manganese ore, 45% Mn and over	unit	.80	—	.95
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96%	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore	lb.	1.00	—	3.00
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.16	—	.17½
Ilmenite, 52% TiO_2	lb.	.02	—	.....
Rutile, 95% TiO_2	lb.	.11	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Nominal †See New York Market Letter

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45@ $4.00
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45@ 4.00
Tees, 3-in. and larger	100 lb.	2.45@ 4.00
Plates	100 lb.	2.65@ 4.00
Rivets, structural, ¾-in. and larger	100 lb.	4.50
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.60
Sheets, No. 28 black	100 lb.	4.35@ 6.50
Sheets, No. 10 blue annealed	100 lb.	3.55@ 6.00
Sheets, No. 28 galvanized	100 lb.	5.70@ 8.50

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage, for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

WESTEND (San Rafael P. O.)—The Westend Mining Co. has awarded the contract for the construction of a borax plant, to John Simpson Co., Grant Bldg., Los Angeles. Estimated cost, $50,000.

Connecticut

BRIDGEPORT—The city voted $550,000 bonds to construct a sewage disposal plant, etc., in the eastern section of the city.

MERIDEN—E. Miller & Co., 99 Center St., is having plans prepared for the construction of a 5-story factory on Center St., for the manufacture of lamps. Estimated cost, $100,000. Orr & Dell Grella, 956 Chapel St., New Haven, archts.

MIDDLETOWN—Wilcox, Crittendon & Co., Inc., 8 South Main St., plans to build a 1-story foundry. Estimated cost, $50,000.

WINDSOR—The Merwin Paper Co., Rainbow St., will build a 2-story, 42x125-ft. factory. Estimated cost, $30,000. Work will be done by day labor.

Delaware

WILMINGTON—A. R. Harrigan, 819 Van Buren St., is in the market for material handling equipment and machines for making concrete drain tile, hollow blocks and concrete bricks.

Illinois

CHICAGO—The Flexible Steel Lacing Co., 522 South Clinton St., has awarded the contract for the construction of a 1- and 2-story, 125x260-ft. factory at 4619 Lexington St., to J. C. Carnegie & Son, 189 West Washington St. Estimated cost, $200,000. Noted Feb. 18.

CHICAGO—The E. F. Kiefer Tanning Co., 416 West Lake St., plans to build a 3-story, 100x200-ft. tannery on Kingsbury St. and Wabansia Ave. Estimated cost, $150,000.

KEWANEE—The city plans to install intercepting sewers, tanks and sprinkling filters. Estimated cost, $250,000. Alvord & Burdick, 8 South Dearborn St., Chicago, archts.

STERLING—The Fort Dearborn Mfg. Co. has awarded the contract for the construction of a 100x120-ft. foundry, here, to H. D. Moreland & Co., 3701 Sheffield Ave., Chicago. Estimated cost, $50,000.

Iowa

COUNCIL BLUFFS—The Bd. Educ. will soon award the contract for the construction of a 2-story, 75x135-ft. school. A chemical laboratory will be installed in same. Estimated cost, $300,000.

GLIDDEN—The Bd. Educ. received bids for the construction of a 3-story, 90x162-ft. school from W. F. Kucharo & Co., 622 Hubbell Bldg., Des Moines, $170,654; the Western Constr. Co., Earlham, $173,000; Garmer & Stiles, 422 Flynn Bldg., Des Moines, $173,989. A chemical laboratory will be installed in same.

HUMESTON—The city will receive bids until May 18 for the construction of a sewage disposal plant, etc. M. G. Hall, engr.

Massachusetts

DANVERS—The School Bd. plans to construct a 3-story high school here. A chemical laboratory will be installed in same. Estimated cost, $350,000.

SPRINGFIELD—H. L. Sprague, archt., 310 Main St., will soon award the contract for the construction of a 1-story, 60x130-ft. manufacturing plant addition, for the Natl. Papeterie Co., Orleans St. Estimated cost, $40,000.

Michigan

MT. CLEMENS—S. S. Kresge Co., Kresge Bldg., Detroit, has awarded the contract for the construction of a 1-story, 120x823-ft. pottery plant, including kiln room, to G. A. Fuller Co., 549 Penobscot Bldg., Detroit.

Minnesota

BUHL—The Bd. Educ. has awarded the contract for the construction of a 2-story, 148x245-ft. addition to the high school, to the Natl. Constr. Co., Virginia, at $208,714. A chemical laboratory will be installed in same.

HERMAN—The Bd. Educ. will soon award the contract for the construction of a 2-story, 94x130-ft. school. A chemical laboratory will be installed in same. Estimated cost, $125,000. A. H. Morken, ch. L. F. Broomhall, 410 Alworth Bldg., Duluth, archt. and engr.

HIBBING—The Bd. Educ. has awarded the contract for the construction of a 3-story, 174x417-ft. addition to the high school on 3rd St., to Jacobson Bros., Columbia Bldg., Duluth, at $549,500. A chemical laboratory will be installed in same.

Missouri

KANSAS CITY—The Sinclair Refining Co., 111 West Washington Ave., Chicago, has awarded the contract for the construction of a 1-story, 14x36-ft. filling station, to the Weimmer Constr. Co., Ry. Exch. Bldg. Estimated cost, $9,000.

New Jersey

CAMDEN—George D. Wetherill & Co., Haddon Ave. and White Horse Pike, has awarded the contract for the construction of varnish kilns, to J. S. Rogers, Drexel Bldg., Philadelphia, Pa. Estimated cost over $10,000.

NEWARK—The United Color & Pigment Co., Evergreen and McClellan Sts., has awarded the contract for the construction of a 1- and 2-story paint factory, to Joseph Jewks & Sons, 676 Montgomery St., Jersey City. The company will be in the market for chemicals to be used in the manufacture of paint.

PLEASANTVILLE—The City Council has awarded the contract for the construction of a screening and pumping station buildings, to Seaman, Letzkus & Smith, at $42,914; for the installation of mechanical equipment, cost, $32,361 and force mains, cost, $21,890, to Simpson & Brown Co., 90 West St., New York City. Noted April 7.

New York

BUFFALO—The Standard Oil Co., Elk and Babcock Sts., has awarded the contract for the construction of several additions to the Atlas Plant here, to John W. Cowper Co., Inc., Fidelity Bldg.

LONG ISLAND CITY—The Elcaya Co., Inc., 148 Madison Ave., New York City, is building a 4-story, 100x100-ft. factory and laboratory on 1st St. and Freeman Ave. Estimated cost, $75,000. J. Baker, 6 Jackson Ave., archt. and engr. Noted May 12.

LONG ISLAND CITY—The Nichols Copper Co. has filed plans for the construction of a 1-story building here. Estimated cost, $20,000.

North Carolina

LEXINGTON—The Bd. Comrs. plans to build a 2-story, 77x209-ft. high school here. A chemical laboratory will be installed in same. Estimated cost, $80,000. J. H. Cowles, supt.

ST. PAUL—The town will receive bids until May 20 for the construction of sewers, including a sewage disposal plant, etc. J. C. Lenthe, mayor.

Ohio

CINCINNATI—The Hercules Rubber Corp., 908 Union Central Bldg., plans to construct a 2- or 3-story, 200x200-ft. factory for the manufacture of auto tires. Estimated cost, $500,000. W. G. Brown, 2301 Union Central Bldg., engr.

CLEVELAND—The city received bid for the construction of a filtration plant at Baldwin, from R. E. Carey Co., West 112th

CLEVELAND—The Gilmore Chemical Co., 9498 St. Catherine Ave., has awarded the contract for the construction of a 1-story, 40x100-ft. factory addition, to the William Dunbar Co., 8261 Cedar Ave. Estimated cost, $25,000.

CLEVELAND—The Interstate Foundry Co., 3161 East 61st St., has awarded the contract for the construction of a 1-story, 80x160-ft. sand and core building, to the A. A. Lane Constr. Co., 1836 Euclid Ave. Estimated cost, $100,000.

LAKEWOOD (Cleveland P. O.)—The Bd. Educ. plans to build a junior high school on Jackson Ave. A chemical laboratory will be installed in same.

MASSILLON—The Massillon China Co., Inc., plans to construct a 1- and 2-story, 100x200-ft. pottery manufacturing plant, along the Baltimore & Ohio R.R. tracks north of West Main St. The plant will consist of 13 kilns, etc. Estimated cost, $200,000.

Pennsylvania

HOLMESBURG (Philadelphia P. O.)—The Robertson Lubricants Co., Bulletin Bldg., has awarded the contract for the construction of a 1-story, 26x60-ft. factory here, to Barclay, White & Co., 1713 Sansom St. The company will be in the market for chemicals which will be used for the manufacture of lubricants. Estimated cost, $10,000.

Texas

DALLAS—The Bd. Educ. will receive bids until May 29 for the construction of a 3-story high school on Haskell and McKinney Sts. A chemical laboratory will be installed in same. Estimated cost, $300,000. C. M. Moore, secy. W. B. Ittner, 911 Locust St., St. Louis, Mo., archt.

TEXARKANA — The Southern Steel Products Co., 520 Spring St., will build a refinery. Estimated cost, $60,000. Work will be done by day labor.

West Virginia

CLARKSBURG—The Phelps Can Co., Lawrence St., Baltimore, plans to build a 1- and 2-story plant on a 4½-acre site here, for the manufacture of cans, to include an 85-ft. main building and 6 adjoining buildings. Estimated cost, $100,000.

Wisconsin

MILWAUKEE—H. A. Poppert, 504 Cedar St., is in the market for brass foundry supplies.

SHEBOYGAN — The Amer. Hide & Leather Co., 1102 Wisconsin Ave., is having preliminary plans prepared for the construction of a 2-story, 50x130-ft. addition to its tannery on Wisconsin Ave. Estimated cost, $50,000. F. Schnellen, mgr. Juul & Smith, Imig Bldg., archts.

Cuba

CIENFUEGOS—The city will receive bids about June 1 for the construction of a mechanical filtration plant to have a 17,000,000-gal. capacity. Estimated cost, $150,000. A. Potter, 50 Church St., New York City, engr.

Ontario

GALT—The Galt Brass Co. will build two 1-story additions to its present plant here. Estimated cost, $50,000.

GUELPH—T. Eaton Co., Ltd., 190 Yonge St., Toronto, plans to build an office building and an addition to its store foundry and factory here. Estimated cost, $115,000. H. McGee, supt. W. A. Mahoney, 73 Quebec W., archt.

LONDON—C. H. Hyman & Co., Richmond St., is building a bark house in connection with its tannery on Richmond St. and will be in the market for leaching equipment. Estimated cost, $50,000. H. A. Meltride, Molsons Bank Bldg., archt.

OTTAWA—The city, c/o Sproule & Lee, archts., 2 College St., Toronto, will soon receive bids for the construction of a hospital to include an X-ray equipment. Estimated cost, $2,500,000.

TORONTO—The Hobbs Mfg. Co., 178 King St., W., has awarded the contract for converting a building into a plate glass factory, to William T. Sparling & Co., 126 Bay St. Estimated cost, $[illegible].

TORONTO—The United [illegible] Co., Ltd., 78 Broadview Ave., has awarded the contract for the construction of a one story factory addition on Broadview Ave., to E. E. Keating, 167 Yonge St. Estimated cost, $[illegible].

SARNIA—The Holmes Fdry. Co. has awarded the contract for the construction of a foundry building, to Wells & Gray, Confederation Life Bldg., Toronto. Estimated cost, $100,000.

SAULT STE. MARIE—The Algoma Steel Corp. has awarded the contract for furnishing finishing mills with hot beds and tables in connection with the $7,000,000 steel plant extension here, to the Morgan Eng. Co., Alliance, O.

Quebec

MESOPOTAMIA—The Shell Transport & Trading Co. plans to construct buildings and tanks and install equipment in connection with the proposed development of the oil fields here.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold a regular meeting June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its semi-annual meeting in Montreal, June 21 and 22; Ottawa, June 23; Shawinigan, June 24 and 25, and La Tuque, June 26.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS will meet in St. Louis May 27 to 29.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18, inclusive.

THE CHEMICAL SOCIETY OF THE COLLEGE OF THE CITY OF NEW YORK announces the following lecture in the Doremus Lecture Theater: Friday, May 14, at 4 p.m., F. A. Epps, chief engineer, the Foamite Firefoam Co. (*Experimental, cinema and lantern.*)

THE INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA plans to hold its annual convention in the Auditorium Theater, Chicago, Ill., May 19, 20 and 21.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15. Chinese delegates have chartered the S. S. Ecuador for transportation to this conference.

THE NEW JERSEY CHEMICAL SOCIETY will hold a regular meeting and ladies' day Saturday afternoon and evening June 5, at Rutgers College, New Brunswick, N. J.

THE SOCIÉTÉ CHIMIE INDUSTRIELLE will hold a meeting at the Chemists' Club, May 14.

THE SOCIETY OF CHEMICAL INDUSTRY, American Section, will hold a meeting, May 21, at the Chemists' Club.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

Industrial Notes

THE CARBORUNDUM CO. of Niagara Falls, N. Y., is to spend approximately half a million dollars in extending and improving its plant at Niagara Falls and its two big furnace plants, one at Niagara Falls, Ont., and the other at Shawinigan Falls, Que. The plan includes a 3-story addition to the paper and cloth plant at Niagara Falls in which are manufactured carborundum paper and cloth, carborundum garnet paper and cloth and aloxite cloth. This addition, which has just been finished, is 432 ft. long and 81 ft. wide and will provide greater facilities for the storing and curing of all paper and cloth products, and for the extension of the rubber-bonded wheel department. Another addition, just completed, will extend one of the wheel-making and kiln departments, the new building being two stories high, 96 ft. long and 64 ft. wide. Both of these new structures are of concrete and are of the most modern type. Other big extensions and improvements have been planned and work will be started immediately. These plans call for additions to the crushing departments and other improvements at the furnace plant at Niagara Falls., Ont., where the abrasive aloxite is made and at Shawinigan Falls, Que., where is located an extensive carborundum furnace plant.

THE LAKEWOOD ENGINEERING CO., Cleveland, Ohio, awarded the first prize of $1,000 for the best treatise on industrial haulage using Lakewood Tier-Lift trucks to Clarence Irving McNair, Jr., of Cloquet, Minn. Mr. McNair, who is secretary of the Northwest Paper Co. of Cloquet, won the prize with a paper entitled "Analysis of the Application of the Tier-Lift Truck to the Pulp and Paper Industry." The treatise indicates the possibilities of considerable savings in the handling of ground wood pulp by Tier-Lift to and from storage either with or without a steam house process. The arrangement suggested by Mr. McNair would effect a reduction of wood pulp losses due to deterioration from the growth of fungi or to disintegration from over-long storage. Second prize was awarded to F. C. Peters, chief mechanical engineer, and G. R. Reese, assistant mechanical engineer, New Jersey Zinc Co., Palmerton, Pa. This treatise, which deals with the handling of zinc oxide in barrels and bags, contains valuable data for the movement of bag or barrel packages. Theodore M. Prudden of the Whitin Machine Works, Whitinsville, Mass., was awarded third prize for an analysis entitled "The Tier-Lift Truck—Its Field of Usefulness." F. L. Usner, with L. V. Estes, Inc., of Chicago, received honorable mention. Mr. Usner's paper, "The Tier-Lift Method Applied to the Paper Industry," is an excellent supplement to Mr. McNair's treatise. It deals with the handling of baled rags and paper-making stock and contains valuable suggestions for the handling of finished rolls of paper. A splendid paper by Frederick L. Fish, industrial engineer with the Fisk Rubber Co., Chicopee Falls, Mass., was also given honorable mention. This treatise, "Application of Tier-Lift Truck to Stores Problem of Handling Materials," while it deals more specifically with the rubber industry, contains valuable suggestions for the general handling of stores. The award committee, consisting of A. Russell Bond of the *Scientific American Monthly*, Prof. Dexter S. Kimball, dean of the School of Engineering, Cornell University, and Irving A. Berndt, vice-president of C. E. Knoeppel, pronounced the standard of papers submitted unusually high and declared that the data received will add materially to present-day knowledge of factory haulage.

THE DRYING SYSTEM, INC., has recently moved its offices and factory to 11-17 South Desplaines St., Chicago, Ill. The increased floor space secured will allow an added production of varnish drying equipment.

THE ROHDE LABORATORY SUPPLY CO. has been incorporated under the laws of New York, and will be located at 17 Madison Ave., New York City, for the export and import of apparatus and instruments for all branches of science, chemicals and reagents.

THE INTERNATIONAL TIME RECORDING CO., of Endicott, N. Y., has established a distributing agency in Memphis, Tenn., with W. M. Richards in charge of the district.

THE WEATHERCROFT CO., of Cleveland, Ohio, has established branch offices in the Randolph Building, Memphis, Tenn. This branch will be in charge of F. H. Ford and will distribute roofing liquid and plastic cement.

THE CHINCA CHEMICAL CO., INC., has recently erected a plant at 344 Poplar Ave., Memphis, Tenn., for the manufacture of extracts, medicines and non-alcoholic beverages.

THE MOLINE-HOOPER CO. has been organized, with headquarters at Memphis, Tenn., to take over the Gale-Hooper Co., effective June 1, 1920. The officials of the new company are also officials of the Moline Plow Co. The new organization will engage in the manufacture of farm implements in general, as well as tractors and automobile trucks.

THE SQUARE D COMPANY, Detroit, Mich., announces that D. H. Colcord has been appointed advertising manager. Prior to this change he served in the capacity of director of research engineering, which position has been taken over by L. W. Strong, formerly of the publicity department of the Westinghouse Air Brake Co.

M. S. ORTH, president and director of Marden, Orth and Hastings Co., has severed his official connection with that company and will devote his time to other interests. Mr. Orth, who is one of the largest stockholders, retains his interests in the company.

THE COMBUSTION ENGINEERING CORPORATION, with offices at 11 Broadway, New York City, announces with regret the resignation of E. P. Moritz, its vice-president, in charge of sales. Mr. Moritz had been ill for some time previous to his resignation and owing to his continued ill health it has been necessary for him to retire from active business for some time. No successor to Mr. Moritz has been named by the company.

Manufacturers' Catalogs

THE CHARLESTON INDUSTRIAL CORP., which is operating the City of Nitro, W. Va., has issued a booklet entitled "Public Utilities, City of Nitro, W. Va." A technical description is given of the various public utilities which have been and are now in constant operation. Descriptions are also given of the boiler plant, power plant, steam and air distribution system and electrical system, fire alarm system, gas distribution system, water system, sewer system, railway system, together with maps and illustrations.

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, announces a new publication, which is catalog No. 259, entitled "Jeffrey Shredders, Type E." Illustrations and descriptions are given of this Type E swing hammer shredder (ball-bearing) which is used for reducing wood chips, bark and other fibrous materials. Particular attention is called to the simplicity of design, provision made for capacity, for durability and accessibility of working parts, and its adaptability to the handling of a variety of materials under different conditions of installation and operation. Illustrations are also given of installations, together with plant layouts, engineering information and other data of service to plant manager and superintendent.

THE UNDER-FEED STOKER CO. OF AMERICA, Detroit, Mich., has just received from the press two catalogs, one on the "Design and Operation of Heating Furnaces," by Nelson G. Phelps, and the other "Industrial Heating Furnaces Equipped With Jones Under-Feed Mechanical Stokers." Many interesting photographs are given of actual installations, together with descriptive matter.

THE GRISCOM-RUSSELL CO., New York City, is distributing a small folder, Leaflet No. 6, which briefly describes all of the apparatus manufactured by this company and which is designed to be a ready reference. Bulletin No. 1,140 illustrates and describes the Stratton steam separator.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, May 19, 1920 *Number* 20

Latest Pronouncement On Damage by Smelter Smoke

FEDERAL Judge T. D. JOHNSON recently handed down an opinion and interlocutory decree which later will be summarized at length in these columns in connection with a brief historical review of the smoke litigation in the Salt Lake Valley, Utah. It may not be amiss, however, now to point out the important findings of the court.

An interesting swing of opinion regarding the real nature of smoke damage may be noted. Thus, the so-called Godfrey decree, which caused the abandonment of more than one smelting plant in that region and the installation of efficient dust-catching devices in the others, accepted the idea that certain plant and animal injury was due largely to compounds of sulphur and arsenic which condensed on particles of soot or other solid matter and settled with them to the ground. In this latest decree, however, the Judge stipulates that the smelters shall so operate that the chimney gases shall be as free as possible of all solid matter "except unconsumed carbon." Evidently this is a recognition of the experimental demonstration that plant injury is caused by breathing dilute SO_2 gas into stomata or breathing pores of the foliage, there to be converted into sulphuric acid by the nascent oxygen and moisture accompanying reduction of CO_2 in these little cells.

On the basis, implied if not expressed, that smoke damage in the vicinity of modernly equipped smelters is due solely to unduly high concentrations of SO_2, the Court finds:

First: That there is no so-called "invisible injury" to vegetation; that plants to be injured by SO_2 must be definitely marked or bleached; and that the sulphur content of plants is not an index of injury due to SO_2.

Second: That there is no injury to screening or wire fences because of the action of such gases as come from the smelters at Midvale and Murray.

Third: That there is no injury to animal life because of the operation of these plants.

Fourth: That there is no injury to health, except that resulting from nervous excitation and fearsome worries of supersensitive inhabitants. As a matter of fact, this mental condition seems to be prevalent among many so-called "smoke farmers." No solution of the smoke problem would be satisfactory to them short of absolute elimination of any smell of smoke. As a matter of fact, the Judge remarks that this condition would probably effectively bar smoke damage upon plants, due to the extreme dispersion then existing; and is a consummation to be hoped for.

It may fairly be said that the Court takes too narrow a view as to the law in this regard. If his idea should be carried to the extreme, that there shall be absolutely no nuisance to any one because of the operation of an industry, then no industry could survive. Even the street cars could not run nor could railways operate because, surely, these utilities annoy some people. The "balancing of inconveniences" has not been taken into account, and if the Court's view were to prevail, then logically a single irritable person might close an industry from which thousands of people gain livelihood.

Dr. P. J. O'GARA, of the American Smelting & Refining Co., may be pardoned if he sets another feather in his cap as a result of this decision, for it is unquestionably his enthusiastic and able smoke investigation which has indicated the safe method of operation for the Murray plant, to mention but one. Both his company and the United States Smelting Co., co-defendants in the present case, have maintained experiment stations, and of their work the Court says: "The research work of these scientific men has been admirable, and it is unfortunate that the plaintiffs and other farmers of the community have not taken more interest in the experimental farms of the defendants and profited by the information acquired in the operation of said farms and the experiments made at these stations."

Twenty years ago we recognized that fume particles would cause damage in territory surrounding smelters, and in the intervening time we have discovered how to eliminate all solids, given the necessary incentive, by dust chamber, baghouse and electrical precipitator. Little progress, however, has been made in abating the sulphur nuisance. One could on occasion build a smelter in a desert region, but straightway transportation and labor troubles cost more than smoke damage. Purchasing easements or title outright to nearby farms is a very expensive and not altogether sure alternative, as more than one manager can attest. Consequently the idea advanced long ago that SO_2 must be dispersed through high central chimneys and properly diluted by air before reaching the growing plants still remains valid, fortunately upheld by precise experimentation undertaken during the past few years.

In fact, this remains the only practicable solution of the smoke problem now known. Various projects for neutralization have been suggested, and the production of elemental sulphur from SO_2 has been thoroughly investigated, but it is unlikely that these methods can be utilized. Sulphuric acid and liquid sulphur dioxide are now manufactured at several smelters, but few of them are situated so that a considerable outside market can be served. An internal market for sulphur as a metallurgical reagent sounds like an attractive possibility, but on sober second thought it is seen to be only a palliative—smelters already have too much of it in their systems and eventually it must be eliminated in some way or other as a non-offensive or useful solid, liquid or gas. That is exactly the problem which always must be met!

Standardization That Will Work

ALMOST commendable step forward is being taken by the Association of Scientific Apparatus Manufacturers through the work of its Committee on Standardization of Apparatus. Apparatus catalogues filled with wonderful pictures and long lists of apparatus of every size and style and shape to suit any need or whim of the user are very impressive. But anyone who has undertaken to purchase from such a book has found it more of a disappointment than a real aid. It is most encouraging therefore to learn that the apparatus manufacturers are rapidly changing their practice so that they intend hereafter to list in their catalogues only the sizes and styles that they actually produce and regularly carry in stock or are on their shelves as purchases from other makers, domestic and foreign.

About one-half of the sizes of porcelain dishes or beakers will amply serve the need of any laboratory. In fact it is the practice of many to order either every alternate or every third size listed. Those who have ordered the even numbered sizes would be just as happy and just as well served with the odd numbers and vice versa. We, therefore, commend the tendency to eliminate some of these sizes that are merely listed, and actually to keep in stock ready for delivery everything that is described in the catalogue.

A standardization by all the manufacturers working together will have many other virtues besides making it possible to carry in stock all the listed equipment. It makes very little difference to the laboratory man whether a 400-c.c. flask is fitted by a number 5 or a number 7 rubber stopper, but he will appreciate it greatly if all makers will produce the same size flask with the same size neck so that when one is broken it may be replaced by another that may have been purchased from a different dealer without the necessity of using a different sized stopper in the apparatus. This interchangeability, though not vital, is of sufficient importance to justify considerable expenditure by the makers of glassware, whether blown or molded, to get together upon a common basis of size and style. Temporarily, the cost will be appreciable, but ultimately the gain to all parties concerned will far offset this temporary financial burden.

It is to be hoped that the Association of Apparatus Manufacturers and the American Chemical Society committees jointly will be able to make rapid progress to the ends which they have in mind. We would urge upon all purchasers of apparatus to extend to these committees their most cordial co-operation and support. Unnecessary difficulties need not be imposed because of individual whim or preference. You may be temporarily inconvenienced by having to change your practice as to size or style of apparatus, but ultimately you will greatly gain by the adoption of general specifications which all manufacturers and all users can strive together to maintain. When some of these ideals of standardization have been achieved, your purchasing problems will be greatly simplified; the bids you receive from different dealers will be comparable and will mean something to you; you can anticipate prompt deliveries of exactly what you order, and the cost of the product will ultimately be reduced because of the greater simplicity and lower expense of doing business upon a rational, practical basis.

Boiler Economy From Distilled Feed-Water

A CASUAL reader might wonder what place in the columns of CHEMICAL & METALLURGICAL ENGINEERING a subject would have so clearly understood to be in the field of mechanical engineering as steam generation and steam plant efficiency. Yet his doubts would be cleared if he remembered that a chemical engineer's problems are largely connected with the application of mechanical engineering to chemical and physical processes, such as the mixing and handling of materials of all sorts, their heating or refrigeration to various temperatures under various pressures, and the evaporation of large quantities of solutions, with or without the recovery of solvents. And by far the larger majority of his heating processes are conducted by means of steam. Yet chemical operations may commonly be observed proceeding with such an utter disregard of steam economy as to remind one of the ancient atmospheric engine which prompted JAMES WATT to invent the condenser.

Evaporating practice, it is true, has been perfected to the point where multiple effect operations are common, yet probably few chemical engineers have been prompted to suggest the same principles and much the same equipment for their boiler plant. Even at that they would only be utilizing a practice long standardized in steamship design.

All these reflections were suggested by hearing a recent address by PERCY H. THOMAS on the Chile Copper Co.'s large steam-electric plant at Tocopilla, Chile. Situated as it is on a desert coast, the amount of fresh water available was so limited that conditions actually were similar to those encountered by shipbuilders, and the same solution was arrived at, namely, running all prime movers in closed circuit with a condensing system, and making up by distilled water any deficiency due to leaks and imperfect condensation. At first blush, distilled water seems to be a rather expensive boiler feed, but actually it presents some important advantages both of convenience and cost.

At Tocopilla the main units are turbo-generators with the last stage under 28.5 to 29 in. vacuum. All the steam auxiliaries, however, work at normal pressure and exhaust into a single low-pressure evaporator shell, which in effect is quite similar to the surface condenser so familiar to power plant engineers. This condensed steam is then returned to the boilers as hot water, and its latent heat produces almost pound for pound the same amount of steam from the salt water surrounding the condenser tubes. Losses here are only those of radiation, which can be insulated to a minimum, and those due to a continuous wastage of a small amount of hot concentrated brine. Vapor from this hot brine is liquefied in turn by the condensate from the main exhaust, and even its latent heat is returned to the boilers. By such means a fresh supply of pure water is always available for a small additional amount of fuel, and the arrangement is such that no great complexity of unusual equipment must be looked after by the power-house employees.

The floating power plants in modern steamships have adopted the surface condenser more from lack of fresh water than from considerations of thermodynamic efficiency. Many land plants favor the jet condenser, usually because certain conditions of cooling water make it undesirable or too expensive to maintain surface condensers, and supply their boilers with a correspond-

ing stream of so-called fresh water, containing a variable amount of gases and solids in suspension and solution. Yet it has been remarked that turbine blades on shipboard were seldom if ever subjected to the destructive erosion so common in stationary plants and ordinarily ascribed to water mist, but really due to minute particles of solid matter. These minor advantages in the engines are of smaller interest to the chemical engineer than the economy in boiler practice which they reflect. Boilers run on distilled water evidently will be comparatively free from incrustations, with a correspondingly efficient heat transfer from the furnace gases to the hot water. Scale-free boilers are safer to operate and last considerably longer, and are capable of quickly assuming a heavy overload with small danger to the equipment.

All these advantages are as real to the boiler house attached to a chemical plant and furnishing steam mostly for evaporative or other heating use as it is for another boiler house generating steam for the hugest engines. Yet the economies are so substantial that a recent power house erected at Buffalo has been equipped for distilled make-up water, even in the neighborhood of such a tremendous reservoir of such excellent water as Lake Erie.

Rise and Fall of The Bessemer Rail

THE statistics of rail production in the United States in 1919, recently presented by the American Iron and Steel Institute, show in even more striking fashion than previous presentations have done the practical elimination of the bessemer rail. Only 214,121 tons of bessemer rails were produced, against 1,893,250 tons of open-hearth, showing a proportion of about nine to one in favor of the open-hearth. Only seven years earlier, in 1912, the proportion had been two to one for open-hearth, while in 1910 the bessemer had predominated, and in 1907 the proportion had been thirteen to one in favor of bessemer.

The nine to one proportion for open-hearth in 1919 was not all the story, however, for the proportion of bessemer in the various weights was as follows:

	Gross Tons, Total	Per Cent Bessemer
100 lb. and over	478,892	2.22
85-99 lb.	965,571	3.11
50-84 lb.	495,577	25.58
Under 50 lb.	263,803	17.72
Total	2,263,843	9.71

The percentages given above are those computed by the Institute, and are of the total output, but 96,422 tons of the total output was in re-rolled rails, so that the proportion of bessemer rails to total of new rails was somewhat larger than indicated. It is clear that the bessemer rail has been eliminated almost entirely for really heavy duty, i.e., for 85-pound rails and heavier.

The supplanting of the bessemer rail appears all the more remarkable when it is recalled that for nearly a quarter of a century the chief use of bessemer steel was for making rails. Captain ROBERT W. HUNT gives the Kelly Pneumatic Process Co. the honor of producing the first bessemer steel made in the United States. It was blown in a 2½-ton vessel at Wyandotte, Michigan, in the fall of 1864, working under American patents which post-dated BESSEMER'S. ALEXANDER L. HOLLEY and his associates were the first to bring the then new process to a commercial success, commencing operation of a 2½-ton vessel at Troy, N. Y., on Feb. 16, 1865, under the Bessemer patents which he had secured some time previous.

The first reported production of bessemer rails was in 1867, 2,277 tons. Ten years later, in 1877, the bessemer rail production, 385,865 tons, exceeded the iron rail production, 296,911 tons. The production of bessemer steel ingots and castings in 1877 was 500,524 tons, so that nearly all the rolling of bessemer steel was into rails. In 1887 there was 2,936,033 tons of bessemer ingots and castings and 2,101,904 tons of bessemer rails, while in 1890 there was 3,688,871 tons of ingots and castings to 1,867,837 tons of rails, but 1890 was the last year in which bessemer rails surpassed all other rolled forms of bessemer steel. The wire nail, a bessemer proposition, came out in 1886 to the extent of an estimated 600,000 kegs, the next year having an estimated production of 1,250,000 kegs. In 1886 it was shown, at the Riverside works at Wheeling, that welded pipe could be made of good quality with bessemer steel. Thus for two decades anyhow bessemer steel reigned supreme as the material one should use if he wanted to make rails. When the full production statistics for 1919 become available a close estimate can be made, but meanwhile the guess may be hazarded that in 1919, while 214,121 tons of bessemer steel rails was produced, about 5,000,000 tons of other finished steel products, bars, pipe, wire, sheets, tin plate, etc., was made of bessemer steel. Even though Mr. HOLLEY was regarded as the foremost apostle of the bessemer process, he once enthusiastically exclaimed: "I expect to live to see the American open-hearth process attend the funeral of the bessemer process!" He died too young, but apparently modern requirements are for better rail steel than can be made in a converter alone.

Only fifty tons of electric steel rails was made in 1919. In 1912 3,455 tons was made and in 1913, 2,436 tons, the two years making a high spot in the statistics for the electric rail. Final results of the experiment are presumably being awaited, but apart from that, it may readily be imagined that there has been neither energy nor money for experiments in the laying of additional electric rails. The matter may be taken up again under more favorable conditions.

Rail exports made a record in 1919 both in quantity, 652,449 tons, and in proportion of total output, approximately 30 per cent. The quantity left for domestic consumption was only 1,551,394 tons, which compares with the record made in 1906, 3,654,794 tons, as in that year there had been 3,977,887 tons production, 4,943 tons imports and 328,036 tons exports. It should not be assumed, however, as has so often been loosely stated, that the railroads were allowed to run down during the period of Government control. Renewals in 1919 were about 1,350,000 tons and in 1918 1,111,638 tons, this comparing with an average of 1,328,316 tons a year in the three years ended June 30, 1917, the period that had been selected as the "test period" in determining the amount of rental the Government should pay the railroad companies. Rail consumption last year was light chiefly because there was practically no new building either of road or of secondary track, and because there was no inordinate wear of rails, as there had been in the first few years of the present century through the introduction of much heavier rolling stock than the light sections then in track were able to carry efficiently.

Readers' Views and Comments

A Study of the Lime-Soda Ash Water Softening Process

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with interest the criticism by W. M. Taylor[1] of the analytical study of Herrle and Gleeson[2], on the lime-soda ash water softening process and find several points with which to take exception. Mr. Taylor's discussion of minimum hardness applies when an insufficient amount of soda ash is used as he recommends, but when a slight excess of it is used, as recommended by the authors, the solubility of the calcium and magnesium carbonates is decreased enormously in accordance with the solubility product law.

As to whether an insufficient or slight excess of soda ash is in accordance with best engineering practice depends absolutely on the way the boilers are run. Large amounts of salts must not be allowed to accumulate in the system, as they cause the vaporization to be irregular, due to variations in concentration set up by localized vaporization and mixing lag, with the result that the very dangerous phenomenon known as priming is effected. The plant engineer who adopts Mr. Taylor's recommendations will have to keep his boilers well blown to prevent scale, or if he prefers to follow the ideas of Messrs. Herrle and Gleeson, he will have to tap off sufficient boiler water to get rid of his salts and prevent priming conditions. Good practice of either method will get results which can be measured in the coal pile.

It is to be regretted that Mr. Taylor criticized Messrs. Herrle and Gleeson so strongly, and assumed that they were "analytical chemists without engineering experience." Furthermore he introduced extraneous matter when he talked about zeolites, which was wholly aside from the subject. CHEMICAL ENGINEER.

Chemical Industry in Sweden

To the Editor of Chemical & Metallurgical Engineering

SIR:—In your journal, vol. 22, No. 10, page 464, in the article "Chemical Industry in Sweden" there is found the following point: "There are a number of works established for the production of chromium salts, but only one of them remains and its future is dependent upon protection, according to the report published in the *Journal* of the Society of Chemical Industry."

The original report was mistaken. Our factory for chrome alum in Hagge, formerly belonging to Sandsta Elektriska Smältverk, carries on its production by a new method, invented by me, and we have no intention to demand protection. Our company not only sells the chrome alum to Swedish tanners, but moreover exports to Norway, Denmark, Finland, Germany and Czechoslovakia.

I would be obliged if you would correct this point in your journal. G. H. HUITMAN.

Director of the A. G. Metalloxider.

Stockholm, Sweden.

[1] CHEM & MET. ENG., vol. 22, No. 12, p. 532.
[2] CHEM. & MET. ENG., vol. 22, No. 6, pp. 269-272.

Conserving Radium as a National Asset

To the Editor of Chemical & Metallurgical Engineering

SIR:—I noticed your interesting editorial of April 7 on "Conserving Radium as a National Asset." I thought you might be interested in a few aspects of the question with which you are doubtless acquainted, but which were not mentioned in your editorial on this subject. It has been estimated at the Harvard Medical School that about 1 g. of radium element would be required for each 1,000,000 of population to treat efficiently the occurrence of cancer. Of the 110 to 120 g. that would be required according to this estimate, perhaps not more than 20 g. is now in the hands of institutions where it is being efficiently used.

The question has been considered by some authorities whether legislation is not justifiable, prohibiting entirely the use of radium for luminous paints. The hardship that might be worked on this industry would not be so great as it might appear on first thought. Mesothorium as a byproduct from the thoria industry is eminently suited for use in luminous materials; has a half-life of about 6⅔ years, corresponding roughly to that of the luminous paints themselves. On the other hand, its very short life compared to that of radium does not render it nearly so suitable for therapeutic purposes. The prospects are that about 4 g. equivalents of mesothorium can be supplied as a byproduct from the thoria industry in the United States annually. This might or might not take care of the total needs of this industry, depending upon its growth, but would be about all that could be expected from this source unless monazite sand were worked primarily for mesothorium, letting thoria become the byproduct. It is doubtful if mesothorium could stand this expense, certainly not for therapeutic purposes.

The general hardship that might be worked by such legislation on radium producers in cutting them off from the market for luminous materials could be justly compensated by an offer of Congress to buy at a fair price all the radium that they could produce. This could then be disposed of by several different plans—either held for sale to hospitals or loaned to them, or, if Congress felt sufficiently generous, presented to them. The total appropriation required to produce radium up to the estimated needs of the country would be about $10,000,000 or $12,000,000—a very small expenditure considering the tremendous importance of the object. The material accumulated would be useful for hundreds of years; a delay in putting some such program into effect might preclude its ultimate possibility at any cost.

You have touched in your editorial on a very large question of public interest and one that I feel ought to be kept constantly in mind. It is improbable that anything effective can ever be done without an active insistence from the medical profession of this country. The signs that such a sentiment is growing within the profession are very encouraging, but its development may be so slow that it will come to a climax too late. That appears to me to be the great danger of the present situation. S. C. LIND.

Golden, Col.

Relationship Between Dendritic Structure and Ferrite Mesh

Fir-Tree Crystals Do Not Influence Directly the Location of Ferrite Shells Either in Ingot Structure or After Drastic Heat Treatments, While the Physical Properties of Normalized Castings Depend Primarily on an Improvement of the Pearlitic Kernels by Gradual Diffusion of Segregates

BY FEDERICO GIOLITTI

WHOEVER is occupied with "normalizing heat treatments"—those reheatings designed to obliterate ingot structure thoroughly and equalize completely any minor segregations of soluble elements—such a one has often had an opportunity to observe anomalous results which are difficult if not impossible to reconcile with the elementary facts plotted in the commonly used equilibrium diagrams. His technical problems are often much too varied and complex to fit into the relatively simple generalizations accepted at present in metallography, depending as they do on the phase changes at different temperatures in the state of solid solution or the state of aggregation of the respective components, modified in turn by the allotropic transformations in the iron. But in addition to this state of affairs, indicating the necessity of seeking data for the completion of metallographical theory, one can readily call to mind many unsolved problems evidently closely connected with theoretical metallurgy and yet closely related to heat-treatment practice.

I have published in collaboration with Dr. P. Forcella in *La Metallurgia Italiana* (vol. 6)[1] a discussion of one of the latter class of phenomena, namely, the relationship between dendritic structure and excess constituent, which was investigated incidentally to a very extensive series of thermal studies. These, it may be said, consisted of analyzing the autographic differential cooling curves of two samples of steel from the same piece, subjected simultaneously to known heat treatments. It may be said that in a great many cases the form of these differential curves (especially for certain types of steel) could not be harmonized with the commonly accepted ideas of diffusion serving as a basis for logical normalizing practice, and in general did not reflect as well as would be imagined the known history of the pieces studied.

A second group of phenomena belonging perhaps to theoretical metallurgy is comprised by facts about the morphological or crystalline character of the metallic phases at various temperatures and after various heat treatments. These will be touched upon in the course of this discussion, from a standpoint already developed by the author in "Crystallography of Alpha and Beta Iron," published in CHEMICAL & METALLURGICAL ENGINEERING, vol. 22, No. 13, p. 585 (March 31, 1920), at which place the relations were discussed which should apparently exist between the structure of the pro-eutectoid ferrite and the forms of the primary austenite crystals.

A material was selected analogous to that studied closely by Tschernoff, and which develops clearly defined dendrites in what is generally considered to be the characteristic shape of freely-growing solid solution crystals. This metal was an acid open-hearth nickel steel of the following composition:

C	0 42	S	0 008
Mn	0 60	P	0 02
Si	0 22	Ni	2 02

The steel itself was cast into 1-ton, square ingots,

[1] These studies were partially published in *La Metallurgia Italiana*, 1913, p. 804: "On the Control of the Preliminary Heat Treatment of Steel in Large Masses," by F. Giolitti and S. Zublena, and more fully analyzed in the present author's book, "Preliminary Heat Treatment of Soft and Medium Steels."

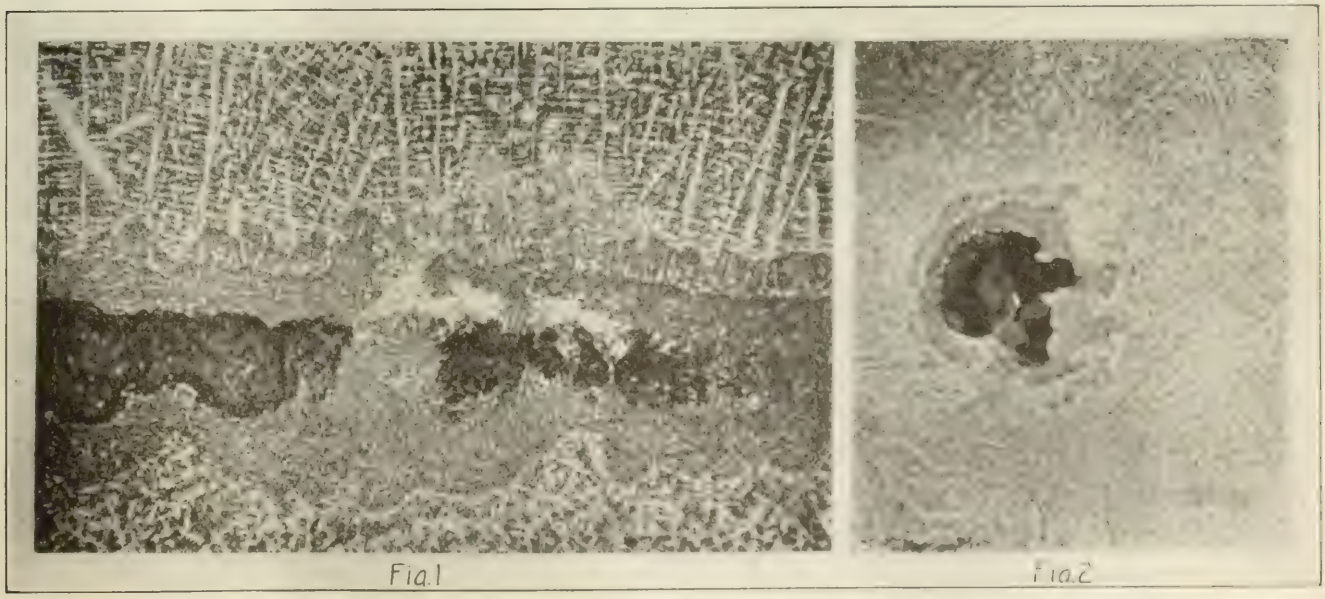


FIG. 1. Section cut along axis of ingot. Cavity extending from left to right represents the pipe, which, of course, was vertical in the original ingot. × 1. Etched 1 hr. with 20 per cent H_2SO_4 at 60 deg. C.

FIG. 2. Cross-section showing structure immediately surrounding axial pipe. × 1. Etched 1 hr. with 20 per cent H_2SO_4 at 60 deg. C.

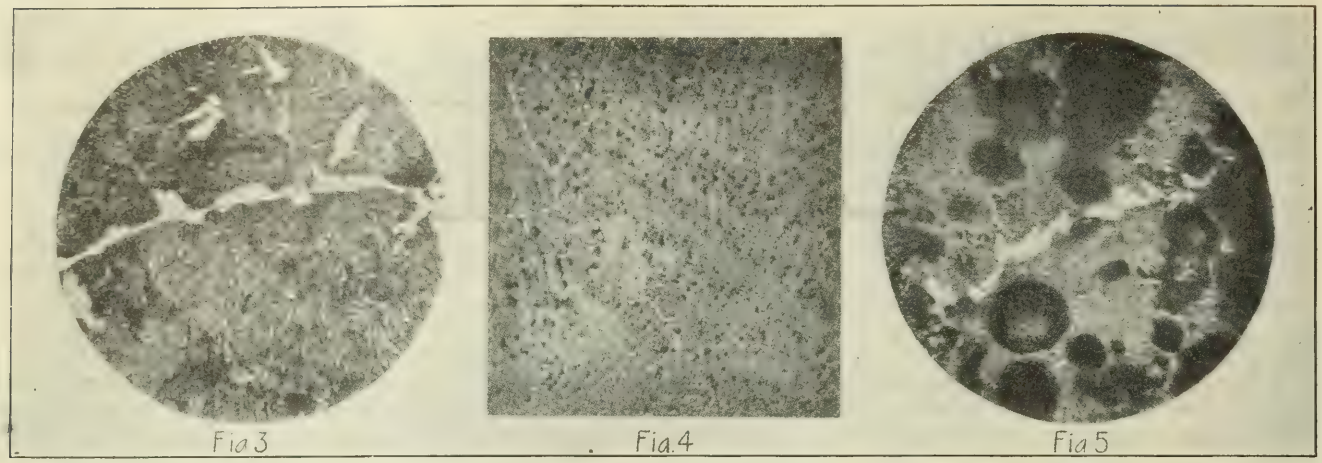


FIG. 3. Free ferrite in ingot, uncontaminated by slag. × 80. Etched in 5 per cent HNO_3 in amyl alcohol.

FIG. 4. Ferrite and dendrite photographed after duplex etching. × 10.

FIG. 5. Part of Fig. 4, magnified 65 diameters.

400 mm. on a side. One of these was cropped somewhat above the bottom of the pipe, and the body of the ingot split along its axis. Figs. 1 and 2 respectively show, at about natural size, the structure surrounding the shrinkage cavity, after etching the polished surface for 1 hr. with 20 per cent sulphuric acid at 60 deg. C. and then slightly polishing the relief with finest emery cloth. Dendritic structure is very clearly exhibited.

Passing over the very interesting change in the metal at the walls of the cavity, the experiments described below will all be made on samples well back into the body of the ingot, and unaffected by any such variation. If such a test piece was highly polished and lightly etched by a 5 per cent nitric acid solution in amyl alcohol, delicate veins of ferrite were seen tracing a network of kernels several millimeters across. The problem now before us is to determine whether there appeared any relationship between form and disposition of dendrites and meshes.

First, it was necessary to show that the ferrite was uncontaminated with slag. I had already determined that granules of slag are sometimes associated with ferrite in certain characteristic forms and positions, which observations I hope to present in detail in a later paper. However, as shown in Fig. 3 (at 80 diameters), the veinlets are free from visible non-metallic inclusions, and consequently their location is independent of flocculated slag, at least.

Duplex Etching

The most evident method of showing how the two structures—that is to say, the free ferrite and the primary dendrites—are disposed each to each was to develop both dendrites and ferrite mesh on the same surface. Since the sulphuric acid attack which develops the fir-tree appearances is the more drastic, it must be used first. Then in order to present a reasonably flat surface for photography after the subsequent nitric attack to develop ferrite, the pitted surface must be repolished, but not heavily enough to plane the surface to the bottom of the depressions defining the primary structure.

After such manipulation, the appearance of a sample at 10 magnifications was photographed as shown in Fig. 4. Examination at once indicates that the veins of mesh-like ferrite do not correspond in any way to elements of the primary crystallization. Thus, one of the larger dendritic aggregations falls entirely in the interior of a large cell in the center of the illustration, so that no vein of ferrite develops on its branches. Only in some cases, as at the bottom of the view, do the veins appear to follow axes of crystalline branches, whereas in many other parts—toward the left and center—the ferrite has a course entirely independent of dendrite branches, cutting them often nearly at right angles, and crossing several cavities en route from branch to branch. This independence of the deeply-dug relief is strikingly shown in Fig. 5, representing a central portion of Fig. 4 magnified to 65 diameters.

This method of etching is open to the objection that a great quantity of free ferrite could exist, ranged along the bottom of the etching pits, and never be developed or seen by the nitric-acid etching. So in order to avoid such a contingency, I utilized the method of making successive photographs of one area. In this procedure, an exposure was first made of a polished surface etched with the nitric-amylic solution, so as to exhibit the ferrite system in its entirety, and a second photograph taken of the same surface after deep etching with hot sulphuric acid, developing the dendritic structure exclusively. Extreme care was used to make the negatives at exactly the same

FIG. 6. Ferrite mesh. Etched in amylic solution of HNO_3. × 3.

FIG. 7. Dendritic structure underlying Fig. 6. Etched in hot H_2SO_4. × 3

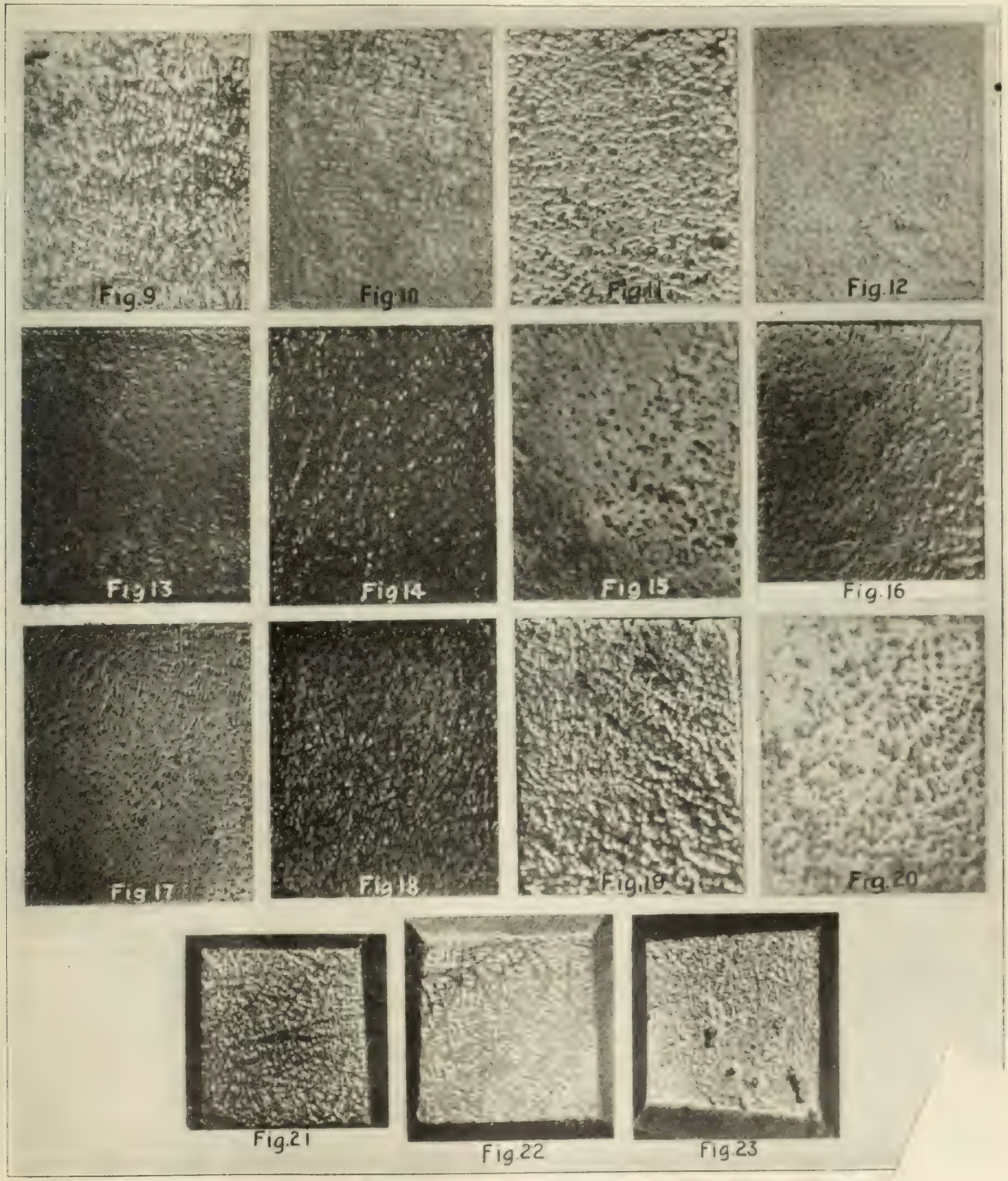
FIG. 8. Negatives of Figs. 6 and 7 superposed in printing frame.

magnification, and of exactly the same field. Then the two negatives were properly superposed in a printing frame, correctly oriented by the use of suitable reference marks, and a single positive made.

Since the glass plates have a considerable thickness, one of the developed films cannot be in close contact with the sensitized paper, and its print will necessarily be somewhat blurred. However, if this one is the negative showing the dendritic system, its print will not suffer, because by its nature it consists of ill-defined elements at best. Consequently a greater deficiency in sharpness of contour does not affect its utility for determining the structural relations we are studying.

In this manner several samples of the ingot were etched and photographed, giving prints similar to those reproduced in Figs. 6, 7 and 8. Fig. 6 shows a surface etched with nitric-amylic solution, Fig. 7 the same area after etching in hot sulphuric, and Fig. 8 is printed from the superimposed negatives.

A study of these and other prints made in the same



FIGS. 9 TO 23. DENDRITIC STRUCTURE DEVELOPED BY DEEP H_2SO_4 ETCHING IN SPECIMENS 1 TO 15
Figs. 9 to 20—Magnified 10 diameters. Figs. 21 to 23—Magnified 3 diameters.

way merely confirms with certainty the observations deduced from Fig. 4, namely, that if in some regions the veins of ferrite appear to accompany the depressed areas separating principal branches (as at the bottom of the figure), there is a much larger number of cases where the veins do not accompany dark depressions, in fact have a course entirely independent of the axes or edges of the limbs. In some of the photographic exposures veinlets of ferrite were occasionally found passing down the ribs of dendrites, but in other prints or even in the same plate, other veinlets favored the depressions between branches. Other ingots of similar steels gave results in every way concordant with these.

For the ingot steels examined, therefore, it seems to be proved that there exists no rigid or constant relation between the reciprocal positions of dendritic elements and ferrite meshwork. Such a fact, if broadly confirmed, would be of greatest importance to metallographers and metallurgists, since the secondary crystallization (i.e., of ferrite or cementite from austenite) is usually regarded as being intimately affected by the system of dendrites, and the position of the ferrite meshwork determined by the difference in carbon concentration, axis to periphery, of the primary austenite. Ziegler[2] and Oberhoffer[3] have indeed advanced the view that accumulations of slag particles have a preponderating effect on the orientation of ferrite mesh; but even this view depends upon the fact that the primary crystallization process determines the location of any segregations of impurities.

Impotence of Single Anneals

To extend the observations it appeared natural to study the variation in relations, ferrite to dendrite, which may be produced by such heat treatments as are known definitely to break up the original ferrite in ingot structure. Such a study might perhaps throw light on the origin of the two crystalline systems, primary and secondary, and by correlating the thermal studies with a careful series of mechanical tests, interesting conclusions might be drawn concerning the specific influence of each structure on the strength, ductility, toughness, fracture and other important physical properties.

Therefore a series of prismatic test pieces about 35 x 35 x 200 mm. in dimension were cut from the ingot first described. Various reheatings were conducted in a small tube furnace, heated electrically by platinum resistance ribbon. A cold specimen was placed in the cold furnace, and current switched on sufficient in amperage to bring the temperature up to the desired point in about 1.5 hr. After remaining at the given heat for the desired time, the sample was either cooled slowly in the furnace (6 hr. to 200 deg. C.) or more rapidly in a wire basket in air. The last three coupons (13, 14 and 15) were given drastic single, double and triple heat treatments, considered in practice most efficacious to transform profoundly the crystalline structure of unworked ingot steel. Table I gives the details. The Brinell number was taken on a machined surface at least 5 mm. below that exposed during heat treatment, so as to avoid any softening due to decarbonization.

The same machined surfaces were then polished and double etched, with a light intermediate polishing, exactly like the procedure described for Fig. 4. Figs. 9 to 20 inclusive show the surfaces of specimens Nos. 1 to 12 inclusive after the deep etching by hot sulphuric acid, and Figs. 24 to 35 their microstructure after a subsequent etching for free ferrite.

As is seen by Figs. 9 to 20 of the etching pits, none of these single heatings, followed by leisurely coolings, has suppressed or sensibly subdivided the dendritic structure, an observation of great interest. Neither has the ferrite meshwork in the samples heated to 700 deg. been destroyed (Figs. 24 to 27), nor has their orientation been changed in any way to one more regularly ordered with the etching pits. This was to be expected, however, since a differential heating and cooling curve taken with Le Chatelier-Saladin apparatus, depicted in Fig. 39, shows that the first transformation point on heating is above 700 deg. C.

Redeposition of Ferrite on Annealing

On the other hand, beginning with the fifth sample (Fig. 28) the heat treatment has caused the carbide in the pearlite kernels to go into solid solution in β or γ iron, and as the temperature increases the ferrite meshes also are absorbed by this austenite. Then on cooling excess ferrite is precipitated into a new meshwork, whose aggregation depends upon the velocity of cooling and, according to many investigators, upon the system of primary crystals. That the size of secondary ferrite mesh is dependent upon velocity of cooling is confirmed by a comparison of Fig. 28 with 29, Fig. 30 with 31, Fig. 32 with 33, and Fig. 34 with 35, each pair of which were reheated in an identical manner, but the even numbered micrographs containing larger pearlite kernels and coarser ferrite shells were cooled much more slowly.

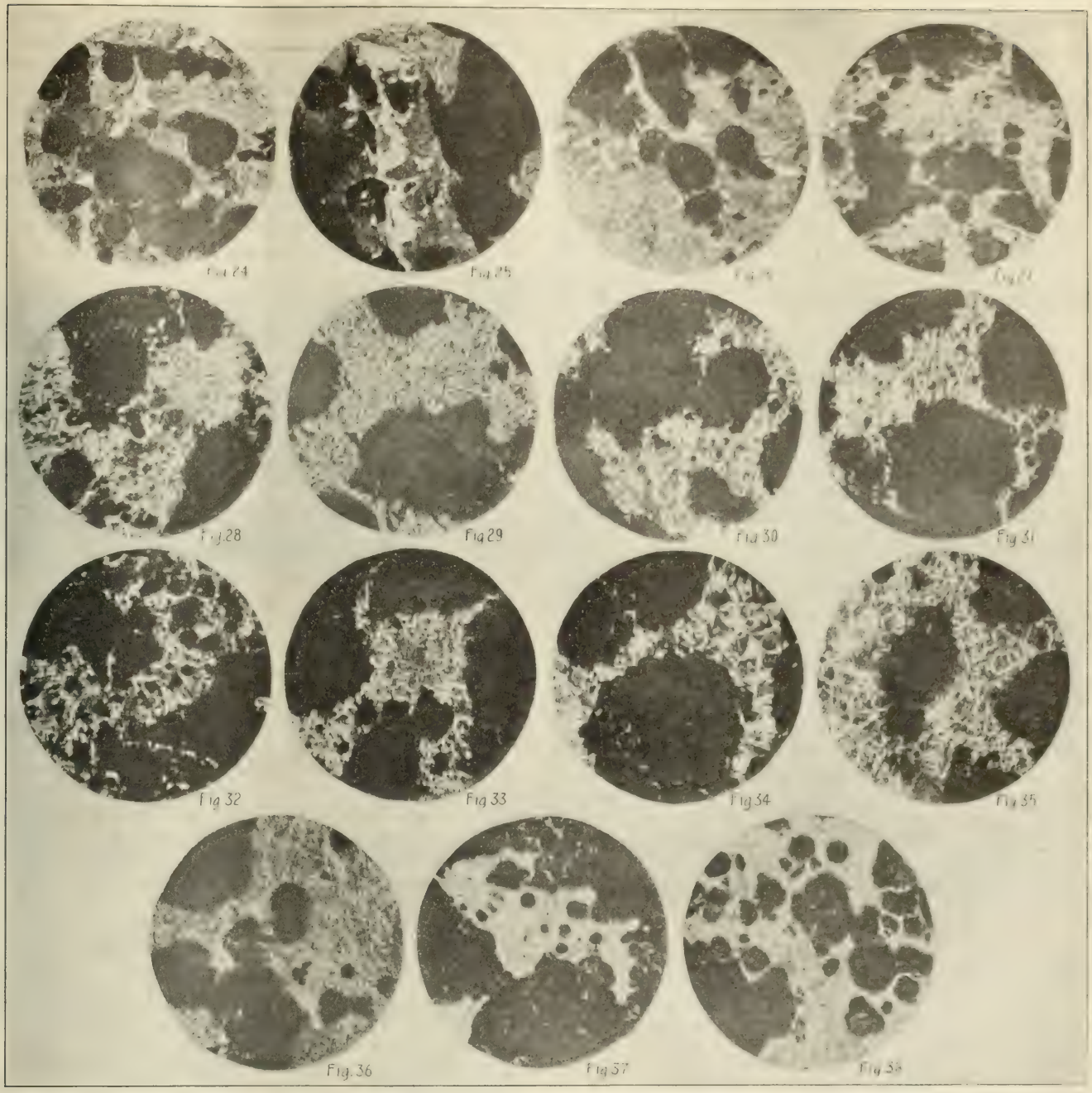
In nickel steels such as the one under examination a very coarse ferrite mesh is especially easily transformed into a very fine network, even by a single reheating followed by a normal cooling.

These well-known facts are mentioned only to call attention to the deduction which can be made from the same micrographs that the dimensions of the elements forming the ferrite mesh depend upon the time and temperature of the precedent heating, as well as upon the velocity of cooling. Comparing micrographs of pairs of samples whose history varies only as to the time at a high heat, it is seen that the ferrite crystals are larger in proportion as the temperature is high and the sustained time is long (Fig. 34). But if we hold with many authorities that this gradual and regular increase in ferrite meshwork is a consequence of a similar increase in the dimensions of the primary crystal constituents in the steel, a corresponding indication should appear in the microstructure of this series of specimens. Examination of the twelve photographs, Figs. 9 to 20 inclusive, shows no indication of such growth in the dendrites developed by hot sulphuric attack.

Unquestionably these two systems of crystals, dendrites and mesh, are morphologically independent during simple reheatings to 900 deg. C. Therefore if ferrite mesh is dependent upon a system of primary crystals, the primary crystals in nickel steels in turn must be independent of the dendrites developed by deep etching. Studies made by superposing photographs as described for Fig. 8 dimly suggest that if there is any such hypothetical interrelation between primary crystals (that is, those which first separate from the cooling liquid) and the fir-tree structure appearing after hot sulphuric acid

[2] "Sur la crystallisation du fer alpha," *Revue de Métallurgie*, 1911, vol. 8, p. 664.

[3] *Z. anorg. Chem.*, vol. 81, p. 156.



FIGS. 24 TO 38. FREE FERRITE CRYSTALS DEVELOPED BY ETCHING SPECIMENS 1 TO 15 RESPECTIVELY IN 5 PER CENT HNO_3 IN AMYL ALCOHOL. × 10

attack, it is at most an "agglomeration" effect, where the different branches of the dendrites may be built up by the union of a large number of minute primary crystals, yet each system seems to be independent of changes and transformations in the other. Such conclusions, if substantiated generally, would modify profoundly the commonly accepted hypotheses connecting segregation of impurities and alloying elements with the mechanism of crystallization during solidification.

Destruction of Dendritic Structure

In order to link up these crystallographic studies with the corresponding mechanical properties, it seemed well to produce if possible a sample void of dendritic structure for use as a basis of comparison. Consequently samples 13, 14 and 15 (Table I) were prepared and photographed. As seen in Figs. 21, 22 and 23, even after the single and double quenching, samples 13 and 14 still possess a dendritic system practically as well defined as any of the others. Only in sample 15, subjected to a triple quench after prolonged heating at very high temperatures, was deep etching unable to develop fir-tree markings.

As could be predicted, the microstructure of these latter specimens (Figs. 36, 37 and 38) does not exhibit any ferrite meshwork at moderate magnifications. Instead, tempering at a heat below the transformation range produces a conglomerate from the solid solution, equalized in carbon content at least by the long sojourn in the austenitic range preceding a drastic quenching.

These simple observations permit one to extend the conclusions already reached in an important direction, and that is that normalizing heat treatments based on diffusing the excess constituent and then preventing its re-segregation by rapid cooling past the critical range are enormously less potent on the dendrite system than

TABLE I.

Specimen No.	Heat Treatment: Heating	Heat Treatment: Cooling	Heat Treatment: Annealing	Brinell Hardness	Macrostructure, Fig.	Microstructure, Fig.
1	1 hr. at 700°	Furnace		179	9	28
2	1 hr. at 700°	Air		179	10	29
3	2 hrs. at 700°	Furnace		179	11	30
4	2 hrs. at 700°	Air		183	12	31
5	1 hr. at 800°	Furnace		179	13	32
6	1 hr. at 800°	Air		179	14	33
7	2 hrs. at 800°	Furnace		179	15	34
8	2 hrs. at 800°	Air		183	16	35
9	1 hr. at 900°	Furnace		183	17	36
10	1 hr. at 900°	Air		183	18	37
11	2 hrs. at 900°	Furnace		179	19	38
12	2 hrs. at 900°	Air		192	20	39
13	11 hrs. at 1,090°	2 hrs. to 800°. Then quenched in water	2 hrs. at 580°	217	21	44
14	9 hrs. at 1,000° 9 hrs. at 1,050°	1 hr., 45 min. to 800° C. Then quenched in water 2 hrs. to 800° C. Then quenched in water	2 hrs. at 580°	179	22	45
15	10 hrs. at 1,190° 11 hrs. at 1,160° 10 hrs. at 1,090°	2 hrs., 25 min. to 800° C. Then quenched in water. 2 hrs. to 800° C. Then quenched in water. 2 hrs. to 800° C. Then quenched in water	2 hrs. at 580°	196	23	46

on the ferrite network, or the crystalline organization which determines its form. Other experiments seem to indicate that one can obtain sensible modifications in form of the dendrites or fir-trees with simple heat treatments, but it is certain that extremely prolonged "heating for diffusion" is necessary to smooth out effectively the local segregations responsible for etching pits ranged along geometric branches.

Mechanical Tests

Returning to the mechanical tests, small Frémont bars shaped like a countersunk rivet (Fig. 41) were cut from each of the fifteen heat-treated specimens. The

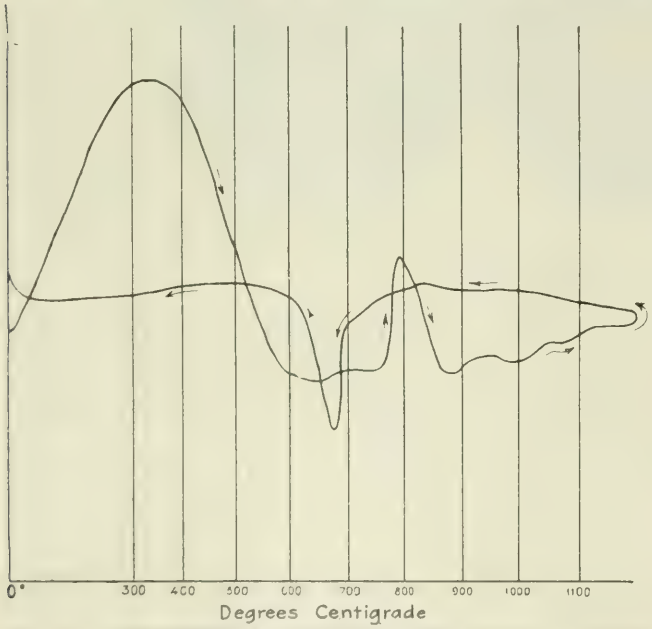


FIG. 39. DIFFERENTIAL HEATING AND COOLING CURVE FOR STEEL UNDER INVESTIGATION

cylindrical part of this little coupon in which rupture will occur is 10 mm. long x 8.2 mm. in diameter. Table II gives the results of the tension tests, and also contains remarks as to the nature of the fracture. Bending tests were also made on the first six specimens, using bars 10 mm. square x 60 mm. long, as listed in Table III. Shock tests in the Frémont impact machine are tabulated in Table IV, using samples 8 x 10 x 80 mm. in dimension, notched on the 8-mm. surface with a semi-cylindrical cut, and the appearance of the fractures given in Fig. 40.

Examination of the test results shows a rough correspondence in certain features to the heat treatments. The latter proceeded from simple to complex by a series of steps, and parallel steps may be discerned in the

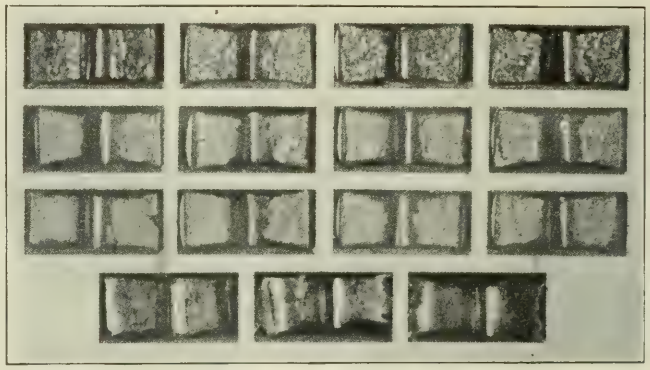


FIG. 40. FRACTURES OBTAINED UNDER IMPACT TEST

structural and mechanical properties. Thus, the dendrite system passes from samples where the heat treatments leave it entirely unaltered to that which produces the most profound transformation possible in practice. Also the character of the fracture, which is always held to be of utmost importance, shows in all three sets of mechanical tests a series of steps from coarsely crystalline or granular to the finest fibrous or silky break. It should therefore be possible to trace some apparent relations between heat treatments, structural constituents and mechanical properties in the unworked nickel steel under study.

Cause of Crystalline Fracture

So-called granules or coarse crystals in the fracture are certainly not essentially due to the development of the fir-tree crystals, but rather are connected very closely with the state of the ferrite meshwork. This is proved by comparing the micrographs, Figs. 9 to 38, with the tabular columns describing the kind of fracture and their appearance as shown in Fig. 40. For gradual stresses (tension), fibrous fractures first appear in sample 5, whose ferrite had hardly been absorbed and the ingot structure therefore but poorly obliterated. From this point on the tension fracture is about the same except for very small variations, until the last three are reached. Normalizing by quenching and tempering produces materially finer fibers in specimens broken under tension.

In the impact test, Table IV and Fig. 40, granular breaks appear in all samples merely reheated, becoming finer as the reheating is the more elevated. Multiple heat treatments (samples 13, 14 and 15) are again able to refine the fracture into a fibrous appearance. However, examination of the micrographs, Figs. 24 to 38, does not show a pronounced variation by steps to correspond to the very pronounced graduations in fracture under impact. For example, sample 6, Fig. 29, has a much finer meshwork than that of sample 11, Fig. 34, yet under impact sample 6 has a fracture fairly de-

scribed as crystalline, and sample 11 as fine crystalline. Apparently, then, in addition to the general effect which ferrite meshwork exerts upon grain size as revealed in fracture, a second unknown influence must be superposed, even though of lesser importance. It seems that this second influence cannot be that of the fir-tree crystals revealed by H_2SO_4 etching, since Figs. 9 to 23 show that the dendritic system remains substantially unmodified. It is not so certain, however, that the various heat treatments, through which the dendrites retain their form and size sensibly unchanged, have not materially changed the absolute concentration of the various elements or compounds (other than cementite) in solid solution with the iron, without dispersing effectively the last parts of the segregations arranged

TABLE II. TENSION TESTS

No. of Specimen	Diameter at Neck, Mm.	Per Cent Contraction	Elongation in Mm. at First Point of Inflection in the Stress-Strain Curve	Breaking Load (Kg.)	Maximum Strain on Initial Cross-section (Kg.)	Maximum Elongation Before Rupture (Mm.)	Kind of Fracture	Remarks
1	8.15	1.33	2.00	3,720	70.45	2.20	Coarsely crystalline	Stretched throughout
2	7.75	10.70	0.75	3,720	70.45	2.80		
3	7.85	8.35	0.75	3,845	72.84	2.75		
4	8.00	4.83	0.95	3,553	67.29	1.75		
5	6.60	35.20	0.25	3,678	69.66	4.00	Fibrous	Necked
6	7.20	22.93	0.25	3,845	72.84	3.05		
7	7.00	27.14	0.25	4,014	76.00	3.90		
8	6.60	35.20	0.25	4,180	79.16	3.80		
9	7.05	26.16	0.40	3,845	72.84	3.25		
10	7.05	26.16	0.35	4,180	79.16	3.45		
11	6.90	29.21	0.40	3,762	71.23	3.55		
12	7.15	23.98	0.40	3,971	75.20	3.05		
13	5.90	48.23	0.40	3,556	67.35	4.75	Fine fibrous	Necked
14	5.85	49.10	0.40	3,853	72.95	4.60		
15	5.85	49.10	0.50	3,512	66.50	4.10	Medium fibrous	Necked

in semi-geometric pattern which are responsible for the appearance of fir-trees on deep etching. Such partial diffusion obviously would not change the arrangement of the etching pits, and any resulting change in speed of acid attack would be difficult to measure.

More Than One Crystalline System Influences Physical Properties

Further analysis of the mechanical tests yields interesting confirmation of the hypothesis that two distinct systems are superposed in effecting variations in physical properties. For instance, in the tension tests—Table II—the ultimate strength wanders somewhat vaguely between extreme values of 66.5 and 79.16 kg. per sq.mm. with no reference whatever to variations in heat treatments. Brinell hardness as reported in Table I also shows similar unconformity.

On the other hand, the first four samples possessing the original ingot structure act precisely as would be expected from a conglomerate of two different elements of considerable size, yet with one, the ferrite mesh, predominating in influence. Thus, only these four samples were stretched throughout their entire length, "necking" but little at the break, and exhibiting a mottled surface appearance due to so-called "lines of Lüders." The small contractions of area are a natural consequence of this condition. Samples 5 to 12, reheated above the critical range, have other properties varying independently of the condition of the free ferrite. Thus the contractions do not vary over a great

TABLE III. FLEXURE TESTS

No. of Specimen	Maximum Load, Kg.	Deformation at Maximum Load, Mm.	Kind of Fracture	Remarks
1	2,887	2.80	Crystalline	Strained throughout
2	3,174	3.00	Crystalline	Strained throughout
3	3,174	4.55	Crystalline	Deformed only near fracture
4	2,927	4.70	Crystalline	Deformed only near fracture
5	3,160	6.20	Fibrous	Deformation well localized
6	3,512	7.75	Fibrous	Deformation well localized

range, but No. 9, with a much coarser network than No. 6, has a larger contraction, as is even more markedly the case when comparing No. 11 with No. 7. On the other hand, the last three samples, containing no ferrite microcrysts, have the largest contraction.

Fracture in Tension Follows Ingot-Ferrite

In order to determine if possible the exact influence which the fine ferrite meshwork existing in the original ingot structure has upon the course of fracture under tension, a flat specimen of the shape recommended by Frémont and illustrated in Fig. 4 was cut and polished on both sides. This sample not only permitted easy photography, but would exhibit in one specimen the strain-effects varying from moderate forces to those producing rupture. In order to examine simultaneously the lines of Lüders (or deformation figures) and the ferrite network, a longitudinal strip was etched down the axis of the test piece by directing a small rivulet of amylic-nitric reagent across the polished surface, with a result pictured in Fig. 41. Elements of the large ferrite network are thus dimly developed.

After breaking, the piece was again photographed as shown in Fig. 42. If this illustration be examined attentively, paying particular attention to the prolongation of the ferrite veins from the areas where they are developed by acid attack through the areas where they are developed by intense strain, the following facts are apparent:

First, the surface along which total rupture took place, even if the slip was only momentary, corresponds entirely to elements of the large ferrite mesh.

Second, elements of network do not seem to be related

TABLE IV. IMPACT TESTS

No. of Specimen	Total Energy Absorbed Kg.-M.	Kind of Fracture (Fig. 40)
1	12	Coarsely crystalline
2	18	
3	20	
4	20	
5	12	Crystalline
6	12	
7	13	
8	13	
9	31	Fine crystalline
10	32	
11	30	
12	30	
13	32	Short fibers
14	32	Fine long fibers
15	32	

to the lines of Lüders. This is especially evident where the surface of the sample begins to enlarge. Here several ferrite veins appear as a direct prolongation of those developed by acid attack, traversing in many places well developed strain figures, which latter are in fact very much smaller in dimension than the kernels enclosed by ferrite shells.

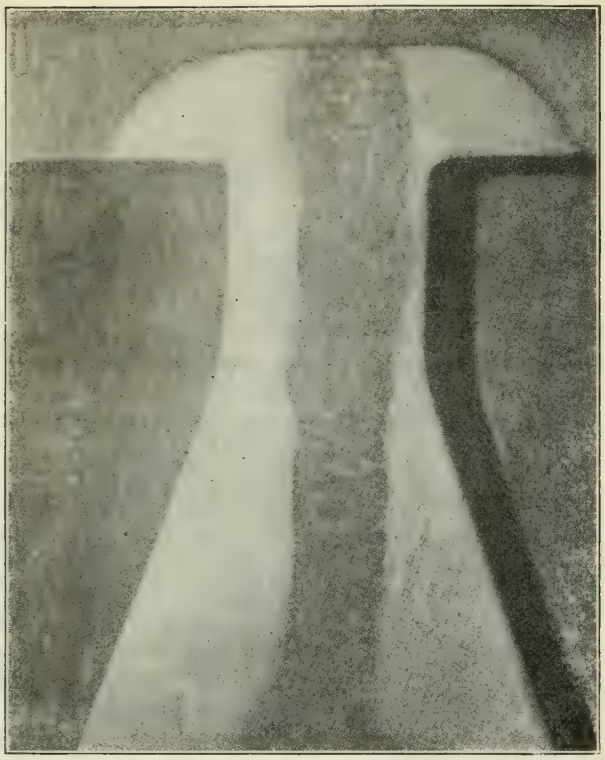


FIG. 41. FLAT TEST BAR, ETCHED PARTIALLY WITH AMYLIC-NITRIC REAGENT

This experiment makes it very clear that the elements of the large ferrite meshwork existing in ingots constitute the surface of lesser resistance along which rupture upon slow stressing takes place considerably before failure at joints of the finer-grained structural system responsible for the deformation figures.

Effect of Reprecipitated Ferrite

Elongations observed at the yield point give a very clear confirmation that in addition to free ferrite a second system of crystallization is increasingly potent in its effect on physical properties. Very large stretches are shown in the first four samples having ingot structure, but the values fall to a minimum immediately the reheating passes the critical range. From this point on, the elongation at yield point increases as the normalizing treatments become more extended, suffering a sudden increase with sample 9, the first having a reheating at 900 deg., but, as before, the values do not seem to have much connection to the amount or disposition of the free ferrite shown in the micrographs. Finally, analogous observations may be made when analyzing the total elongation at rupture. These values, small for the first four samples, increase considerably for the next eight pieces, and still more for the last three, multiple-treated, in fact appearing to be roughly inverse to the size of ferrite mesh.

When testing for static flexure (Table III), the total rupture load does not vary greatly, while the corresponding maximum deformation increases greatly as the heat treatments become more efficacious in eliminating ferrite meshwork. In this case as well, ingot structure is accompanied at failure by mottled surface and non-localized deformation.

Testing under impact brings out the same partial independence of ferrite system. From sample 5 onward there is an undoubted increase in toughness with extended thermal treatment. Beginning with No. 9 (annealed at 900 deg.) there is an especially great resistance to shock, without there being any notable variation in the condition of the free ferrite over that of the four preceding, while from No. 9 on the toughness remains about stationary, even though samples 13, 14 and 15 have extremely fine ferrite. This condition is analogous to that holding for the values of elongation at the elastic limit, an important observation suggesting more than a coincidence and indicating an intimate connection between these two properties. However, it should be remembered that under shock testing the action of a continuous ductile ferrite cement such as exists in the ingot under observation may well be profoundly different than when working under slowly applied loads. Impact may, in fact, cause failure in the kernels rather than failure in the shells.

Conclusions

Such observations establish the following points and define somewhat better the specific function of the ferrite network, previously noted only in general manner as being independent of that of the other co-existing structural systems.

First, in the 2 per cent nickel steel examined, the position and form of ferrite elements is entirely independent of the position and state of the elements of the dendrite system, both when existing totally or partially in the large meshes characteristic of ingot structure, and when the latter is wholly altered.

Second, the elastic behavior of the steel with its original ferrite meshwork is quite unique. The pure iron constitutes a *continuous* plastic system, much more

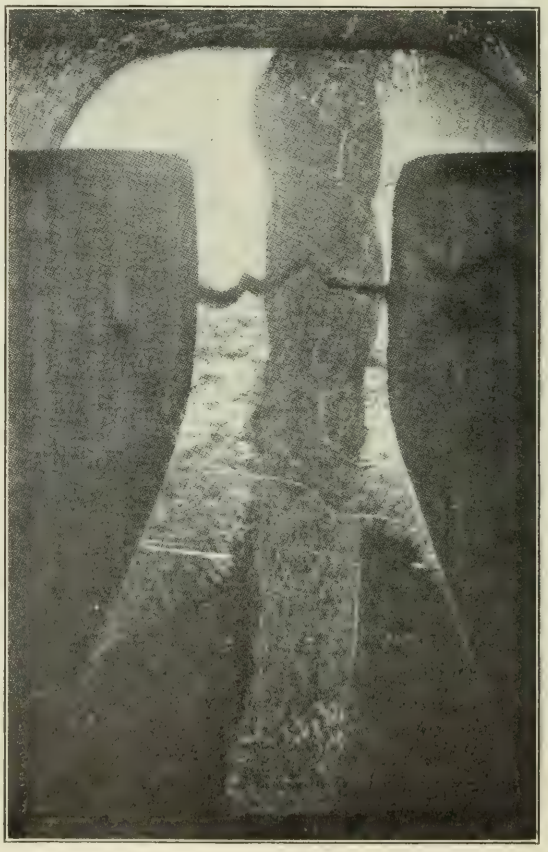


FIG. 42. SAME BAR AFTER FAILURE IN TENSION, SHOWING LÜDERS LINES IN KERNELS AND SLIPPAGE ALONG THE FERRITE SHELLS

easily deformed under gradual stress than the elements of the other structural systems superposed upon it. Under load the total resistance of such ingot metal is determined primarily by the strength of the meshwork, and the elastic properties of such ingot metal conform to those of metals containing a continuous plastic cement binding together kernels of greater toughness and ductility.

Third, once the ferrite meshes have been absorbed in austenite on reheating, it reprecipitates in discrete particles (as has been shown in my previous paper)[4] corresponding more nearly to its own crystalline habit, and simulating a meshwork but in reality remaining essentially discontinuous. In this case the fine and compact elements of the superposed system are more or less continuous. Hence the now isolated ferrite crystallites no longer carry the totality of stress nor exercise a major influence by virtue of their plastic nature, a fact immediately reflected in the physical tests the moment the steel has been annealed above the transformation range. Appearance of fracture, ductility, and toughness immediately show a sharp discontinuity, and thereafter vary with the degree of "normalizing heat treatment" rather than the amount of free ferrite or its state of aggregation.

Proper Heat Treatment Makes Cast Nickel Steel Equal to Best Forgings

Fourth, once these large ferrite shells are destroyed, even heat treatments which allow considerable accumulation of crystalline ferrite in roughly arranged meshwork do not produce corresponding variation in the fracture or other physical properties developed in tension, bending or impact, an indication that they have not yet become truly continuous. Unexceptionably ductile, strong and tough steel with a fine fibrous fracture is obtained from unworked metal only by drastic multiple heat treatments, a conclusion evidently of the highest practical importance in the making of shock-resistant castings of this alloy, and substantiated in everyday manufacture of such important pieces as elements of gun mountings. Many illustrations of physical tests of such pieces are given in the author's book mentioned at the outset of this article.

Fifth, the fracture, ductility and toughness vary consistently with variation in heat treatment, when samples free of ingot structure ferrite are considered. These physical properties do not vary consistently with the microscopic appearance of the ferrite, but appear rather to depend upon the super-position of one or more additional systems of structural elements endowed with characteristic critical intervals. The chief added influence appears to me, if only by the process of exclusion, to be related in some way to the original crystallization of the ingots, and probably is due to improvement of the pearlite ground mass by the gradual diffusion during drastic reheating of those small heterogeneities in the dendrites which are responsible for the etching pits arranged in fir-tree form.

Sixth, a correct explanation of the genesis and transformation of the ferrite system in hypo-eutectoid steels cannot be one involving a close relation to the dendritic system of primary solidification. It must at least be admitted that the elements of the dendritic system are individual crystals resulting from colonies of crystals of secondary origin.

[4] CHEM. & MET. ENG., vol. 22, p. 737 (April 21, 1920).

Montan Wax

By Clarence J. West

Bad as our own fuel troubles have been of late, those of England have been worse. The effort to find relief has led to extremely interesting developments. Of special significance are the achievements in furthering the chemical values obtainable in connection with the use of fuel.

Repeated rumors have come from more or less official sources regarding startling developments in these fields. The latest report (the *Nation's Business*, April, 1920, p. 76) calls attention to the development of lignite as a possible solution of Great Britain's oil problem, and specially to the production of Montan wax from this lignite which, up to the present, has been a complete monopoly of Austria and Germany.

Nature and Uses of Montan Wax

Montan wax comes into commerce as a white, high-melting candle-like material. It is not a paraffine, but a mixture of an acid and an alcohol. While it decomposes when distilled at ordinary pressure, it may be purified by distillation with superheated steam in vacuum.

Montan wax is valuable as a substitute for carnauba wax in the manufacture of shoe polishes, and is also used in the manufacture of phonographic records, and as an insulating material in place of ceresin (purified ozokerite).

Montan Wax From Pyropissite

The best source of Montan wax is the mineral pyropissite, which may contain as high as 70 per cent. This supply, however, is largely exhausted. The next best material is lignite from Thuringen, Saxony, with about 9 per cent Montan wax, although in exceptional cases as high as 20 per cent has been obtained. All the other lignites examined run somewhat below 5 per cent Montan wax.

Montan Wax From Lignite

Some years ago Arthur D. Little, Inc., made an exhaustive examination of the lignite deposits of Canada, with special reference to the possibility of obtaining Montan wax. Samples were obtained from Bienfait, Sask.; Taber, Lethbridge, Drumbellen, and Morimville, Alta.; Nicola, B. C., and Princeton, B. C. Samples of brown lignite from the Estavan district of southern Saskatchewan were also examined. In only one case was Montan wax (benzol extract) found, and that was so small as to be commercially unimportant. When this work had been completed, it was learned that the Standard Oil Co. had made a similar search with similar results.

Montan Wax From Peat

Ryan and Dillon (*Proc. Roy. Dublin Soc.*, 1909) have obtained waxes of very similar properties from certain deposits of Irish peat. Peat is one of the stages lower than lignite in coal formation and so a large number of samples of peats from various Canadian bogs were examined in the same way. All of them were found to contain a small percentage of wax, very similar in characteristics to Montan wax, though not identical with it. In all cases, however, the amount was from 5 per cent downward (on the dry basis) and would not justify the commercial utilization of peat for this purpose.

Information Department,
Arthur D. Little, Inc.

Report of the Rubber Division Meeting and Cellulose Symposium of the A. C. S. at St. Louis

Notes on Physical Testing—Bromine Addition—Value of Shoddy—Recovery of Solvents—Determination of Sulphurs—Accelerators—Dispersion of Pigments—Effect of Compounding Ingredients—Microscopic Testing—Colloidal Studies—Testing of Pigments—Papers on Cellulose

THE second meeting of the Rubber Division of the American Chemical Society, which was held at St. Louis, April 14 and 15, 1920, was even more of a success than that of last September in Philadelphia. The rubber chemists of the country are becoming acquainted. They have met, admired, and are beginning to understand and appreciate the other fellow. Information may be divided into two classes, the purely scientific and that which has trade value, such as trade secrets, formulas, etc. It is recognized that the latter should not be made common property, but it has always proved true that free and open discussion of the fundamentals not only puts the industry on a firm basis but gives one fresh inspiration, new ideas and new applications. The benefits of co-operation in things scientific are apparent. The whole tone of this meeting reflected the willingness of the members to discuss the scientific fundamentals of the industry with material benefit to all concerned.

The papers were not so numerous as at Philadelphia and the discussion of each was in every case of considerable value. It is to be hoped that before the next meeting the members of the division will be provided with abstracts of the papers to be given ahead of time so that they can collect their own data and enter into the discussions to the fullest extent.

Report of the Committee on Physical Testing

Tentative specifications were presented last September, at which time the matter was referred back to the committee so that comments, criticisms, etc., might be submitted. J. M. Bierer called the committee's attention to an apparent error in the bursting test for hose, which was later found to be a typographical error consisting of the omission of the decimal point. W. W. Evans suggested that for the time being both English and metric systems should be used, but that later we should gradually work over to the metric system. The permanent set test as outlined was criticized as long and cumbersome. On the other hand, if a real measure of plasticity is desired some such test is very necessary. Mr. North said that the test could be shortened to three stretches to 60 per cent of the breaking elongation, each held 3 min., with a 1-min. interval between, measuring 10 min. after the third release. Discussion was closed by passing a motion referring the whole proposition back to the committee, which was instructed to co-operate with all parties interested in rubber testing, e.g., Bureau of Standards, Rubber Association, etc., for the development of methods which will be standard throughout the United States.

Bromine Addition to Rubber

W. K. Lewis and William H. McAdams showed that the addition of bromine to rubber may be quickly measured volumetrically and that the disappearance of bromine when corrected for combined sulphur is a direct measure of the rubber hydrocarbon in the stock. The method is not applicable to determining the coefficient of vulcanization. Certain substances, of which MR is the principal offender, were shown to interfere. Dr. Lewis gave some results which checked the actual rubber content of the stocks very closely.

Relative Value of Shoddy in Mechanical Rubber Goods

The question as to when reclaimed rubber ceases to be economical has always been a serious one for makers of the various mechanicals, such as hose, packing, heels, etc. J. M. Bierer gave his findings, but little as to the methods by which his conclusions were arrived at. He presented a very interesting chart showing variation of relative values of reclaim, scrap, and crude rubber, from which it is possible, knowing the market price of crude rubber, to find the price at which tire carcass and shoe shoddy reclaims become unprofitable. From another section of the chart maximum allowable prices for these scraps, depending as before on the price of crude rubber, may be found.

Recovery of Volatile Solvents

Dr. W. K. Lewis discussed the two methods of solvent recovery, which are by absorption, and by compression and cooling. The first one requires that the spreaders be inclosed and that the solvent vapors be swept away by inert gas, thus preventing explosions. The solvent is washed out of the gas in a manner not greatly different from coal gas scrubbing. A 90 per cent recovery on large-scale operation is possible, but considerable funds are required in the initial outlay.

Where the vapors are more highly saturated the compression and cooling method is satisfactory. Not such a large initial expenditure is required.

Determination of True Free and True Combined Sulphur in Vulcanized Rubber

Dr. W. J. Kelly pointed out that the method of determining combined sulphur by subtracting acetone soluble sulphur from total sulphur is erroneous. The acetone soluble sulphur consists of true free sulphur and sulphur combined with certain resins. These may be separated by treating the acetone extract with alcohol previously saturated with sulphur. In this way the resins with their combined sulphur dissolve but leave behind the true free sulphur.

When the extracted sample is boiled with alcoholic potash, practically all of the acetone insoluble resins with their combined sulphur are saponified and removed. Boiling alcoholic potash also removes any sulphur that may be combined with rubber proteins.

This is a very valuable contribution, and should give new impetus to the study of the relation between coefficient of vulcanization and physical properties.

C. R. Boggs pointed out that free sulphur may be measured by suspending a roll of copper gauze in the acetone during extraction. Increase in weight gives free sulphur directly.

Small Amounts of Magnesia and Certain Organic Substances as Accelerators

A paper on this subject was presented by G. D. Kratz and A. H. Flower. The authors compared small amounts of magnesia with various organic accelerators. They advanced the opinion that magnesia functions as a secondary accelerator, i.e., it aids other substances, probably always nitrogenous, in producing the true accelerator which is yet to be discovered.

Dispersing Power of Pigments

W. K. Lewis and F. P. Baker stated that the dispersing power of pigments is a very interesting method for comparing average fineness of a pigment with other samples of the same pigment. When for one sample the dispersing power and size of particle, measured microscopically, are known, the average size of particle of other samples may readily be determined. The method consists essentially of working up a weighed quantity of pigment in linseed oil, diluting it with suitable solvent and measuring the weight of the column of liquid required to obscure the filament of an electric light.

Possibility of comparing fineness of different pigments was discussed. J. R. McGregor pointed out that the index of refraction of the pigments and of the liquid media has a considerable influence, at least in some instances, on such results.

Effect of Compounding Ingredients on the Physical Properties of Rubber

Compounding experiments with varying volume ratios of the more common fillers were described by C. O. North. Value of the pigments mentioned is in following order: Gas black, zinc oxide, magnesium carbonate, tripoli, lithopone and barytes. Mr. North proposed a new method for aiming at the effect of the filler on the rubber regardless of how that effect is produced. Values for the ordinary tests were referred back to the actual volume of rubber present.

The practice of making comparisons on a basis of tensile strength is unfair to stocks high in rubber. Tensile at break was advanced as a better procedure. This is secured by multiplying tensile strength as ordinarily obtained by the final length, dividing by the original length and correcting for volume increase during stretching. Such curves are parallel to those for Stevens Tensile Product value.

A visualization of the physical structure of rubber was presented, i.e., the network hypothesis which is based on the assumption that large colloidal aggregates function as elastic fibers and the shorter ones as plastic material. It is not improbable that the chief effect of vulcanization is to lock up these fibers to form a network. The finer the compounding ingredient the more loops there are to this net and the stronger and tougher the stock.

The reading of this paper was followed by considerable discussion. W. B. Weigand stated that his own data checked Mr. North's very closely. He is of the opinion that the effect of compounding ingredients is largely due to their surface energy. The similarity of the views of the two investigators was quite apparent. The only difference is that the one has created a mechanical hypothesis for purposes of visualization, while the other applies the more or less intangible surface energy, adsorption theory of the colloid chemist.

Microscopic Examination of Rubber Products

H. J. Masson and Irene Diner presented a paper on the application of metallographic and biological methods of microscopy to the examination of rubber. This will no doubt prove a very productive field for research. This paper is the first on this subject.

The technique of the authors is to be commended. Unfortunately they did not have the co-operation of any rubber technologist, and as a result their conclusions were somewhat exaggerated. A very interesting series of photographs was shown.

Rubber Chemistry From the Colloidal Viewpoint

E. B. Spear presented a discussion of coagulation, polymerization, and the effect of compounding ingredients on rubber from the standpoint of one versed in colloidal chemistry. It is hoped that quantitative data may be obtained which will permit of practical application of the colloid theories to the rubber industry.

Symposium on the Testing of Pigments

B. F. Goodrich Co. methods of sampling, testing, and analysis of pigments for compounding were described by W. W. Evans. It was found that the methods of other chemists agreed well with those described by Mr. Evans.

New Business

George Oenslager resigned from the executive committee because of an extended visit to the Orient.

Standardized methods of rubber analysis are booked for discussion at the next meeting.

No action was taken toward a unified method of testing crude rubber. It was the opinion of those present that the various manufacturers preferred their own methods, which for the time are probably satisfactory.

The division took a firm stand against the attempt of some manufacturers to sell accelerators to the rubber industry solely under trade names. In the first place the chemists in attendance agreed not to test such accelerators and in the second the Rubber Division promises to declare the true composition of every accelerator so marketed. This action was taken because of the introduction of an accelerator said to consist of starch and sodium hydroxide, and also the growing tendency to incorporate such substances as barium sulphate into accelerators which are sold at high prices per pound. Trade names are not objected to if the true percentage composition of the accelerator is given at the same time. C. O. North, Frederic Dannerth, C. W. Bedford and H. A. Depew took part in the discussion preliminary to the passing of the above motion.

The marked success of this meeting is merely a beginning. It is hoped that the chemists of every rubber company will endeavor to present at least one paper per year.

In closing this review, the efforts of the chairman, Dr. Warren K. Lewis, of the Massachusetts Institute of Technology, who ran true to form in leading discussion and in generally making the meeting a "go," are to be particularly commended. The highly efficient secretary, Arnold H. Smith, of the Goodyear Tire & Rubber Co., is also to be congratulated on the way he handled his work.

Cellulose Symposium

The advocates of the establishment of a Cellulose Section more than proved its desirability both by providing an excellent program and attracting an attendance of nearly 500 members. Through a misunderstanding, the member of our staff who was to report on the papers of this symposium did not do so, but we are pleased to give the following notes as received from Dr. Gustavus J. Esselen, Jr., of A. D. Little, Inc.:

The Mechanism of the Reactions of Cellulose. J. E. Minor. Miss Minor's paper was presented in abstract. It was a continuation of the work, part of which she published in *Paper*, vol. 25, p. 700 (1919). She looks at cellulose from the modern viewpoint, which regards it as a colloid, and on this basis she considered in her paper a number of the reactions of cellulose, such as oxidation, hydration and solution. Her paper is one of the few which have attempted to present cellulose chemistry from the modern viewpoint. It is a very valuable contribution.

Some Observations on the Determination of Cellulose in Wood. S. A. Mahood. Dr. Mahood's paper presented some recent work of the Forest Products Laboratory at Madison, in which they have studied the determination of cellulose in wood samples, with special reference to the degree of subdivision of the sample analyzed.

Nitrocellulose From Wood Pulp. R. C. Woodbridge, Jr. This paper was presented by title. It appeared in the *Journal of Industrial and Engineering Chemistry* for April, 1920, on p. 380.

Notes on the Manufacture of Nitrocellulose. J. O. Small and C. A. Higgins. This paper was presented in abstract form. It contains a very thorough survey of the many important factors involved in the preparation of nitrocellulose for different purposes.

Certain Aspects of the Chemistry of Cellulose Acetate From the Colloidal Viewpoint. G. J. Esselen, Jr. In this paper, after a brief consideration of some of the colloidal principles involved in the preparation and solution of cellulose acetate, the author presented a theory which attempts to explain why alcohol improves the solubility of cellulose in chloroform and tetrachlorethane and to connect this phenomenon with the known fact that cellulose acetate is soluble in mixtures of alcohol and benzol and in phenols, but is not soluble in alcohol mixed with aliphatic hydrocarbons.

Projects of the Preliminary Committee on American Cotton Research. H. E. Howe. This was a brief outline by Mr. Howe of some of the things in which the committee is trying to interest the cotton manufacturers.

Is It Advisable to Form a Section of Cellulose Chemistry? Jasper E. Crane. Since Mr. Crane was on his way to London, this was a letter from him urging the establishment of a section of cellulose chemistry. The symposium at St. Louis was organized by Mr. Crane.

Cellulose Phthalate; Its Preparation and Properties. H. A. Levey. In this paper there was presented some work carried out by the author for the Bureau of Aircraft Production during the war. The object was to prepare a cellulose ester for use in airplane dopes which would not require acetate of lime, either for its preparation or solution. As raw material, powdered cellulose hydrate was used. Owing to the solid character of the phthalic anhydride, considerable difficulty was experienced in the esterification. A product was obtained which the author claimed corresponded to one molecule of phthalic acid combined with eight molecules of cellulose. Because of the low degree of esterification, no solvents had been found for the material. The work was interrupted by the signing of the armistice.

Production of Petroleum in Mexico

It is impossible to give the exact number of wells under exploitation at present in the Mexican fields, if by exploitation is meant the actual extraction of oil from the wells; nor is it easy to determine the daily production of petroleum, since this is dependent on the industrial needs of the companies, the orders they may have pending, and especially on the available means of transportation. On Nov. 1, 1919, the wells actually producing petroleum numbered 305, with a daily production of 317,000 cu.m., or approximately 2,000,000 bbl. Of course, it is not possible to operate the wells continually at full capacity, nor is it reasonable to expect that the productive capacity of a given well will remain constant for an indefinite period; therefore any speculation as to the productive capacity of the wells is only a relative value. However, even though only 50 per cent of the wells be exploited, and allowing for errors in estimating their possible production, it is safe to say that the Mexican wells now under exploitation are capable of producing 170,000 cu.m. of petroleum per day, or about 1,000,000 bbl.

During the year 1919 exports of petroleum from the various ports were as follows:

	Tons
Tampico	6,342,950
Tuxpam and Puerto Lobos	4,638,511
Puerto Mexico	264,482
Other ports	682
Total	11,246,626

About 75,700,000 barrels.

Official figures showing the value of these exports are not available, but 186,500,000 Mexican pesos has been stated as being an approximate value. Taxes collected for the year were 15,203,986 Mexican pesos.

Refineries Under Construction

The Mexican Government has done everything possible to favor and develop the industry of refining petroleum in the country, in the belief that this branch of the industry would lead to the greater industrial development of Mexico by furnishing the necessary derivative products, offering employment on a large scale, and utilizing to a great extent national resources. Therefore, numerous concessions for the establishment of refineries have been granted, and a great number are now under construction. During the year 1918 there were refined in Mexico 3,795,000 tons of crude petroleum, fuel oil occupying the first place among the refined products, with a total production of 2,883,000 tons. During the same year refined products made up 34 per cent of the total exports of petroleum, which amounted to 7,676,864 tons, and it is estimated that during the year 1919 there was exported 2,653,000 tons of refined petroleum products.

Research in the Non-Benzenoid Hydrocarbon Series

A Constructive Discussion Emphasizing Certain Points in Organic Chemistry—Grouping of Open Chain and Non-Condensed Ring Hydrocarbons—Limits of Applicability of Certain Type Reactions—Influence of Adjacent Radicals—Molecular Rearrangement—Field for Industrial Research

By BENJAMIN T. BROOKS

THE beautiful, interesting, and often facile chemistry of the benzene hydrocarbons has somewhat overshadowed the chemistry of the aliphatic open chain and non-condensed cyclic hydrocarbons. Certainly the chemistry of the former series has been much more fully rounded out. Judging from the customary method of treatment accorded them in our textbooks, there is some confusion in the arrangement of subject matter which does not give the student a proper idea of the close relationships and similarity of chemical behavior possessed by all the non-benzenoid hydrocarbons.

Part of this confusion has probably arisen from the frequent use of the term "hydro-aromatic" hydrocarbons. This term is still employed for cyclohexane and its simple derivatives, although its behavior is almost identical with that of normal hexane. The same applies to cyclopentane and its simple derivatives as compared with normal pentane, yet cyclopentane cannot be termed a "hydro-aromatic" hydrocarbon. Cycloheptane, cyclo-octane, cyclononane, cyclobutane, cyclopropane and ethylene should certainly be classed and described together with cyclohexane, as indeed Aschan and a few others have done. The differences in chemical properties between condensed ring systems of the benzene type and the non-condensed or *non-benzenoid* hydrocarbons are well established, but in spite of the enormous amount of work done, have not yet received adequate explanation.

It is a curious fact that during recent years a great part of the research in the field of the non-benzenoid hydrocarbons has been done in Russia, and most of this work has been very imperfectly abstracted, mostly through German publications. It is difficult indeed to estimate what may be the fate of scientific research in that unfortunate country during the next generation, and it seems worth while therefore to call attention to this relatively neglected field of research.

As regards the aliphatic hydrocarbons proper, these fare very badly in most works on organic chemistry, particularly the briefer textbooks. Usually, the entirely erroneous statement, or implication, is made that the so-called type reactions given for the first two or three members of the methane series hold good for the higher members. Beyond the fact that all of them may be completely burned to carbon dioxide and water, such statements are hardly in accord with the known facts.

Well Developed Sections of Organic Chemistry

The chemistry of the aliphatic and alicyclic series of hydrocarbons may conveniently be classified into certain special chapters, the chemistry of which has in most cases been greatly extended and generally well surveyed. Thus the fatty acids and the chemical technology of the fats and fatty oils; the sugars, starches and celluloses; the amino acids and polypeptides; and the simpler alcohols and the chemical technology of alcoholic fermentation, represent comparatively sharply defined subjects, our knowledge of which is constantly being systematically extended by specialists in these fields of work. When we turn, however, to the non-condensed or non-benzenoid hydrocarbons and their simpler derivatives, we note that the chemistry of the first five members of the methane series and also the ten-carbon-atom or terpene group, mostly cyclic hydrocarbons, have been much more extensively and carefully studied than the remainder. Some of the reasons for this are fairly apparent. Thus, the essential oils afford a convenient source of substances of the terpene group which may generally be isolated easily in a state of purity. The natural fatty glycerides or other convenient sources readily yield a limited number of fatty acids, nearly all of them normal, i.e., acids of one, two, three, four, five, six, eight, ten, twelve, fourteen, sixteen, eighteen and twenty-four carbon atoms. Research in many of these special fields has accordingly been greatly facilitated by the availability of suitable material and has often been much stimulated by an intimate relation to industry.

It may also be pointed out that while in the aromatic series a rich variety of raw materials is easily isolated or prepared, crystalline derivatives are almost the rule, permitting easy purification, identification and manipulation in small quantities; that substitutive reactions are usually capable of control to form chiefly one product or a very limited number of products or isomers; but in the aliphatic series this is not the case. Petroleums probably contain all of the normal paraffine hydrocarbons up to $C_{26}H_{54}$ and perhaps farther in the series, and also most of the more stable naphthenes which are theoretically possible but for the most part yet unknown. Not only is it at present impossible to isolate individual substances from this complex raw material, but methods of synthesis applicable to the higher members have not yet been developed.

Probably the most careful work on the separation of the hydrocarbons by fractional distillation of hydrocarbons has been done by Young and his co-workers. They have shown that in the case of a mixture containing only pentane and isopentane, boiling points 36.3 and 27.9 deg. respectively, no less than thirteen carefully conducted fractional distillations, using a very efficient column, were necessary to effect separation of these two substances in a fair degree of purity. It is extremely probable therefore that most of the older work reporting the isolation of a great number of hydrocarbons from petroleum is entirely erroneous, and that the laborious distillation of petroleum fractions—for example, the "isolation" of a fraction boiling at say 212 to 216 deg. and calling it dodecane on the basis

of an analysis agreeing approximately with the formula C_nH_{2n+2} or $C_{12}H_{26}$—is nothing more or less than a lamentable waste of time.

Limit of Applicability of Certain Type Reactions

Most textbooks of organic chemistry give a number of type reactions which have a certain preparative value in the group methane to pentane inclusive. These reactions are usually briefly stated without any qualifications, even when the reactions as written represent only 10 per cent of the total result. Alkyl iodides are often preferred in reaction writing, probably for the reason that some early writer started the custom, although as Nef has shown for the ether reaction

$$RONa + R_1X \rightarrow ROR_1 + NaX$$

iodides give much poorer yields than bromides or chlorides and that the amyl iodides give olefines practically quantitatively (and this undoubtedly holds for the higher alkyl iodides). The Williamson synthesis has not been successfully carried out with alkyl halides containing more than eight carbon atoms, and nearly all of the amyl, hexyl, heptyl and octyl ethers now supposedly known were described in a single paper and this work has apparently not been repeated. It may also be pointed out that the sulphuric-acid method commonly used in preparing ethyl ether is not applicable to alcohols above butyl in the series.

The Grignard reaction has been a most valuable method of synthesis, yet this reaction also is practically valueless for alkyl halides containing more than six carbon atoms. As pointed out by Grignard and others, the higher alkyl halides not only react very slowly with magnesium but the principal reaction which does take place is the following:

$$RMgX + RX \rightarrow R\text{–}R + MgX_2$$

Thus a bromo hexane will give $C_{12}H_{26}$ almost exclusively.

$$C_6H_{13}MgBr + C_6H_{13}Br \rightarrow C_{12}H_{26} + MgBr_2$$

The above examples are cited in protest against the all too common practice of describing reactions applicable to ethane derivatives as type reactions of the whole aliphatic series.

Instability of the Alkyl Halides

Many of the familiar reactions which fail with the derivatives of the higher paraffines do so on account of the instability of the alkyl halides. Most of the methods of preparing alcohols fail with the higher alcohols, and the most useful method is that of Bouveault and Blanc, i.e., reduction of the ethyl esters of the fatty acids by metallic sodium in absolute alcohol, which method is therefore practically limited to the natural fatty acids. (Conversion of the natural fatty acids of an even number of carbon atoms to acids of odd number of carbon atoms is effected only with some difficulty by Krafft's method or through the α-bromo acids or the amides.) According to some very early work, apparently not since confirmed or extended, the condensation of the higher alkyl halides by metallic sodium to hydrocarbons and sodium halides

$$2C_{10}H_{21}X + 2Na \rightarrow C_{20}H_{42} + 2NaX$$

proceeds with much better yields in the case of the higher alkyl halides than with the simpler members. Judging from the work of Nef on ether formation, the chlorides should give much better yields than bromides or iodides.

A property of the higher alkyl halides which does not appear to have been carefully investigated is their reaction with alkali cyanides, hydroxides, sodium malonic ester, aniline, quinoline, etc., to give in part saturated hydrocarbons. With sodium cyanide, for example, one would expect largely olefine and a little alkyl cyanide or nitrile; with caustic alkali one would expect olefine and a little ether. But ring formation occurs to a considerable extent, with the elimination of halogen acid from two carbon atoms which may be near each other in space, as

$$\begin{matrix} CH_2CH_2CHH{-}R \\ | \\ CH_2CH_2CH_2Br \end{matrix} \rightarrow \begin{matrix} CH_2CH_2CH{-}R \\ | \quad | \\ CH_2CH_2CH_2 \end{matrix} + HBr$$

analogous to the formation of the cyclo propane ring by elimination of HBr from bromodimethyl glutaric ester (Perkin and Thorpe, *J. Chem. Soc.*, vol. 75, p. 48) and the reaction

$$CH_3COCH_2CH_2CH_2Br + NaOH \rightarrow CH_3COCH\text{——}CH_2$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad CH_2$$

observed by Lipp (*Ber.*, vol. 22, p. 1,207).

Influence of Adjacent Radicles

The properties of the ethylene bond present an array of incompletely solved problems. Here again the briefer textbooks of organic chemistry usually present a number of type reactions without qualifications, whereas it is not too much to say that the properties of the ethylene bond depend very largely upon the character of the groups or atoms adjacent or near to it.

Thiele's well-known theory of partial valence attempted to account for many observed peculiarities of conjugated double linkings. The addition of halogens, particularly bromine, to olefines is commonly stated to be a characteristic reaction, but it should be pointed out that there is probably every gradation in speed of reaction between bromine and substituted ethylenes, from ethylene and propylene which combine with bromine at —80 deg. with a velocity too great to be experimentally measured (Plotnikov), to the substituted ethylenes containing several strongly electro-negative groups, studied by Bauer (*Ber.*, vol. 37, p. 3,317; 1904), which are entirely inert to bromine. Reactions which are less energetic than the addition of bromine are often markedly affected by minor structural differences. One case in which advantage is taken of such behavior is in the manufacture of isoprene from normal pentane by one of the Badische processes. The process yields a mixture of normal and iso amylenes. On treating with HCl the latter reacts only with the amylene

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>\!C{=}CH.CH_3 + HCl \rightarrow \begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>\!CCl.CH_2CH_3$$

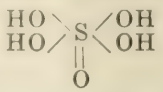
and this reaction product may then be separated by distillation and the unchanged amylenes put through the isomerizing process again.

The addition of water to olefines by means of aqueous sulphuric acid has heretofore been assumed to take place exclusively through the hydrolysis of alkyl sulphuric esters,

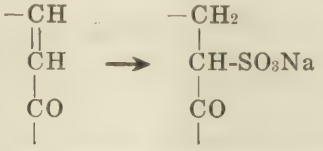
$$\begin{matrix} R\,CH \\ \| \\ R_1CH \end{matrix} \rightarrow \begin{matrix} R\,CH_2 \\ | \\ R_1CHOSO_3H \end{matrix} + H_2O \rightarrow \begin{matrix} R\,CH_2 \\ | \\ R_1CHOH \end{matrix} + H_2SO_4.$$

This reaction is best carried out in the cold and the alcohol is separated by pouring into ice water, yet the

alkyl sulphuric esters made by the action of sulphuric acid on alcohols are not appreciably hydrolyzed by water at 0 deg. Other evidence also points to the possibility that hydration of olefines by aqueous sulphuric acid is due to the intermediate formation of unstable esters of ortho sulphuric acid $H_2SO_4H_2O$ or



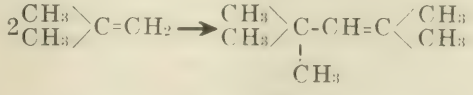
An American petroleum company has recently undertaken the manufacture of a series of the simpler secondary and tertiary alcohols from petroleum or oil gas olefines. In connection with the addition of water to olefines by aqueous sulphuric acid, it may be recalled that in a few instances water alone will react with the double bond, as with the ketenes $(R)_2C{=}CO$. Also the remarkable reactivity of the olefine bond in the group –CH=CH–C=O– has been the subject of considerable research and speculation. Substances containing this group are often easily "hydrolyzed" by dilute acids with rupture of the carbon chain, e.g., mesityl oxide, citral, pulegone, etc. The extreme reactivity is also shown by their ability to combine directly with a wide variety of substances. The addition of sodium acid sulphite to carvone, citral, citronellal and the like to give stable sodium sulphonates of the type



is well known, but the addition of malonic ester, aceto acetic ester and hydrocyanic acid to olefines of this type is perhaps not so well known. It may be of interest to note that the group –CH=CH.CO– is also necessary to the perfume value of many substances, for example ionone.

Polymerization

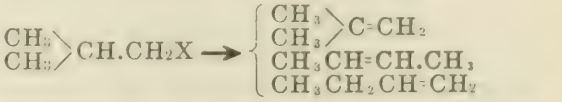
One of the most common and yet obscure properties of olefines is their tendency to polymerize. Conjugated diolefines possess this property to a high degree, as is now well known through the researches on the preparation of synthetic rubbers from butadiene, isoprene and dimethyl butadiene. Very few simple cases of polymerization have been studied, but Kondakow (*J. prakt. Chem.*, N. F. 54, p. 447; 1896) showed that di-isobutylene possesses the constitution indicated in the following:



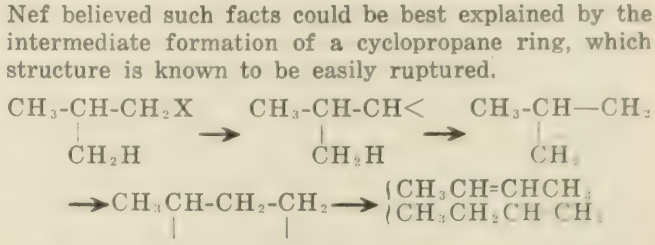
Such polymerization may be effected by a wide variety of substances. In the case of concentrated sulphuric acid, which is known to form alkyl sulphuric esters at least in part, it is not difficult to construct a theory by which such changes may be accounted for. But the mechanism of polymerization under the influence of metallic sodium, heat and light is not so easy—in fact it is entirely obscure. The mechanism of the polymerization of hydrocarbons is undoubtedly intimately connected with the fundamental properties of molecules and our theories of valence. Further information regarding the effect of heat and light on the vibration or "loosening" of the valency electrons will undoubtedly go far to explain the polymerization of olefines, as well as the shift in position of double bonds which is so frequently observed to occur.

Instability of Molecular Structure

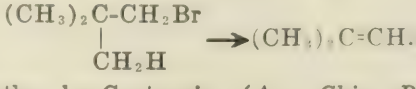
Mobility or instability of the carbon atom structure is one of the most striking properties of non-benzenoid substances. Thus isobutyl alcohol and the primary isobutyl halides yield a mixture of butylenes which has been shown to contain isobutylene and α and β normal butylenes.



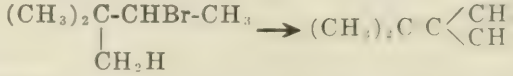
Nef believed such facts could be best explained by the intermediate formation of a cyclopropane ring, which structure is known to be easily ruptured.



A similar example has been reported by Tissier (*Ann. Chim. Phys.*, Ser. 6, vol. 29, p. 361.)

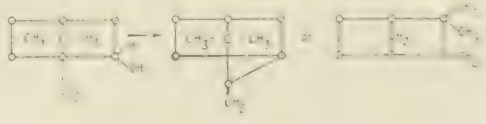


and another by Coutourier (*Ann. Chim. Phys.*, Ser. 6, vol. 26, p. 464).

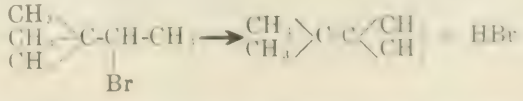


Other well-authenticated and striking changes in structure occur in the cyclic series, the change of the six carbon ring to the seven carbon ring, the change of the six carbon ring to the five carbon ring and vice versa and particularly the series of such cases recently studied by Meerwein (*Ann. Chemie*, vol. 376, p. 152, 1910; vol. 405, p. 129, 1914; vol. 417, p. 255, 1918) in his study of camphene and the borneols. Thus Meerwein has proved that 1.1 methyl α oxethyl cyclopentane on dehydration yields dimethyl cyclohexene

analogous to the structural changes in the formation of camphene from isoborneol by loss of water



Probably the best known type of molecular rearrangement, in the aliphatic series, is the pinacone-pinacoline conversion. But many similar rearrangements fall outside this class, for example



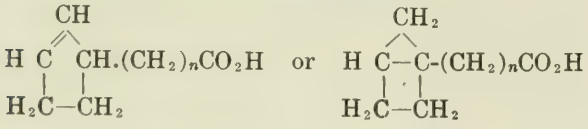
to which Tiffeneau refers as "retropinacoline rearrangements." Meerwein has recently made a systematic study of pinacones in an effort to determine the relative ease

of "migration" of different groups. So far our knowledge of these molecular rearrangements is little more than a catalogue of the facts, but it is probably not rash to hazard the opinion that our next real advance in our understanding of these facts will come not from organic chemists but from those physical chemists who are investigating atomic structures and valence.

Field for Industrial Research

There are innumerable definite subjects for investigation which would be of industrial interest and possibly valuable. Good methods for the synthesis of the higher alcohols and aldehydes are lacking. No satisfactory method for the synthesis of menthol has been developed, although the hydrocarbon paramenthane can be readily made by the hydrogenation of paracymene. We are apparently on the threshold of the chemical utilization of the simpler olefines, particularly ethylene and propylene. Large-scale development work recently carried out indicates that ethyl alcohol, acetaldehyde, acetone, glycols, chlorhydrins and chlorinated solvents will be manufactured on a large scale, probably from oil gas. The possible uses in syntheses of the reactive chlorhydrins and the corresponding oxides, such as ethylene oxide, propylene oxide, amylene oxide and the like, are many.

Petroleums offer an enormous, though difficult, field for industrial research, but the utilization of petroleum hydrocarbons in chemical ways has undoubtedly been held in check by our lack of knowledge of the non-benzenoid hydrocarbons generally. As regards the origin of petroleums it is of interest to note the recent finding of a highly unsaturated hydrocarbon, $C_{29}H_{48}F_6$ in shark liver oils. It is now fairly well established that the naphthenic acids of Russian petroleum are derivatives of cyclopentane, and Power and Barrowcliff have found similar acids in certain vegetable oils. They conclude that the optically active acids of chaulmoogra oil are also derivatives of cyclopentane,



Formation of Petroleum

Although Engler has shown that the destructive distillation of fats or fatty oils under pressure yields a mixture composed chiefly of hydrocarbons and closely resembling crude petroleum, this by no means proves that petroleums were formed in this manner. Petroleums are sometimes found trapped in undisturbed strata, free from volcanic intrusions or other source of heat, as in the Trenton limestone in Ohio, but proponents of the Engler theory state that during the long periods of geologic time these same changes may occur at much lower temperatures than those employed experimentally by Engler, a proposition naturally incapable of proof or disproof. It should be pointed out, however, that we are entirely in the dark as to how saturated hydrocarbons are formed by biochemical processes in nature—for example, normal heptane in the oleoresin of *Pinus sabiniana*, and paraffines in many essential oils, as in the common rose.

Unsaturated hydrocarbons, such as the terpenes, are conceivably formed by decomposition of terpene alcohols, which can be duplicated in many cases *ex vitro* by treating with organic acids, formic or oxalic, at very moderate temperatures. Some have claimed that anaërobic fermentations, such as would doubtless occur in organic remains under water and mud and which is commonly observed in the decomposition of cellulose to methane, furnish us with the most plausible theory of the origin of petroleum. Certain micro-organisms build up complex waxy substances, as for example the tubercle bacillus, and Reichenbach first recognized paraffine as one of the products of decomposition of organic matter. As has been pointed out by Maberry, the action of sulphur and air, or oxygen, on petroleums has probably modified them to a great extent.

As regards sulphur, Erdmann has recently shown that this element combines directly with olefines, apparently as S_3, forming what Erdmann terms thiozonides. Beyond this we know only that when strongly heated together, sulphur and heavy hydrocarbons give hydrogen sulphide and tar or coke. Friedmann's attempt to form benzene and toluene by removing hydrogen from cyclohexanes by heating with sulphur was negative. The structure of the well-known and valuable ichthyols is not known, but products closely resembling the natural Austrian ichthyol have been manufactured in this country since the Austrian supply was cut off in 1914.

Fatty Acids and Asphalts From Paraffine

The oxidation of paraffines and the non-benzenoid hydrocarbons generally by air or oxygen has been studied but little. Byerly developed his well-known process of manufacturing asphalt by air blowing the heavy petroleum residuum, and this process is apparently catalyzed by small quantities of sulphur. In this process water is formed and the product contains very little oxygen, but recent work indicates that true fatty acids can be made by the air oxidation of paraffine at about 150 deg. The latter process has probably been inspired by the desirability of manufacturing fatty acids from petroleum hydrocarbons. It is of course possible that some empirical method may be stumbled upon which will serve as a manufacturing process, but a problem of this magnitude deserves careful research of the highest order.

Unsaturated Hydrocarbons

In connection with the oxidation of saturated hydrocarbons the problem of utilizing the unsaturated hydrocarbons of petroleum distillates should be mentioned. At the present time these substances are largely lost by the present refining methods, treating with concentrated sulphuric acid, etc. With the advent of shale distillation, which is bound to become of increasing importance as the supply of natural crude petroleum dwindles, the solution of this problem will become of increasing importance. For most purposes of lubrication it is, in the opinion of some, not necessary to remove the olefines and it is established through the work of Dunston and Thole and others that olefines possess somewhat greater viscosities than the corresponding saturated hydrocarbons. Hydrogenation of such material is technically very difficult on account of the poisoning of the catalyst by sulphur, always present in such oils. It is more likely that research will indicate a method of converting these olefines into other and valuable products which can be removed from the remaining saturated hydrocarbons. They are much more readily oxidized than saturated hydrocarbons, and it is possible that the solu-

tion of the economic production of fatty acids may lie in this direction. The chlorhydrins and glycols of the higher boiling olefines have not been prepared, probably for the reason that very few of such olefines are known or have been synthesized or isolated in a pure state. The glycols would undoubtedly be solid waxes possessing valuable properties. It is fairly obvious that a great deal of careful research on pure substances is needed to further our knowledge of these hydrocarbons, such work to proceed hand in hand with, or in advance of, the industrial developments, which procedure has yielded such fruitful results in the special field of the terpenes, essential oils and camphors.

Finally, it may be pointed out that there is no collected chemical literature published which brings the chemistry of the non-benzenoid hydrocarbons together in a systematic way and in such a manner as a student may easily study it. There are a number of very excellent works on the terpenes, the largest of which, Semmler's "Die Aetherische Oele," is about eighteen years out of date. The same may be said of Aschan's "Chemie der Alicyclische Verbindungen." Both of these works are also limited to the fields indicated by their titles. Vol. I of Engler's "Das Erdöl" is largely a catalog of the hydrocarbons noted by Beilstein, and their physical properties and more important chemical properties are briefly noted. Much valuable and up-to-date material is found scattered in several lesser works, such as E. J. Parry's "Essential Oils," Gurwitsch's "Wissenschaftliche Grundlagen der Erdölbearbeitung," Gildemeister's "Aetherische Oele," Meyer and Jacobson's famous "Lehrbuch" and the like. The compilation of a volume such as that of Aschan, including the open chain hydrocarbons as well as the cyclic ones, and brought up to date would undoubtedly facilitate and induce further research and the development of new experimental methods in this field, which in some directions is comparatively neglected but potentially most rich.

British Officials to Visit Industrial Centers

The British Department of Overseas Trade has completed arrangements for the periodical dispatch of certain of its officers having specialized knowledge of particular trades to the important industrial centers of the United Kingdom in order to bring the department into direct contact with the provincial firms. The co-operation of the Association of British Chambers of Commerce and, through it, that of the local chambers of commerce have been secured.

It is planned that the visits shall be monthly and cover in each case about five days. Publicity will be given in advance of the proposed visits of officers, and provincial firms desiring an interview are expected to make application to the Chamber of Commerce in the most suitable center. The visiting officers will deal with problems connected with overseas trade possibilities and conditions and discuss as far as possible such matters as:

1. Contracts open to tender.
2. Overseas demand for particular goods.
3. Importers of various goods in overseas markets.
4. Agencies for British manufacturers.
5. General conditions obtaining in overseas markets, including:
   - (*a*) Best method of marketing and distribution.
   - (*b*) Credit conditions.
   - (*c*) Terms of payment.
   - (*d*) Nature of competition and best methods of meeting same, etc.
6. Shipping and transport.

Development of Kauri-Gum Industry in New Zealand

Since the close of war more attention has been given to the development of the kauri-gum industry in New Zealand than any time during the past five years, with the result that it seems probable that greater quantities of kauri gum and its byproducts will be produced than heretofore.

Oil From Kauri Peat Swamps

There are very extensive kauri-peat swamps in New Zealand that have been placed at the disposal of interested parties by the New Zealand Government on a leased basis. The present area which the Governor General by Order in Council may set apart for the development of this industry is 10,000 acres which may be leased for forty-two years, with no party to receive a lease exceeding 3,000 acres. The lessees have to pay a low rental and also a royalty on kauri oil and other valuable products obtained.

The New Zealand Peat Oils (Ltd.) has taken one grant of 3,000 acres, and is now developing it with reasonably good prospects of success, having tested four samples taken from different depths of the swamp which yielded an average of 29 gal. of crude kauri-gum oil to the ton, with a yield of 4,300 cu.ft. of gas per ton. This company proposes to push the development of this industry during the coming year.

Kauri-Gum Extraction and Grading

A new method of gathering and grading kauri gum has lately been undertaken, whereby kauri-peat swamps that are thoroughly pregnated with kauri gum in different stages of decomposition can be worked with reasonably good success, according to late reports. It is claimed that if this process succeeds, as indicated at present, there can be more kauri gum secured from the deposits in the North Island than has been secured to date, though of an inferior grade to that which has been gathered.

It is proposed to sort this kauri gum into about three or four grades according to size, which means largely according to the degree of decomposition. It is claimed any grade would be sufficient in quality for the manufacture of the lower grades of varnishes and similar products, and would be exceptionally good for the manufacture of linoleums and that line of goods and it is expected that these qualities of kauri gum can be produced in such quantities as to be sold for a very much more reasonable price.

Production of Kauri Gum

The production of kauri gum during the seven years previous to the beginning of the war averaged not far from 8,000 tons per year, while since that time it has scarcely averaged 4,000 tons, and during the year ended March 31, 1919, amounted to only 2,338 tons. Of the output of 8,473 tons for 1914 the United States took 4,531 tons, the United Kingdom 3,335 tons, Germany 373 tons, and the remainder was well scattered over ten other countries; while for the year ended March 31, 1919, the United States took 1,371 tons of the 2,338 tons, the United Kingdom 346 tons, Canada 572 tons, and Australia 49 tons.

Of late quite large quantities of kauri gum have been going forward to the United States as shipping space could be obtained, and there are still large quantities in hand for export.

The Chemistry of Leather Manufacture*

By Dr. James A. Wilson

THE leather business is a chemical industry, but has not been developed by chemists, although dating back to ancient times. It has been only in the last thirty-five years that the chemist has in any way been connected with the operations of leather manufacture. Up until five years ago he was called in only to settle disputes between the buyer and seller on the various chemicals purchased for the business. This condition still exists in a great many tanneries.

The chemist has not altered the fundamental principles of the industry. but he has improved upon the processes, and it may be predicted that within the next few years he will do much to change the operation entirely. There are no up-to-date books published at the present time on this branch of the industry.

Consecutive Stages in the Treatment of Hides at the Tannery

Hides are received at the tannery in four conditions—namely, fresh, salted, and dried hides, and hides that have been both salted and dried. The first operation is to soak the skins in water to remove dirt and blood and at the same time swell the fibers to a normal condition. When the hides are removed from these soaks, which require from four to five days, they contain about 80 per cent water.

They are then taken to the beam house, where everything is to be removed except the hide fibers and grain. The main mass of the hide consists of fibers with an epidermal layer containing the hair on one side. Beneath this epidermal layer is a second layer which contains the roots of the hair. In order to free the hide from hair it is soaked in a solution of lime in excess with sodium sulphide. Addition of sodium sulphide in the lime water cuts down the time of dehairing from two weeks to from one to three days. This alkali destroys the under layer of skin which holds the hair, so that when the hide is taken from the bath it may be easily brushed free by hand. The chemistry involved in this operation is supposed to be the hydrolysis of the under layer of skin. The hide fibers swell further during this process and after the hair has been scraped off and all extraneous substance removed, it is taken to the bating house. The old method of bating consisted of soaking in dung, but this has been displaced by the use of so-called bates—mixtures of sodium chloride and trypsin. While soaking in this solution the swelling caused by liming is somewhat counteracted.

Chemical Action in Tanning by the Chrome Method

If the leather is to be tanned by the chrome method a mixture of hydrochloric and sulphuric acid is added to acidify the hide before it goes to the $CrOHSO_4$ solution. This acidification is to prevent any precipitation in the chrome bath. Chemical control is exercised during this pickling process.

In chroming leather, the basicity and the chromium concentration must be correct. By far the most important factor is the content of neutral salts, that is, of ammonium chloride, lithium chloride, magnesium chloride or sodium chloride. The real chemical action consists of the formation of a chromium collagenate in the leather, by reaction between the tannin and hydroxyl group, and the resulting substance may be considered as an analogous compound to chromium acetate. If too large a quantity of the neutral salt is present, the quantity of solvent is reduced because of the hydration of this salt, which thus increases the per cent of all constituents present in solution. The test for the end of this reaction is made by placing a piece of the leather in water and boiling for five minutes, during which time no change can take place in the general visual appearance.

Vegetable Tanning

In vegetable tanning no acid or pickling bath is used, the chemical action being a combination between tannin and the amino group. One of the common tanning materials is hemlock liquor, prepared by extracting hemlock bark with water. The hide first goes through a weak solution of this liquor and gradually moves forward to solutions of increasing strength and astringency. This may be done either by changing the hide from vat to vat or by pumping in stronger liquors each time.

Of all the vegetable tanning extracts available, quebracho—secured from South America—is cheapest, most plentiful and gives excellent weight to the hide, and would ordinarily be used where the finished product is to be sold by weight. It is considered by many tanners that quebracho bark cannot be used alone in tanning because of its high astringency and that the first steps of the process must be accomplished with gambier or sumac. Experiments made by the speaker showed, however, that quebracho extract can be used without resorting to the other more expensive extracts by simply diluting with gallic acid or similar diluent.

Oiling the Hides

After the leather is tanned, either by the chrome or vegetable process, oil must be incorporated into the hides to make them pliable and tough. This is usually done by treating them with an emulsion of hot oil and water in a process called "drumming," during which the oil is taken into the hide and water forced out. This operation requires only from ten to fifteen minutes. In case of some of the heavier leathers heavy grease is rubbed into the hides. About 6 per cent of oil by weight is absorbed in the light leathers and as high as 20 per cent in the heavier leathers where the grease treatment is used. Mineral oil is necessary during the drumming operation to dissolve the solid fatty acids from the hide, while vegetable oil is necessary because it does not leave grease on the surface of finished leather. Thus a proper mixture of both is necessary to successful operation.

Microphotographs of finished leather sections show that the substance is a fibrous material. The animal source of a particular finished leather can easily be detected by magnifying a sample to ten diameters, each different kind of hide showing a distinctive appearance.

Leather chemists have much in common with the scientists at the universities, and need the co-operation of both physicists and chemists in the development of their industry. Many problems can be made available to the research department of any university desiring to enter into the subject.

*Abstracts of remarks presented at the Chicago Section meeting, American Chemical Society, April 23, 1920.

A Comparative Test Upon High-Speed Steels—III

A Detailed Description of the Method of Procedure in Testing Sixteen Different Commercial Brands of High-Speed Tool Steel, Together With Data as to the Performance of Each Individual Tool, Its Chemical Composition, Heat Treatment, and Hardness*

By A. J. LANGHAMMER, M.E.†

VARIOUS steps in the preparation for a test are fundamentally important and must be carefully planned and performed to insure ultimately correct data. The essential factors are composed of the following steps, each one of which will be briefly described: First, procuring specimen bar of high-speed steel; second, making of tool; third, heat treatment of tool; fourth, grinding of tool; fifth, apparatus used and working details, and sixth, chemical and metallographic tests.

Procuring Specimen Bar of High-Speed Steel

A small order specifying the "best grade" of high-speed steel was placed with the various steel manufacturers. No mention was made of the fact that this steel was to be used for test purposes. A reasonably short time for delivery was specified. Upon receipt of shipment, each item was held for the personal attention of the man in charge of the test. After general physical inspection every bar was duly labeled and carefully stored until all the steel ordered had been received.

Making of Tool and Heat Treatment

A short piece was cut by a power hack saw (not nicked and broken) from the end of each bar and the latter then inspected at the "cut." Hereupon another piece was cut off for chemical and metallographical investigation. Finally, four pieces, each 6 in. in length, were cut for the test tools proper. Every tool was at once marked permanently with a symbol (A, B, etc.) representing the brand of steel and then stamped number 0, 1, 2 or 3 to differentiate among the tools of the brand. This designation was adhered to throughout the test and provided positive means of identification at all times as well as a concise method for comparison. The symbols chosen, too, were of such nature that they did not directly reveal the brand of the steel, which practice provides for absolute impartiality on the part of the experimenters. All the tools were then machined on a milling machine to the dimensions and tool angles indicated[1] in Fig. 2, viz: 6 deg. clearance at the nose and 10 deg. at the heel, 14 deg. side slope, 0 deg. back slope, 32 deg. horizontal clearance and 8 deg. vertical clearance, 84 deg. lip angle, and 90 deg. cutting angle. A slight cut was also taken from the base to insure a perfect seat. After machining, the tools were rough-ground to insure a minimum of finish-grinding upon hardening. All tools were then subjected to complete inspection and necessary corrections made, whereupon they were ready for hardening.

Once the tools were "made," and then only, every steel manufacturer or his representative was advised that a test was being conducted and they were given the choice of either hardening the tools themselves, having our man harden the tools under their direction, or send in their specifications for heat treatment and permit us to do the hardening without their supervision. It was understood, of course, that in each case the hardening had to be done in our plant and under constant observation. In the majority of cases the second proposal was accepted, i.e., our tool hardener performed the work in accordance with the verbal instructions of the steel companies' experts. Each representative had our entire equipment at his disposal and while he was at work no rival steel man was present. Our equipment was quite complete and the needs of each agent were easily satisfied. Every man was told that the heat treatment was the only factor he could control and that but one test of four tools could be made. He was therefore duly cognizant of the great importance of his work and was perforce extremely careful. Complete observations were made as to the methods applied and the behavior of each tool carefully noted, especially while at the high heat. A separate data sheet and discussion of the different methods of heat treatment applied are given in Table II in conjunction with the summary of chemical analysis and reproduced herewith.

Two furnaces were employed, one for the low or preheat and the other for the high heat. In each case the temperatures were adjusted to the satisfaction of the steel men before the tools were put into the furnace. Semi-muffle type oil-fired furnaces were used.

Grinding of Tool

It is generally conceded that probably more tools are spoiled through overheating in grinding than in any other way. As pointed out above under "Making of Tool," all tools were rough-machined and rough-ground before hardening, thereby reducing the chances for ruining in grinding. A high-grade tool grinder performed the work under constant supervision, and in this way the danger of overheating was minimized and the correct values of cutting angles assured. The machine used was a Taylor automatic tool grinder and particular care was exercised to see that the copious stream of cooling water provided was applied to the nose of the tool directly at the point of contact with the emery wheel. After the tools had been finish-ground, each one was inspected for flaws in the material and all cutting and clearance angles were checked. The base of each tool, in addition, was inspected for deformation, since a perfect seat in the holder is essential.

After the tools were put through the first run they were reground to the original design except that the radius at the nose of the tool was double that of the original value, i. e., $\frac{1}{16}$-in. radius on the first run and $\frac{1}{8}$-in. on the second run. Of course, in the regrind here was more chance for injuring the tools. It is felt, how-

*For Parts I and II, see CHEM. & MET. ENG., vol. 22, Nos. 18 and 19, May 5 and 12, 1920, pp. 829 and 889.

†Industrial engineer, Thompson & Black, engineers and accountants, New York and Detroit.
Formerly mechanical engineer, Packard Motor Car Co.

[1]See CHEM. & MET. ENG., vol. 22, No. 19, May 12, 1920, p. 890.

TABLE II. COMPOSITION AND HEAT TREATMENTS OF TOOL STEELS TESTED

Brand	Chemical Composition * Carbon	Tungsten	Vanadium	Nickel	Chromium	Cobalt	Uranium	Heat Treatment: Preheating	Hardening	Quenching Medium	Drawing Temperature	Remarks on Heat Treatment
A	0.79	12.8	1.74	0.10	3.78	None	None	All tools slowly preheated to 1550-1600 F.	The temperature in the hardening furnace was maintained at practically 2300 F. The tools were withdrawn and quenched when the condition of sweating was satisfactory to the expert representing the steel company which produced the brand being hardened.	Oil	1050	Cyanide on tip of tools during hardening.
B	0.64	16.9	0.92	0.10	2.42	None	None			Lead at 1050 F.	1100	"B" tools withstood the high heat very well.
C	0.40	18.00	0.51	Tr.	3.53	None	0.11			Lead and kerosene.	1050	Tools 0 and 1 quenched in lead. Tools 2 and 3 quenched in kerosene.
D	0.62	14.86	1.05	Tr.	3.59	None	0.10			Lead at 1050 F.	1100	One-half of tool immersed in lead. Relatively short heat.
E	0.49	17.35	0.23	Tr.	2.78	None	0.14			Lead	1100	
F †	0.67	19.70	0.99	0.21	3.78	None	None			Oil and lead	1100	Tools 0 and 1 quenched in lead.
..	0.65	15.79	0.49	0.24	3.44	None	None					Tools 2 and 3 quenched in oil.
G	0.62	18.26	0.75	Tr.	3.70	None	None			Oil	1050	
H	0.66	18.30	0.45	None	4.17	None	None			Lead at 1050 F.	1075	
J	0.68	18.12	0.48	Tr.	2.63	None	0.10			Oil and lead	1050	Tools 0 and 3 were immersed half way in oil; then they were placed on the floor and thus drawn.
K	0.59	13.34	0.95	Tr.	3.64	None	0.15			Oil	10.75	
L	0.76	21.92	1.05	None	5.27	None	None			Lead at 1050 F.	1050	
M	0.69	16.95	0.75	0.18	3.09	None	None			Oil and kerosene.	1100	Tool 2 quenched in oil. Tools 0, 1 and 3 quenched in kerosene. "M" tools withstood the high heat very well.
N	0.66	13.55	2.20	0.10	3.59	None	None			Oil	1050	
O	0.67	13.50	0.99	0.20	4.30	None	None			Oil and lead	1100	For tool 0 only. Tools 1, 2 and 3 were not drawn.
P	0.38	15.27	0.05	0.20	2.85	None	0.14			Lead	1100	Blistered on heating.
R	0.65	17.08	0.58	0.20	2.78	None	0.10			Oil and lead	1075	Tools 0 and 2 were quenched in lead. Tools 1 and 3 were quenched in oil.
13, 14‡	0.75	11.12	2.10	0.32	5.13	None	None					

The samples for chemical analysis were obtained from the same section of the bar of which the tools were made.

The temperature of the lead bath used in quenching was maintained at a temperature of 1050 F. The tools were immersed in the molten metal for about 3 min., and then allowed to cool in the air.

* Phosphorus and sulphur below 0.04 per cent in all cases.
† The second analysis under F gives that of a second bar obtained subsequently.
‡ This steel was not tested, but its microstructure is shown in Figs. 13 and 14.

ever, that with the care and vigilance that was exercised, this possibility was eliminated.

Apparatus Used and Working Details

As stated in a foregoing paragraph, the machine tool used was a new 8-in. Lo-Swing lathe, shown[2] in Fig. 3. The general set-up is shown[3] in Fig. 1. Attention is especially invited to the particularly rigid method that is used for holding and driving the work. It is also to be observed that the set-up included but one tool block and that the tool traveled from the point shown to the dome end of the cylinder. Fig. 4 shows[4] very clearly the method of clamping the tool and attention is called to the unusual area of tool base that is clamped and supported, as compared with the ordinary lathe tool post.

When each cut was started the tool was carefully "fed in" until the proper depth of cut ($\frac{5}{32}$ in.) was reached. The tool was then fed by hand longitudinally for about $\frac{1}{4}$ in. for the purpose of checking the "turned" diameter. In this way the depth of cut was held very close—within the limits of plus or minus 0.0025 in., to be exact. Only after the correct depth of cut had been attained was the longitudinal power feed engaged (0.054 in. for first run and 0.090 in. for second), the stop watch being started at the same time. As soon as the cut was "across," the watch was stopped and the time recorded. This was repeated until the tool failed, whereupon the total time or life of the tool was at once computed by the observer, which figure was later checked in the office. All other tools were then put through the test in the same way. Whenever a tool failed in cutting, the "burned" part of the cylinder that was caused by the tool failing was turned off with a tool that was not a test specimen, thereby relieving the succeeding test tool of the handicap of cutting metal hardened by burning. In this way every test tool started to cut under identical conditions, which was especially desirable in our case because of the relatively short length of the material cut.

As a further check on the life of each tool, the actual number of cylinders machined was recorded and then compared with the total time credited to the tool.

After the life of each tool was recorded and these data checked, the results were plotted and are shown in the graphical representation on "curve sheets," reproduced in Figs. 5 and 6. The time or life of each tool was plotted as abscissæ, while the brands were indicated as ordinates. In both runs the value representing the total life of each set of tools is shown on the same sheet. It will have been noticed that each individual tool was stamped with a symbol representing the particular brand from which it was made and that the tools in each brand were numbered 0, 1, 2 and 3. By using this differentiation and referring to the data sheets on chemical analysis, heat treatment, and the curve sheets, the why and wherefore of exhibited characteristics can usually be traced quite easily. To facilitate this work, however, a series of data sheets under "Notes on Performance" have been included below.

Chemical and Metallographical Tests

It has been pointed out that a short piece was cut from each bar of steel for the purpose of procuring the chemical analysis of each brand. The work was done in the Packard laboratory and as some of the data appeared questionable, check samples were sent to a local laboratory and again to New York, each report concurring in our analysis, except in the case of uranium. Both outside laboratories reported more than 0.20 per cent uranium in brand "D" but only a possible trace in half a dozen other brands.

Several microphotographs were made and will be published later with a separate discussion. In the same

[2] See Chem & Met. Eng., vol. 22, No. 19, May 12, 1920, p. 891.
[3] See Chem. & Met. Eng., vol. 22, No. 19, May 12, 1920, p. 889.
[4] See Chem. & Met. Eng., vol. 22, No. 19, May 12, 1920, p. 891.

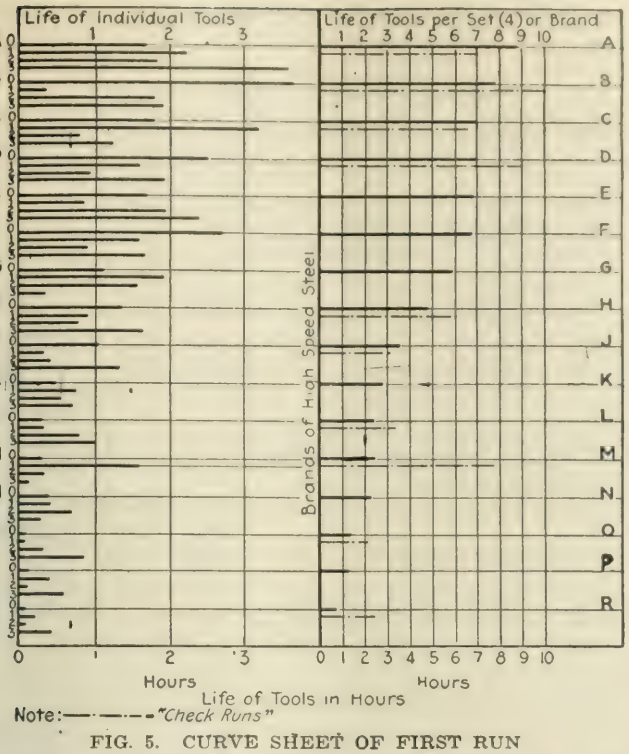


FIG. 5. CURVE SHEET OF FIRST RUN

Turning Liberty motor cylinders 5½ in. diameter. Tool with ⅛-in. radius nose; cutting speed, 35 ft.; feed, 0.054 in.; depth, 3/32 in.

way, while Table II shows the chemical analysis, comments thereon will be given subsequently.

Table VII, giving the scleroscope hardness of each individual test tool, is included for checking purposes. It is contended that the degree of scleroscope hardness is in no way related to red-hardness, once a certain initial hardness (about 80) has been attained. In other words, if one tool registers 83 and another 88, it does not follow that there will be any difference in the cutting qualities of the two. Hardness readings should be taken of each tool after the finish grinding for the first run and used as a general indicator. The given data were secured at that time. The readings taken at the nose tip are, of course, lower in value than those of the group taken farther back on the lip surface. This is due to the fact that in the first instance the drop hammer rebounded from an overhung surface, while in the latter case the footing was solid, the heel being directly beneath the point where the reading was se-

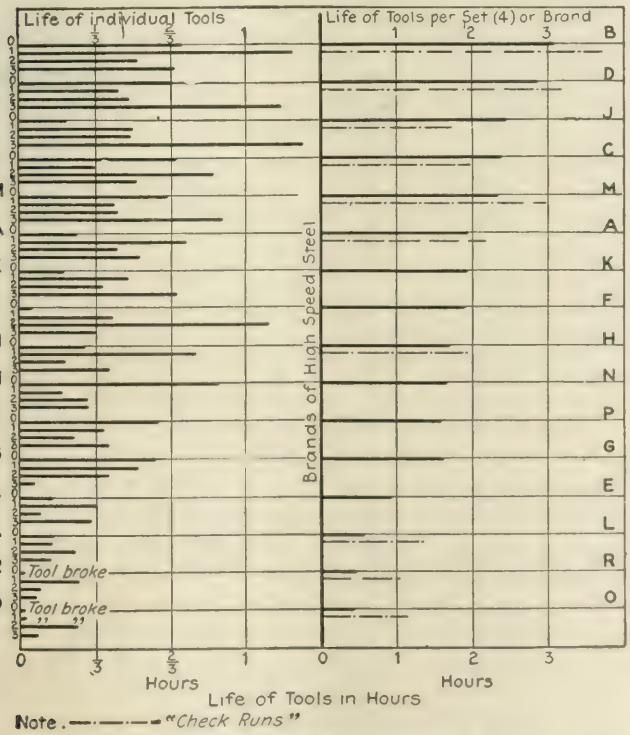


FIG. 6: CURVE SHEET OF SECOND RUN

Turning Liberty motor cylinders 5½ in. diameter. Tool with ⅛-in. radius nose; cutting speed, 35 ft.; feed, 0.090 in.; depth 3/32 in.

TABLE IV. NOTES ON PERFORMANCE OF FIRST RUN

Brand	No.	Time	No. of Cylinders	Remarks
L	0	20.6 min.	4	Dulled quickly; then failed.
	1	20 5 min.	4	Dulled quickly, then failed.
	2	47 8 min.	9	Failed slowly
	3	56 2 min.	11	Failed quickly
		Total time, 2 hr. 25 min. 6 sec.		
C	0	1 hr. 48.0 min.	21	Showed wear early but continued to cut.
	1	3 hr. 12.9 min.	38	Failed rapidly.
	2	49.0 min.	10	Failed suddenly.
	3	1 hr. 17.3 min.	15	Showed wear early but continued to cut.
		Total time, 7 hr. 7 min. 12 sec.		
A	0	1 hr. 40.4 min.	20	Tool indicated wear and then failed.
	1	2 hr. 14.5 min.	27	Failed slowly
	2	1 hr. 52 min. 42 sec.	22	Failed slowly.
	3	3 hr. 39 min. 18 sec.	44	Failed gradually.
		Total time, 9 hr. 26 min. 54 sec.		
B	0	3 hr. 40.5 min.	44	Failed very slowly.
	1	21.6 min.	4	Nose chipped.
	2	1 hr. 51.5 min.	22	Failed slowly
	3	1 hr. 56.7 min.	23	Failed after showing dullness.
		Total time, 7 hr. 50 min. 18 sec.		
O	0	4.6 min.	1	Tool broke.
	1	2.1 min.	¼	Tool broke.
	2	20.5 min.	4	Dulled quickly; then failed
	3	52.2 min.	10	Failed suddenly.
		Total time, 1 hr. 19 min. 24 sec.		
M	0	19 min. 17 sec.	4	Showed chipped cutting edge
	1	1 hr. 36 min. 6 sec.	19	Failed suddenly
	2	20 min. 56 sec.	4	Showed slightly chipped cutting edge and failed quickly
	3	7 min. 15 sec.	2	Failed quickly.
		Total time, 2 hr. 23 min. 34 sec.		
H	0	1 hr. 21 min. 30 sec.	16	Failed slowly
	1	56.0 min.	11	Uniform wear
	2	47.0 min.	9	Failed quickly.
	3	1 hr. 39 min. 38 sec.	20	Failed slowly.
		Total time, 4 hr. 44 min. 8 sec.		
K	0	31 min. 14 sec.	6	Dulled quickly
	1	46 min. 49 sec.	9	Failed suddenly.
	2	34 min. 56 sec.	7	Nose chipped slightly but continued to cut.
	3	44 min. 14 sec.	9	Failed quickly.
		Total time, 2 hr. 37 min. 13 sec.		
J	0	1 hr. 6 min. 28 sec.	13	Failed slowly
	1	19 min. 8 sec.	4	Dulled, then failed quickly.
	2	27 min. 36 sec.	5	Dulled, then failed rapidly.
	3	1 hr. 20 min. 5 sec.	16	Failed quickly
		Total time, 3 hr. 13 min. 17 sec.		
D	0	2 hr. 29 0 min.	30	Failed slowly
	1	1 hr 37.3 min.	19	Failed slowly
	2	59 0 min.	12	Failed gradually.
	3	1 hr. 55 9 min.	23	Failed slowly
		Total time, 7 hr. 1 min. 12 sec.		
P	0	4.2 min.	1	Failed quickly.
	1	24 9 min.	5	Dulled early
	2	6.4 min.	1	Failed quickly
	3	36.0 min.	7	Failed suddenly
		Total time, 1 hr. 11 min. 30 sec.		
N	0	23.0 min.	4	Dulled quickly but continued to cut.
	1	25.8 min.	5	Failed quickly.
	2	44 1 min.	9	Failed slowly.
	3	18 3 min.	4	Showed wear, then failed.
		Total time, 1 hr. 51 min. 12 sec.		
R	0	3 4 min.	1	Nose broke.
	1	9 8 min.	2	Failed quickly.
	2	0 8 min.	0	Failed quickly
	3	27 3 min.	5	Failed gradually
		Total time, 41 min. 18 sec.		
E	0	1 hr. 44.0 min.	21	Failed quickly
	1	52 3 min.	10	Failed rather slowly
	2	1 hr. 58.9 min.	24	Failed slowly
	3	2 hr. 24 0 min.	29	Failed slowly
		Total time, 6 hr. 59 min. 12 sec.		
F	0	2 hr. 45.8 min.	33	Failed slowly
	1	1 hr. 36 3 min.	17	Chipped but continued to cut
	2	55.5 min.	11	Failed quickly
	3	1 hr. 38.8 min.	20	Showed wear early
		Total time, 6 hr. 56 min. 24 sec.		
G	0	1 hr. 8 1 min.	14	Showed wear but continued to cut
	1	1 hr. 55.6 min.	23	Failed slowly
	2	1 hr. 33 1 min.	19	Cut roughly but held its size
	3	19 3 min.	4	Failed quickly.
		Total time, 5 hr. 54 min. 6 sec.		

TABLE V. NOTES ON PERFORMANCE OF SECOND RUN

Brand	No.	Time	No. of Cylinders	Remarks
C	0	41 min 42 sec	10	After 30 min. 54 sec., rapid wearing was apparent though the tool continued to cut.
	1	19 min 13 sec	5	Failed suddenly.
	2	51 min 36 sec	12	Showed wear three minutes before failure occurred.
	3	33 min 12 sec	8	Failed gradually.
		Total time, 2 hr. 25 min. 43 sec.		
N	0	53 min 30 sec	14	Failed suddenly.
	1	11 min 24 sec	3	Showed wear after the second cylinder.
	2	18 min	4	Failed slowly.
	3	18 min 18 sec	5	Failed slowly.
		Total time, 1 hr. 41 min. 12 sec.		
E	0	9 min 12 sec	2	Tool indicated dullness and then broke.
	1	20 min 30 sec	5	Failed gradually.
	2	5 min 24 sec	1	Tool broke.
	3	19 min 48 sec	4	The nose chipped after 4½ min., but continued to cut, though irregular.
		Total time, 54 min. 54 sec.		
O	0			Broke on first run.
	1			Broke on first run.
	2	15 min 30 sec	4	Dulled quickly but continued cutting and then failed suddenly.
	3	4 min 30 sec	1	Tool broke.
		Total time, 20 min.		
M	0	38 min 30 sec	9	Failed very slowly.
	1	25 min 22 sec	6	Failed suddenly several minutes after showing wear.
	2	26 min	7	Tool broke.
	3	54 min	14	Failed suddenly.
		Total time, 2 hr. 22 min. 52 sec.		
P	0	37 min	9	Failed slowly.
	1	22.5 min	5	Failed rapidly after becoming dull.
	2	14 min	4	Failed suddenly.
	3	24 min 48 sec	6	Failed gradually after first indication of dullness.
		Total time, 1 hr. 38 min. 18 sec.		
G	0	36 min 18 sec	9	Showed wear 1 minute before it failed.
	1	32 min 18 sec	8	Failed gradually in last 3 minutes.
	2	24 min	6	Failed slowly.
	3	3 min 36 sec	1	Tool broke.
		Total time, 1 hr. 36 min. 12 sec.		
H	0	17 min 42 sec	4	Grew dull 4 minutes before failure.
	1	47 min 6 sec	9	Failed very slowly.
	2	12 min 54 sec	3	Began to dull on the second cylinder.
	3	24 min 36 sec	6	Failed suddenly.
		Total time, 1 hr. 42 min. 18 sec.		
A	0	15 min	4	Nose chipped slightly after seven minutes running, then failed gradually.
	1	44 min 12 sec	11	Failed very slowly after first indication of dullness.
	2	26 min 30 sec	6	Failed gradually in the last four minutes.
	3	31 min 6 sec	8	Gave indication of dullness eight minutes before failure.
		Total time, 1 hr. 56 min. 48 sec.		
L	0	8 min 35 sec	2	Dulled quickly, wear increasing rapidly until failure occurred.
	1	8 min 12 sec	2	Failed slowly.
	2	14 min 6 sec	4	Showed wear on second cylinder but failed slowly.
	3	7 min	2	Failed gradually after the cutting edges chipped slightly.
		Total time, 37 min. 54 sec.		
B	0	43 min	11	Failure extremely slow after showing initial dullness.
	1	1 hr. 13 min	18	Failed suddenly.
	2	30 min 15 sec	8	Failed slowly.
	3	40 min 30 sec	10	Failed very slowly after first signs of dullness.
		Total time, 3 hr. 6 min. 46 sec.		
J	0	12 min 30 sec	3	The nose of the tool broke off while feeding across.
	1	30 min 48 sec	8	Failed rapidly after indicating wear.
	2	29 min 42 sec	7	Showed wear two minutes before failure occurred.
	3	1 hr 14 min	18	Gave indication of wear, the nose of the tool breaking while the power feed was engaged.
		Total time, 2 hr. 27 min.		
R	0			Tool broke when feeding in by hand to the proper depth.
	1	15 min	4	Grew dull soon after the start.
	2	5 min	1	Failed rapidly
	3	4 min 12 sec	1	Failed rapidly
		Total time, 24 min. 12 sec.		

TABLE V. (Continued)

Brand	No.	Time	No. of Cylinders	Remarks
K	0	11 min 48 sec	3	Failed suddenly.
	1	28 min 48 sec	7	Became dull and failed within one minute.
	2	22 min 12 sec	6	Failed six minutes after the first signs of wear.
	3	42 min 30 sec	10	Failed very slowly.
		Total time, 1 hr. 43 min. 18 sec.		
D	0	47 min	12	Failed very slowly.
	1	26 min 42 sec	7	Failed very slowly.
	2	29 min 18 sec	7	Failed gradually.
	3	1 hr 10 min	17	Gave indication of wear 35 minutes before failure occurred. Almost impossible to ruin the tool as it continued to cut while at a high red heat.
		Total time, 2 hr. 53 min.		

A marked characteristic of this steel is the tendency to dull quickly but continue to cut. It is also very difficult to "burn," and cools quickly after the cut is finished.

Brand	No.	Time	No. of Cylinders	Remarks
F	0	2.4 min	1	Tool broke.
	1	25 min	6	The nose of the tool broke but continued to cut for ten minutes before failing.
	2	1 hr 7 min	17	The nose of the tool chipped after 15 minutes.
	3	20 min	4	Dulled quickly but continued to cut.
		Total time, 1 hr. 54 min. 24 sec.		

TABLE VI. RECAPITULATION OF TEST RESULTS

Brand	First Run: Total Time for Four Tools H.	Min.	Sec.	First Run: Average Time for One Tool H.	Min.	Brand	Second Run: Total Time for Four Tools, Hr.	Min.	Sec.	Second Run: Average Time for One Tool, Min.
A	9	26	54	2	21 7	B	3	6	46	46 6
B	7	50	18	1	57 5	D	2	53		43 2
C	7	7	12	1	46 8	J	2	27		36 7
D	7	1	12	1	45 3	C	2	25	43	36 4
E	6	59	12	1	44 8	M	2	22	52	35 7
F	6	56	24	1	44 1	A	1	56	48	29 2
G	5	54	6	1	28 5	K	1	43	18	25 8
H	4	44	8	1	11 0	F	1	54	24	28 6
J	3	13	17		48 3	H	1	42	18	25 5
K	2	37	13		39 3	N	1	41	12	25 3
L	2	25	6		36 2	P	1	38	18	24 1
M	2	23	34		35 9	G	1	36	12	24 0
N	1	51	12		27 8	E		54	54	13 7
O	1	19	24		19 8	L		37	54	9 5
P	1	11	30		17 9	R		24	12	6 0
R		41	18		10 2	O		20		5 0

TABLE VII. HARDNESS OF TEST TOOLS

Brand	No.	Scleroscope Reading: At the Extreme Tip of the Nose	Scleroscope Reading: ½ In. Back of Nose
J	0	70–75	80
	1	62–64	78
	2	65–68	82
	3	62–67	78
C	0	65–68	78
	1	65–70	80
	2	65–70	88
	3	65–70	78
A	0	68 70	82
	1	73–75	82
	2	65–70	82
	3	65–70	85
R	0	70–72	85
	1	68 70	82
	2	70–72	80
	3	70–75	80
D	0	73–75	83
		60 65	75
	2	65–70	79
	3	74–76	90
N	0	70 72	80
	1	62–64	80
	2	70 74	80
	3	70–72	87
F	0	70 72	82
	1	65–70	85
	2	60–65	78
	3	70 72	82
O	0	65 70	77
	1	65 70	82
	2	68 70	80
	3	65 68	80

Brand	No.	Scleroscope Reading: At the Extreme Tip of the Nose	Scleroscope Reading: ½ In. Back of Nose
H	0	68–70	82
	1	65–70	82
	2	65–70	77
	3	70–73	80
M	0	68–70	80
	1	65–70	80
	2	70–73	85
	3	70–72	87
L	0	70–75	85
	1	70–75	82
	2	68–70	75
	3	70–72	82
B	0	65–70	78
	1	65–68	75
	2	70–73	80
	3	70–75	85
P	0	60–65	72
	1	58–60	65
	2	60–62	72
	3	65–67	70
R	0	65–68	78
		60–65	77
	2	60–64	75
	3	60–65	72
K	0	65–70	78
	1	62–65	81
	2	60–65	74
	3	65–70	80

cured. It will be noted that in general the hardness varied from 75 to 85, or within 10 points.

(Part IV, the last of the series, will be published in our next issue.)

Legal Notes

By Wellington Gustin

Reliability of Trade Journal Quotations in Trade Contracts

On appeal to the Supreme Court of Washington, the Trans-Pacific Corporation has been able to have the judgment obtained against it by the Marden, Orth & Hastings Corporation reduced from $15,680 to $13,440. The reduction is due to the difference in the market price of Manchurian pressed soya bean oil. The lower court had found that the breach of the contract for sale of said oil had occurred on April 11, 1918, while the Supreme Court determined the date to have been Feb. 19, 1918.

The action arose out of a contract between the parties for the delivery of 400 long tons of the soya bean oil. The contract of sale, under date of November, 1917, called for a price of $14.25 per 100 lb., the oil to be shipped immediately from the Orient and delivered c.i.f. (cost, insurance, and freight paid) at Seattle, Washington. The oil in due course should have arrived in Seattle in about four weeks. The contract was made through Horace J. Holley & Co., brokers, and payment was to be made upon arrival of the oil at Seattle.

After making the contract the Trans-Pacific Corporation requested and obtained from the purchaser corporation a letter of credit of $130,000 issued by the Equitable Trust Co. of New York. This was done as a matter of accommodation by the purchaser to aid the seller in procuring and shipping the oil from the Orient, so as to hasten delivery. The letter of credit referred to the shipment of oil as f.o.b. Seattle, when it ought to have been c.i.f. Seattle. This error, however, was corrected within a few days at the request of the seller. But some delay was occasioned thereby in furnishing the letter of credit as requested, which the seller claimed was an excuse for its failure to deliver the oil as contracted for, the price of oil advancing in the meantime.

There was nothing in the contract indicating that the purchaser was to furnish any letter of credit to aid the seller in procuring the oil in the Orient. Further, there were negotiations subsequently between the parties and an extension of time was mutually agreed upon for delivery of the oil. Hence this excuse for failure to deliver was unavailing.

Holding of Court as to Date of Breach of Sale Contract

The Supreme Court fixed Feb. 19, 1918, as the date for breaching the contract by the seller, because the purchaser had notified the latter by letter that, unless some definite advice be had as to delivery of the oil by that date, it would buy the quantity contracted for in the open market and charge the difference in price to the seller. The seller made no response to this letter and the purchaser wrote other letters demanding damages for failure to deliver the soya oil. Finally the seller wrote the purchaser, April 11, declining to accede to its demands. This date was fixed upon by the trial court as the date for breaching the contract when the market price of the oil was 16c. per lb. in Seattle. But the Supreme Court held that the purchaser's letter fixed the date as of Feb. 19, when it gave notice that it would go into the open market and buy. The price of the oil at this date was 15¾c. per lb., which marks the reduction in the judgment rendered.

Legal Validity of Trade Journals' Market Quotations

Finding a proper market price for determining the damages resulting upon a breach of a sales contract is often a difficult matter. Market quotations in recognized journals and trade papers have become acceptable to the courts in finding values, and this results in a great advantage to business men and to trade and industry. Men may contract with reference to such quotations, and have a ready basis for determination of their losses and gains.

In the instant case the market value of soya bean oil at Seattle was established by quotations from a trade journal. Appealing from the trial court's ruling admitting several issues of the journal in evidence, counsel for the seller contended such market reports were too unreliable to be received as evidence. The Supreme Court held that, since other evidence showed the journal to be one of repute, and its quotations of market prices of oils, including soya bean oil, to be accepted by the trade generally throughout the United States as reliable and trustworthy, the journal was properly received in evidence.

The general rule as to the admissibility of such evidence to show market value of standard commodity of merchandise was quoted by the court as follows:

"It is a rule recognized generally that market reports or quotations as contained in newspapers, trade journals, trade circulars, price lists, etc., are competent evidence of the state of the market. Indeed, such reports, based as they are upon a general survey of the whole market, and constantly received and acted upon by dealers, are far more satisfactory and reliable than individual entries or individual sales or inquiries, and courts would justly be subject to ridicule if they should deliberately shut their eyes to the sources of information which the rest of the world relies upon, and demand evidence of a less certain and satisfactory character. Such evidence is within an exception to the general rule barring the admission of hearsay evidence inasmuch as it comes from a public authentic source which is deemed to give it reliability."

No Liability if Experienced Employee Chooses Unsafe Methods

In case of negligence brought by an employee against the Monroe Oil & Fertilizer Co. a judgment in favor of the company has been affirmed in the Georgia Court of Appeals. The evidence shows that the plaintiff employee undertook to put a belt on a rapidly revolving pulley, and was injured in so doing. It also appears that the employee had a choice of two ways of putting the belt on the pulley, one a safe way and the other a dangerous one. Both of these ways were known to the employee and he chose the dangerous way.

The employee having selected the dangerous way, he cannot recover of the employer for his injuries thus sustained, although his conduct in selecting that way may not have amounted to actual rashness, said the court.

The Galvanometer*

By E. F. Northrup

BY MEANS of instruments we learn that certain forces in nature are active and energy transformations are in progress, the very existence of which would otherwise remain forever hidden because they affect no sense of the living organism. Thus instruments are required for the detection of the feeble electric currents which circulate in the soil, or the magnetic field of the earth, or the radio-active transformations of slowly disintegrating matter, or Roentgen rays, or ultra-violet radiation, or long electromagnetic waves. These forces and many others excite no response in the living organism, which is unprovided with senses for their detection. (One may here suggest that perhaps Sir Oliver Lodge, or his associates, will yet devise an instrument which will be sensitively responsive to disembodied spirits when they make a near approach. The invention would be welcome because the five senses of most people seem disappointingly inadequate for giving informing knowledge!)

The facts are that the history of the acquisition of modern scientific knowledge in all its branches is closely paralleled by the history of the invention and the perfecting of scientific instruments; instruments which reveal existences in nature to which none of the five senses is even qualitatively responsive, and a multitude of other instruments which aid and supplement the senses by immensely extending their range.

If, in some museum of high repute, a Hall of Fame should be established wherein would be gathered, and historically grouped, typical examples, held worthy of admission, of all scientific instruments of investigation, an observer would have before his eyes the entire history of science from the days of Gilbert, or of astronomy from the days of Tycho Brahe. In this Hall of Fame in prominent setting would be seen the galvanometer. Beneath it would be placed a large card on which would be printed the fascinating story of the wizard-like achievements of modern electrical science, alone made possible because of the invention of this wonderful little instrument.

Discovery of the Galvanometer

The real discoverer of the galvanometer was Oersted, when in 1820, only one hundred years ago, he noted that a compass needle placed close to a wire transversed by the electrical current set itself at *right angles* to the wire. Here was discovered a new force entirely unique, and an instrument absolutely new was invented. This force could never have been noted if man had worked with his five senses only.

All galvanometers constructed from that day to this depend for their action on this observation made by Oersted. In some instruments the wire which carries the electric current is stationary and a delicately suspended magnetic needle is allowed to turn. In another class of instruments the wire which carries the current is wound up into a coil and this coil is delicately suspended and turns in the field of force supplied by a massive magnet, itself held stationary. Thus galvanometers are divided into two general classes: moving-magnet and moving-coil galvanometers, but both groups operate alike obedient to the forces discovered by Oersted.

The moving-magnet galvanometer was brought to a high state of development and given astonishing sensitivity by the then Sir William Thomson. Due to his invention of this marvelously sensitive detector of feeble electric currents, the successful registering of signals sent over the first transatlantic cable was made possible. To it we owe, in truth, the first realization of practically instantaneous communication between the two worlds on the opposite sides of the Atlantic.

The Moving-Coil Galvanometer

The moving-coil galvanometer has no single achievement so brilliant as this in its record, because it can be made only a fifth or a tenth as sensitive as the moving-magnet form. It is, however, a far more convenient and less erratic instrument to work with, and for this reason has taken its place, in preference to the more sensitive moving-magnet galvanometer, as the most used of scientific tools in every laboratory of physical research and instruction throughout the world. When this instrument is supplemented with current-carrying shunts, currents of the greatest magnitude producible—20,000 amp. or more—can be measured, and yet this simple instrument when designed to peer, as it were, into the micro-cosmic world can detect the existence of an electric current too small for the imagination to conceive. Thus a moving-magnet galvanometer, with good working qualities and designed for very moderate sensibility, will give a millimeter deflection on a scale one meter from its mirror when 188×10^{-9} amp. flows through its coil. This figure means nothing to the mind unless translated into an idea which in some measure can be conceived. Thus the current which this galvanometer will easily measure bears the same relation to an ampere, which is about the current used to operate a large incandescent lamp, as do 240 centimeters to the diameter of the earth.

The moving-coil galvanometer has received at the hands of designers protean forms and has been made to meet the most varying requirements. No single instrument can fill all the requirements of a laboratory of instruction or the exacting demands of research. Certain features, however, have come to be recognized as useful embodiments in any instrument of this type. Among features which I judge to be generally desirable may be listed the following:

Extreme Simplicity of Construction

Most laboratories make use of many galvanometers and simplicity of construction enables the instruments to be manufactured at low cost so many can be purchased. Then, too, those unfamiliar with the handling of galvanometers will much more readily acquire skill in handling an instrument of good performance but simple construction than they would one of slightly better performance obtained at the expense of refinements secured by more elaborate construction.

Moving Parts Visible

It is a great convenience to have the entire moving system of the galvanometer plainly exposed to view. The instrument is much more readily leveled up and when using the instrument to detect when a Wheatstone bridge or other instrument is balanced, it is convenient to be able to make preliminary adjustments by observing the movements of the coil itself, re-

*From Pyrolectric Bi-Monthly Bulletin No. 11.

ferring to the spot on the scale only when the adjustments grow close.

Protected Suspensions

The upper suspension of a galvanometer is readily broken and the lower spiral suspension becomes easily tangled. The upper suspension should therefore be attached to a delicate spring at its upper end so that a slight pull on the suspension will only stretch the spring and not break the suspension. The lower, spirally wound, suspension should consist of a long spiral not easily tangled.

Adjustment to Zero

The adjustment of the moving coil to bring the no-current reading to the zero of the scale should be easily effected; a touch of the forefinger on the adjusting device should do this.

Good Working Parts

The rotating parts should be so proportioned that without loss of sensitivity the galvanometer will reach a full deflection in from two to three seconds.

Sensitivity

It is a frequent error to adjust a galvanometer to a far higher sensitivity than the nature of the work requires. A sensitivity of ½ megohm for each ohm of coil-resistance will more than meet general requirements. High sensitivity obtained at the expense of an unstable zero reading is always to be avoided.

Coil Clearance and Stability

The inexperienced find usually extraordinary difficulty in setting up and operating a galvanometer which possesses a very small coil clearance. The slight advantage of extra sensitivity obtained by making the coil clearance very small is wholly offset by the practical difficulties in setting up and operating the instrument. The accidental passage through the coil of a large current is sooner or later likely to happen and provision should be made to prevent in this case the coil from spinning several times around, thus twisting up its suspensions.

Galvanometer Mounting

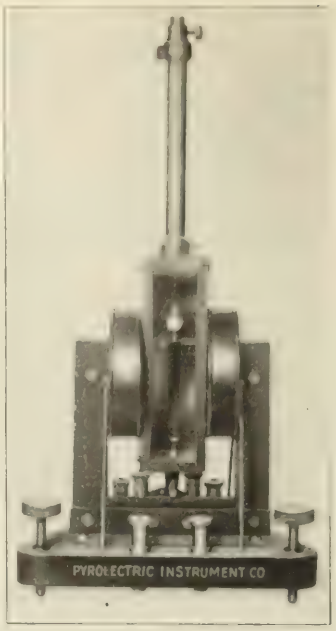
The instrument should be so designed that, with little trouble in effecting the change, the galvanometer may be mounted either on a wall or on a stand to be used on a bench or table.

Alternating Current Galvanometers

The alternating current galvanometer, such as illustrated, while primarily designed for use with alternating currents, is extremely valuable for several classes of work in which the direct current galvanometer is ordinarily employed. The following applications are pertinent:

1. For the accurate measurement of the resistivity or conductivity of salt solutions and other electrolytes.

Various devices have been employed for measuring the resistivity of electrolytes, using the Wheatstone bridge method and an alternating current as a measuring current. Among these devices the instrument most used as a detector is the telephone receiver. The a.c. galvanometer may, however, be substituted for telephone receiver to very great advantage.



A. C. GALVANOMETER

2. For the measurement of the resistivity of molten salt.

This may be done by a method not essentially different from that described by Northrup & Sherwood in the *Journal of the Franklin Institute* for October, 1916, in a paper entitled "New Methods for Measuring Resistivity of Molten Materials; Results for Certain Alloys." The above-mentioned paper describes a method in which a "resistometer" is used in conjunction with an a.c. galvanometer and Kelvin double bridge.

3. For the measurement of resistivities of molten metals. Metals in a molten state and at a high temperature invariably develop parasitic emf.'s where the potential terminals are located, and thus preclude the use of direct currents when measuring resistivities by the Kelvin double bridge method. By using alternating currents and an a.c. galvanometer their resistivities are easily measured. See numerous papers by the writer, in *Journal of the Franklin Institute.*

4. For the measurement of any resistance in which small irregular emf.'s exist.

By the use of an a.c. galvanometer and an alternating current, the resistance of a circuit or portion thereof containing a thermal emf. or even small battery emf.'s is measured as readily as a resistance free from these emf.'s is measured by using direct current and an ordinary d.c. galvanometer.

5. For high sensitivity direct current characteristics.

When the field coils of this instrument are excited with direct current, the sensitivity obtained is dependent on the strength of the field current. It is possible to produce a sensitivity of measurement (either current or voltage sensitivity) with this instrument that is unattainable with other instruments.

The writer prefers the a.c. galvanometer for all classes of resistance work and uses it invariably in his own laboratory.

The Potash Deposits of Germany

The potash deposits of Germany, which were discovered by the Prussian Government in 1843 at Stassfurt while boring for rock salt and which occur in upper layers of rock salt in the plains of northern Germany, have been estimated to occupy a volume of 10,790,000,000 cu.m. and to contain 20,000,000,000 metric tons of potash salts, corresponding to about 2,000,000,000 metric tons of potash (K_2O), a quantity sufficient to supply the world for 2,000 years at the present rate of consumption. These beds, according to the United States Geological Survey, Department of the Interior, were first exploited about 1860, and have furnished practically the entire world's supply of potash for many years.

New Process of Japanning

Baking japan as ordinarily used in manufacturing consists of two elements, the base and the solvent. The base is usually some variety of asphalt, combined with linseed or some similar oil, the whole making a hard rubbery-appearing substance. This must be liquefied for use, and the common practice is to dissolve it in naphtha or kerosene. The process of japanning various metal articles consists in dipping them in the liquid japan, and then baking them in an oven.

Owing to the volatile and inflammable type of the solvents used, this baking process is somewhat hazardous. After several bakings have been consummated, the atmosphere in the oven resembles that of the inside of a gasoline engine cylinder, only needing a spark, or even excessively high temperature, to cause an explosion of great force. Occasionally the results of these ovens blowing up have been disastrous, due to losses from fires, caused by the explosion.

Non-Combustible Japan Solvent

The manufacturers consequently became interested in the possibility of developing a type of japan which has a non-combustible solvent. The Research Laboratory of the General Electric Co. was requested to try to evolve such a product, and a course of research resulted in the development of a variety of japan which eliminated the necessity of a solvent possessed of the destructive propensities of the conventional kinds.

This water japan, as it is called, is an emulsion of the asphalt oil base with water. By this is meant that infinitesimal particles of the base are held in suspension in the water, instead of being dissolved in it. It was found that this japan had no tendency to settle out, even after months of storage, and that, owing to its being "suspended" in water, losses by evaporation were practically negligible.

Methods of Japanning

The methods of applying the japan are two in number: the electric dip and the hot dip.

The first method, or the electric dip, which is the most appropriate for small articles, consists in placing them, charged positively, in a negatively charged iron tank of japan. The result is that an even, smooth coating of japan is deposited on the articles in question, and, since the japan is deposited free from solvent, there is no resultant drip when the lot is conveyed to the baking ovens.

The second method, or the hot dip, which is applicable to large pieces of metal, was found more or less by chance. It has been the custom in the laboratory to pre-heat the metal before dipping, in order to free it from dirt and grease. This pre-heating evidently had the same effect of causing the japan to form a deposit on the metal as the giving to it of a positive electrical charge would have.

A third method is also sometimes used which is a combination of the two already mentioned; that is to say, the metal to be japanned is both heated and positively charged.

The result has been that a variety of japan has been evolved that gives exactly the same effects as the solvent variety. It is cleaner to handle, owing to the absence of drip, and eliminates the danger from explosions and disastrous fires that were such an unpleasant feature of the old form of this highly necessary compound.

Apparatus for Rapid Determination of Moisture

A labor-saving weighing device for determining the amount of moisture in a sample of paper, coal, glue, dye, soap, etc., has recently been brought out on the market by the Williams Apparatus Co. of Watertown, N. Y.

The apparatus consists of a double-walled electric oven with thermostatic control. Torsion balances accurate to 0.1 per cent, with weighing pan so constructed that the sample can be weighed either outside or inside the oven, is situated on top of the oven. The beam of the balance is designed so that the percentage of moisture can be read directly, thus eliminating all calculations.

To determine the percentage of moisture in a sample, set the thermostat to hold the temperature at the desired point. Temperature of the oven is then read from a thermometer inserted through the side. After constant temperature has been obtained, adjust the balance to equilibrium by means of tare weights, and weigh sample in the usual manner. Place the weighed sample on a weighing pan in the oven and allow it to remain until balances no longer register a loss. Again bring balances to equilibrium by means of sliding weight on beam. The sample is then at constant weight and the percentage of moisture is used directly. The time required is usually about ten minutes. Separate pans are provided so that several samples may be drying at the same time.

The advantage of such a mechanism in control work over the old method of weighing is self-evident, when one considers the considerable amount of time lost by the old method in weighing, using a dessicator, cooling, reweighing, and then repeating the process until a constant weight is finally obtained.

Power Hammer for Pulverizing Pig-Iron Samples

The time and labor required for pulverizing samples of pig iron for analytical purposes can be greatly reduced by the use of a Fairbanks power hammer, which the United Hammer Co., Boston, Mass., has designed for laboratory use. Pieces of pig iron ½ in. to ⅝ in. diameter can be pulverized in two or three minutes so that particles are fine enough to pass an 80-mesh sieve.

In one plant where this machine was installed it formerly required the labor of three men with 26-lb. sledges for twelve minutes to reduce ½-in. cubes to a sufficient degree of fineness. By the use of the power hammer the labor of two men was dispensed with and the time of the operation reduced from twelve minutes to two minutes.

The Fairbanks machine is built in two types, either belt- or motor-driven, with a 100-lb. weight of ram and 2-in. mortar and pestle. The advantages of the machine are simplicity of operation, the fact that it is under control of the operator at all times and that it is capable of striking a blow of about 600 lb. when running at 300 r.p.m.

Synopsis of Recent Chemical & Metallurgical Literature

Infusorial Earth Industry.—The results obtained during fifteen years of research and practical work by A. BIGOT, on infusorial earth, are described in the February, 1920, issue of *Revue de l'Ingénieur et Index Technique*, pp. 301-326. After giving some information on the raw material, its formation and geographic distribution, he describes and illustrates diagrammatically the influence of heat on its properties. Thus: The porosity increases with the temperature, but its aspect and volume remain the same up to about 700 deg. C. (1,290 deg. F.). Above 700 deg. C. (1,290 deg. F.) and especially beginning with 1,000 deg. C. (1,830 deg. F.) the shrinkage is very pronounced, the density rising from about 0.5 to about 2.2. The vitrification point and temperature of fusion vary between 1,300 and 1,600 deg. C. (2,370 and 2,910 deg F.) according to its chemical composition. The higher the percentage of silica the higher the melting point.

M. Bigot describes and illustrates its main properties, especially its power of absorbing gases and liquids, and its hardness. It is also sound-proof and a heat-insulator. These properties contribute to the great variety of its industrial applications, among which the most important are:

(1) As oxidizer and antiseptic used for bleaching, disinfecting and purifying.

(2) To precipitate gelatinous, colloidal or albuminous matter, in sugar refineries, breweries, distilleries, wineries, or oil refineries.

(3) To absorb liquids, when it finds convenient applications in the manufacture of dynamite, as a disinfectant, a fine abrasive, in fertilizers, in paints, in pharmaceutics and perfumery.

(4) As a sound insulator it can be used in the form of powder, granules or bricks. Taking the sound-insulating property of air as unity, that of a 0.5 density infusorial earth would be about 500.

(5) For light building construction.

(6) As heat and cold insulator, when it is used mainly as insulating material in the construction of industrial furnaces and refrigerators.

Resistance of Steels to Machining.—An explanation of the fact that some steels of a given tensile strength cannot be machined with tools which can be used for steels of higher tensile strength based upon the supposition that tensile strength at the neck is directly proportional to the cutting hardness is advanced by CH. FREMONT in a note presented at the March 1 meeting of the French Academy of Sciences (*Comptes Rendus*, vol. 170, No. 9, pp. 513-514). He cites the case of a steel of tensile strength of 78 kg. per sq.mm. (111,000 lb. per sq.in.) which could not be machined by a certain tool, whereas another steel of tensile strength of 121 kg. per sq.mm. (172,000 lb. per sq.in.) was readily cut by the same tool. If, instead of figuring the tensile strength of the steel on the basis of the original cross-section of the test piece, the ultimate strength be calculated on the basis of net section of the test piece at rupture, more concordant results may be expected. Thus the above-mentioned two steels of tensile strength of 78 and 121 kg. per sq.mm. have in reality a final tensile strength on the net section of 195 and 165 kg. per sq.cm., by which fact the author explains why the given tool could act on the second and not on the first steel.

Influence of Cadmium on Brass.—In the November-December, 1919, issue of the *Revue de Métallurgie*, LEON GUILLET gives a description of the influence of cadmium on brass. The study is timely because the greater part of zinc from western United States contains cadmium in varied amounts. He worked on brasses composed of electrolytic copper, belgian zinc (Vieille Montagne) which is free of cadmium, and metallic cadmium.

The first series of alloys he prepared contained copper 70 per cent, zinc 30 to 25 per cent and cadmium up to 5 per cent. These were submitted to mechanical tests and metallographical studies both before and after the mechanical tests. He gives tables of the different alloys he made and their behavior.

The tests show that:

(1) Up to 0.74 per cent Cd the tensile strength, elongation, resiliency and hardness are not affected.

(2) With 1.67 per cent Cd the elongation diminishes, the alloy becomes brittle and the hardness is somewhat increased.

(3) With 1.92 per cent Cd tensile strength is low, the elongation very small, the resiliency (Charpy impact) low.

(4) With 4.11 per cent Cd the tensile strength becomes insignificant.

The main conclusions to which he arrived are:

One per cent cadmium in brasses with 70 to 60 per cent copper has no appreciable effect.

A cadmium content of more than 1 per cent has a detrimental influence, especially on resiliency.

The changes in the mechanical properties of the brasses are due to the cadmium being present in a free state in the alloys.

Electric Steel Furnaces in Australia. — According to a recent article in the *Industrial Australian*, the manufacture of electric steel has been in operation for some time in Australia. The first plant erected was that of Australian Electric Steel, Ltd., at Alexandria, Sydney, comprising two furnaces of the Electro-Metals type, each having a capacity of two tons. The plant is equipped with all the usual appliances for foundry work, and castings have been turned out in considerable variety for special purposes. Ingots have also been supplied ranging in size from 4 in. square up to 24 x 12, and some of these have already been used for the forging of railway axles with successful results.

In Victoria an important step was taken last year by the Railway Commissioners toward introducing electric furnaces at the Newport shops, when three members of the staff of the Railway Department were sent to America and Canada for the purpose of making inquiries and securing all the information necessary to enable a furnace to be installed. An ample supply of cheap electric current will soon be available for use at Newport from the Department's own power house, and it is desired to take advantage of this fact to supply the demands of the railways for high-grade steel castings.

The Victorian Iron Rolling Co., of Melbourne, is also installing a plant for the production of high-grade steel. In this case the furnace will have a capacity of six

tons, and it is expected to produce about 30 tons of steel per day. The electric current is to be obtained from the Melbourne City Council's mains, and the plant will be in operation within the next few months. In the Newcastle district another company, the Commonwealth Steel Products Co., is about to commence operations. This firm is now erecting a complete plant for making electric steel, rolling tires and forging railway axles, close to the Waratah railway station. The plant is now being erected, and the furnace will use scrap steel. It will derive its current from the Newcastle City Council's supply, and will require 1,500 hp. to operate it. Special interest attaches to the tire mill, which is of a type used extensively both in America and in England, but is the first of its kind to be installed in Australia.

Recent Chemical & Metallurgical Patents

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Manganese and Its Alloys.—Manganese or manganese alloys, low in carbon and silicon, are obtained by oxidation of a manganese alloy comparatively rich in silicon, for example, one containing more than 20 per cent of manganese and more than 10 per cent of silicon, by means of air or oxygen with or without manganese oxides or lime. The production of silicomanganese and the oxidation of the silicon may be effected in the same furnace or in successive furnaces, or ordinary silicomanganese may be mixed in the solid state with the oxidizing agents and the mixture heated to the necessary temperature, or molten silicomanganese may be bessermerized in a basic neutral or acid-lined converter with or without the addition of lime or manganese oxides, or a raw manganiferous material may be reduced with carbon in such a way as to form a manganese silicide which is thereafter oxidized. A similar procedure is used for the production of chromium and its alloys. (Br. Pats. 135,186 and 135,187—1919. AKTIEBOLAGET FERROLEGERINGAR 1, Stockholm; Jan. 21, 1920.)

Treating Fibrous Materials.—Straw, wood, flax, jute and other vegetable fibrous materials are boiled in water with a mixture of one to four parts chalk or other form of calcium carbonate and one part of an alkali compound of low causticity, such as sodium sesquicarbonate, to produce fibers suitable for spinning, for yarns, or for rope making, or to obtain a paper-making material. The residual liquor or the paste settling from it may be used as a detergent with or without the addition of sodium carbonate or soap. (Br. Pat. 135,240—1919. AMBER SIZE & CHEMICAL CO., London, and C. WEYGAN, Maidenhead, Berkshire; Jan. 21, 1920.)

Catalysts.—Catalysts, more particularly for use in the hydrogenation and dehydrogenation of organic substances, are prepared by heating (while excluding air and without the introduction of a reducing agent) an organic salt of a catalytic metal capable of producing hydrogen, for example nickel formate or oxalate, or a mixture of salts such as sodium formate and nickel sulphate. Acetates and lactates may also be used. Other catalytic metals are cobalt, iron, copper, manganese and cerium. The organic salt may be mixed with a substance which will form a support for the catalyst, and will be either inert or adapted to modify the activity of the catalyst or the cause of the reaction. Examples of such additions are infusorial earth, silica, boric acid and the carbonates, formates, and oxalates of the alkali, alkaline earth and earth metals. As a support there may also be used a metal, preferably the same as the catalytic metal in the form of wire, strip, sheet or cloth, the organic salt or mixture of such salts being either pasted on or formed either directly or indirectly on the surface portions of the metal support. (Br. Pat. 135,510—1919; A. BROCHET, Montereau, France; Jan. 28, 1920.)

Purifying Oils, Fats and Fatty Acids.—Fatty acids and their glycerides, especially fish oil and fats, are purified and deodorized by heating, admixture with a porous and powdered substance such as kieselguhr, and treatment with a non-oxidizing gas or a non-aqueous vapor such as petroleum ether or ethyl acetate. (Br. Pat. 135,295—1919. G. CALVERT, Elmhurst, Middlesex; Jan. 21, 1920.)

Vaccines. — Detoxicated vaccines are prepared by dissolving bacteria in alkali and reprecipitating with acid, the process being repeated until the supernatant liquid gives no precipitate with picric acid. As a modification the first precipitate may be washed with a solution of NaH_2PO_4 or other weak acid to remove toxins. The precipitate obtained by either method is either dissolved in alkali or mixed with a solution of NaH_2PO_4 for use. (Br. Pat. 136,036—1919. D. THOMSON, London; Feb. 4, 1920.)

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Ammonia Saturator.—Ammonium sulphate is prepared by absorbing the ammonia in sulphuric acid flowing over staggered baffle plates in a lead-lined cast iron tower. The flow of gas and acid is counter-current. (1,331,784; ARTHUR ROBERTS of Evanston, Ill., assignor, by mesne assignments, to American Coke & Chemical Co.; Feb. 24, 1920.)

Synthetic Thymol from Para-Cymene.—Para-cymene (1-methyl-4-isopropyl-benzene) is nitrated so that one NO_2 group is introduced in position 2. The nitro-cymene is reduced with iron and hydrochloric acid to amino-cymene or cymidine, which is sulphonated. The cymidine sulphate is converted into cymidine sulphonic acid by a "baking process" similar to that employed for the preparation of sulphanilic acid from aniline sulphate. This produces 1-methyl-2-amino-4-isopropyl-3(or 5)-sulphonic acid. The animo group is eliminated by diazotizing and reducing with alkaline stannous chloride or copper powder and formic acid. The sulphonic group may now be substituted by hydroxyl by fusion with sodium hydroxide. This gives 1-methyl-3-hydroxy-4-isopropyl-benzene or thymol. After acidifying the solution, the thymol is recovered by steam distillation. (1,332,680; MAX PHILLIPS of Evansville, Wis.; filed under the act of March 3, 1883; March 2, 1920.)

Current Events
in the Chemical and Metallurgical Industries

May Meeting of the New York Section, A. C. S.

The regular May meeting of the New York Section of the American Chemical Society was held Friday evening, May 7, in Rumford Hall. Dr. Ralph H. McKee presided. Herbert S. Sidebottom read the minutes of the preceding meeting and then asked Ellwood Hendrick to report on the action of the council at St. Louis. Three papers were then read.

The General Chemistry of Gelatine

Dr. Jacques Loeb, of the Rockefeller Institute for Medical Research, gave some valuable information recently found in his investigations on gelatine. He reported conclusive evidence that the three states of gelatine are entirely dependent on the hydrogen ion concentration.

In using different methods from those generally applied by colloid chemists, the speaker arrived at results which can be summarized as follows:

Gelatine behaves chemically like an amphoteric electrolyte which at hydrogen ion concentrations higher than 2×10^{-5}N combines with anions forming gelatine-acid salts (e.g., gelatine chloride, gelatine sulphate, gelatine ferrocyanide, etc.), and at hydrogen ion concentrations below 2×10^{-5}N combines with cations forming metal gelatinates (e.g., Na gelatinate, Ca gelatinate, etc.). At the hydrogen ion concentration of 2×10^{-5}N (or pH = 4.7)[1]—the so-called isoelectric point of gelatine—gelatine combines practically with neither anion nor cation.

These results can be demonstrated qualitatively in a most striking way. Different samples of 1 g. of finely powdered gelatine are prepared by treatment with different acid or alkali for different hydrogen ion concentrations; the powdered gelatine is then put on a filter, the excess of free acid or alkali is washed off with H_2O, and the gelatine samples are all repeatedly washed in the same way with the same concentration of a solution of salt, e.g., M/64 $AgNO_3$ on the filter (under stirring). The free $AgNO_3$ left between the particles is then washed away with H_2O, the gelatine is melted and so much water is added that the volume is 100 c.c. in each case. The hydrogen ion concentration of each sample is determined. When the test tubes containing these gelatine solutions are exposed to light, those with a hydrogen ion concentration above 2×10^{-5}N (pH = 4.7) all turn brown or black in less than twenty minutes, while the others remain permanently clear. In gelatine solutions with a pH of 4.7 or less, all the silver was washed away; in the solutions above a pH = 4.7 it was not washed away, since it was in chemical combination. In a similar way it can be demonstrated with the proper reagents that in all cases the gelatine samples of a pH > 4.7 contain only the metal of the salt with which the gelatine had been treated, and that all samples with a pH smaller than 4.7 contain only the anion of the electrolyte with which gelatine had been treated, while at pH = 4.7 the gelatine contains neither. This characteristic fact can be demonstrated no matter what the salt is which had been used.

The speaker was able to show that these combinations of gelatine with ions occur in stoichiometrical proportions. Thus Mg, Ca, Ba and SO_4 combine with gelatine in equivalent proportions, while H_2PO_4 combines in molecular proportions.

The speaker has been able to show that these stoichiometrical relations furnish the key for the understanding of the physical properties of gelatine. It was found, for example, that gelatine phosphate shows at the same hydrogen ion concentration almost quantitatively the same osmotic pressure and other properties as gelatine salts with monovalent anion; e.g., gelatine chloride. This was expected from the fact that the anion which combines with gelatine is not the trivalent anion PO_4 but the monovalent anion H_2PO_4. On the other hand, the osmotic pressure, swelling and viscosity of gelatine sulphate are considerably lower, which was to be expected from the fact that the analytical results have shown that the ion combining with gelatine in this case is the divalent anion SO_4. The full experiments were published or will appear in the *Journal of General Physiology* (published by the Rockefeller Institute).

Silica Gel and Its Uses

Dr. W. A. Patrick of Johns Hopkins reviewed briefly his work upon the adsorbent properties of silicic acid gel. This gel is prepared by treating sodium silicate solution with hydrochloric acid. The gel is washed thoroughly and dried at 110 deg. C. in vacuo. Even when dried in this manner, the gel contains 5 to 6 per cent H_2O (as determined by heating in a platinum crucible with a blast lamp), but this is retained so tenaciously that the vapor pressure of water in the gel is zero mm. at 300 deg. C.

With proper precautions this material can be reproduced with definite exactness and this, together with the fact that it is chemically inert, makes it an almost ideal substance for the study of the laws of adsorption. A thorough investigation was made, using sulphur dioxide at various temperatures between—80 deg. C. and +100 deg. C. It was found that the irreversibility of adsorption noticed by previous workers on silica gel was due to the presence of traces of air in the vapor. Experiments with air-free sulphur dioxide showed the process to be perfectly reversible. The empirical equation of Freundich was found to hold over almost the entire range studied. The chief disadvantage in the use of this equation, however, is the fact that the constants are not independent of temperature. Consequently, a large number of isotherms must be determined experimentally.

From a study of their results, Dr. Patrick and his

[1] The symbol pH (Sörensen's logarithmic symbol) represents the logarithm of the hydrogen ion concentration with the sign changed. In the present instance the logarithm of the hydrogen ion concentration is $\log 2 + \log 10^{-5} = 0.30103 + (-5) = -4.7$ or 4.7 with the sign changed, so that pH = 4.7.

co-workers came to the conclusion that the adsorption of gases or vapors at all temperatures below the critical could be predicted from a knowledge of the physical constants of the gas or vapor alone. In developing this theory, a relation between the weight of gas adsorbed and the equilibrium pressure was sought. It was finally found that such a relation did exist if the volume were used instead of the weight and if the equilibrium pressure were replaced by the corresponding condensation pressure, that is $p \div p_o$ where p is the partial pressure of the gas over the adsorbent and p_o is the vapor pressure of the liquid at the temperature of measurement.

But the vapor pressure of a liquid in a capillary tube is lower than the normal vapor pressure because the liquid in capillary is under tension or negative pressure. This effect can be calculated thermodynamically. The corresponding effect on the density of the liquid in the pores can be calculated, provided the compressibility coefficient is known. Unfortunately, this has not been determined for liquid sulphur dioxide, but Richards' relation between surface tension and compressibility ($\beta\sigma^4_3 = k$) suggested the use of σ in modifying the empirical equation.

The following equation (in which the constants are independent of the temperature) was found to hold for the experimental data.

$$V = K\left(\frac{p\sigma}{p_o}\right)^{\frac{1}{n}}$$

For the system silica gel-sulphur dioxide, $K = 0.1038$ and $\frac{1}{n} = 0.447$.

From the industrial point of view, silica gel offers certain advantages as an adsorbent material. While its ability to adsorb gases is about the same as that of charcoal, it is chemically inert and stable up to 700 deg. C. Furthermore, it can be easily and cheaply prepared on a commercial scale. It has been applied industrially in the drying of air and other gases, in the recovery of gasoline from natural gas and also in the recovery of solvents.

Electro-Endosmosis

Dr. T. R. Briggs of Cornell closed the program with an account of electro-endosmosis—the phenomena observed in the transposition of liquids through porous diaphragms when under electric potential. It is a general law that if two substances are brought into contact with each other, the one possessing the higher dielectric constant will become positively charged. Water has a very high dielectric constant and therefore, when under sufficient electric potential and in contact with a stationary diaphragm having a smaller constant, migrates from anode to cathode, conducting electric current in a similar manner to positively charged ions, colloidal particles, etc. If the diaphragm particles were not rigid and were free to move, they would migrate toward the anode, conducting electric current of opposite sign to that carried by the water particles. This latter phenomenon is known as cataphoresis.

Electro-endosmosis has been applied industrially as a means of pumping water from such materials as peat, but the process has not been rewarded with financial success, not, however, because it was an uneconomical or impractical method of drying. Cataphoresis has given a very satisfactory method for preparing pure clay. The clay substance is electrically conducted to and deposited in a revolving drum pole in a very pure state. A series of photographs was shown giving views of a plant and drawings of the installation. In Germany an attempt has been made to generate electric current by pumping water through diaphragms, but the frictional losses were too great to make it a competitor of the dynamo.

New Jersey Chemical Society

The regular meeting of the New Jersey Chemical Society was held in Newark Monday evening, May 10. After an informal dinner President Carleton Ellis opened the meeting. The secretary read the acceptance of many new members and announced that the society now has a membership of 390. Announcement of an excursion to the Seaboard By-Product Coke Co. on Saturday, May 22, was made.

H. E. Otting, assistant superintendent, Nestlé's Food Co., New York City, then gave a résumé of the work done by the chemists in the milk industry.

The Chemist in the Milk Industry

Too much credit cannot be given the chemist to his service both to the manufacturer and consumer of milk. By means of the Reese Gottlieb test he has brought about a standardization of milk and milk products which enables the manufacturer to meet all the existing Government requirements and insures the consumer a standard product.

He has furnished the manufacturer with accurate reports of milk products going into a case of finished goods and so developed plant control work as to keep a close check on all operations, thus reducing costs to a minimum. In addition he protects the manufacturer and consumer by careful inspection of fresh milk received at plant, and tests both raw materials and finished products for conformity to standards.

No minute detail is allowed to escape and special attention is given to the sanitary condition of the plant and its operation so that now the milk industry may be said to be run on a scientific basis.

Various milk products, such as evaporated milk, condensed milk, homogenized milk, malted milk, milk powder and infants' food were exhibited and their process of manufacture described.

Zinc Manufacturing Industry of New Jersey

John S. McKaig, of the New Jersey Zinc Co., gave a brief description of the development of the wonderful zinc deposits of Franklin Furnace, N. J. The concentration of the ores, smelting and refining of the metal, packing and shipping methods were well illustrated with moving pictures of their plant.

Some of the uses of zinc and its compounds, particularly zinc oxide as a pigment in paint and a filler in rubber, were then discussed.

Detroit Engineering Society

The Detroit Engineering Society held its annual meeting in the Palm Room of the Hotel Cadillac, Friday, April 23, with the following speakers: Mortimer E. Cooley, dean of engineering, University of Michigan; William H. Walker, director of the division of industrial co-operation and research, Massachusetts Institute of Technology; Harry M. Nimmo, publisher of the Detroit *Saturday Night;* Frank F. Kedzie, president Michigan Agricultural College, and Gardner S. Williams, of Ann Arbor, Mich.

Fate of Dyestuffs Bill

So successful has been the filibuster in the Senate against the dyestuffs bill that it is practically certain that the measure cannot become a law in its present form. What is more, there seems to be no middle ground on which the contending forces in the Senate can meet. The filibuster was non-partisan. While Senator Thomas of Colorado has taken the most prominent part the movement probably has more sympathy on the Republican side than it has on the Democratic side. The fate of the legislation is very uncertain.

While much of Senator Thomas's four-day speech against the bill was very obviously for time-consuming purposes, a considerable portion of his remarks was especially pertinent. A good idea of his argument, and of the nature of the opposition, however, can be obtained from the following short extracts from his remarks:

"Mr. Irenee du Pont was before the committee, an enthusiastic advocate of this bill. He had a right to come, and it was perfectly proper that he should urge consideration of any measure designed, as this is designed, to encourage his business. The companies which he represents in part are among the most prosperous in the United States. During the war they numbered their profits in hundreds of millions. Taken collectively, I have no doubt that with the exception of the Standard Oil Co. and the United States Steel Corporation, the du Pont aggregation is the most formidable of all American enterprises; and I shall not undertake even to guess at the extent of its accumulated millions. It is in powder, and in all the collateral branches of the industry, and it is also in the dyestuffs business.

"A man representing the colossal combination with untold capital not only demands an absolute embargo, but as high a tariff as possible, so that if the embargo should happen to leak they will still have another wall, amounting virtually to prohibition; and, in addition, he asks for the suspension of the Sherman anti-trust law, not as affecting the entire country but only as affecting the dye industry.

"I do not hesitate to say that if it is necessary in order to sustain this industry that we suspend a law universally applicable and designed to protect the people against combinations, plus an embargo, plus a prohibitory tariff, then we ought not to sustain the industry at all. It is the most monstrous proposition in legislation that has confronted me during my term of service. It is the most impudent proposal that I have encountered while serving upon the Finance Committee. . Its end must needs be absolute monopoly; and I here predict, although I am not a prophet nor the son of a prophet, and may not live to see it, that if this bill becomes a law within the next five years the dye industry of the United States will be entirely in the hands of the du Ponts and the National Aniline Co.

"Embargoes are un-American, to begin with, and even when they are universal they are unjust. During the administration of Mr. Jefferson an embargo was laid upon all foreign commerce. The majority of intelligent sentiment at that time, in my judgment, very properly denounced the policy as a grave and intolerable injustice, but it was at least impartial. Like the dews of heaven, it fell upon the just and unjust. This embargo involves one, and one only, of the industries of the country, and leaves the others to go their way until in good time and due to considerations material, political, and otherwise, the terms of the legislation shall be widened and its wings extended that it may shelter other industries seemingly needing that method of protection.

"I think I have said all that I care to say upon this bill. As I stated some time ago, during the progress of the bill through the Senate I expect to offer two or three amendments, and it is only fair to the Senator having charge of the bill that I should outline them. One is the amendment which I offered yesterday to the anti-dumping bill, and which proposes an income tax upon political contributions in excess of $1,000. Another will be the repeal of the excess-profits tax and the substitution in its place of a consumers' tax. The others will be comparatively unimportant. I shall, of course, when the occasion is appropriate, offer these amendments, and have something to say to the Senate regarding them."

Consideration of Conference Report on Water-power Bill

Consideration of the conference report on the water-power bill was not taken up on May 11, as had been expected. Opposition to the conference bill developed such strength that it was evident that considerable discussion would be indulged in. For that reason the Knox peace resolution was given right of way.

The opposition comes largely from New England Senators, who contend that the bill gives the Federal Government unwarranted jurisdiction over matters coming properly within the province of the state. It is possible that certain changes in verbiage may satisfy the opposition, but as the parliamentary situation makes a filibuster easy of accomplishment it is expected that important concessions will be forced before the Senate is allowed to vote on the conference report.

House Accepts Conference Report

The conference report was accepted in the House by a vote of 259 to 30. On the motion to resubmit the bill to the conference committee, with instructions to insist upon disagreement with the Senate amendments regarding the definition of "navigable waters" and regarding charges, the vote was 86 for recommitment and 209 against. The motion to resubmit also provided for agreeing with the Senate amendment regarding the distribution of power to municipalities, which had been stricken out in conference.

While the adoption of the conference report was hailed on one hand as the best example of constructive legislation of recent years, a very determined minority sees in the bill the surrender of one of the last great public assets and a dangerous infringement upon the rights of the states. The definition of "navigable waters," as agreed upon by the conferees, was declared to violate "settled principles of law" as well as the rights of the states and of individuals. That these arguments did not carry very great influence may be judged from the vote. The vote was not partisan.

Representative MacGregor of New York, one of those voting against the conference report, objected particularly to the amendment requiring a license to distribute power to communities in the vicinity of the plant.

Representative Sinnott, one of the leaders of the House, in the course of his remarks on the bill, said: "All through this bill the right of the state is recognized. The state may fix charges and may also control securities."

Budget Bill

The conferees on the budget bill have practically reached an agreement and promise is held out of legislation before adjournment previous to the national conventions. Budget legislation, which has the approval of both parties, is expected to result in the saving of large sums annually in the conduct of the various Federal agencies. The conference bill will place all responsibility for estimates of expenditures with the President, but will put the Bureau of the Budget in the Treasury Department.

Exports and Re-exports of Chemicals

Exports of chemicals during March, 1920, were valued at $18,885,433, according to figures compiled by the Bureau of Foreign and Domestic Commerce. This is an increase of $5,675,498 in the value of chemical exports for February. Some of the items making up the total, as well as revised figures for March, 1919, are:

Exports of Chemicals:	March, 1919	March, 1920
Acids:	Lb.	Lb.
Carbolic	204,960	214.002
Nitric	58,386	106,883
Picric	633	173
Sulphuric	972,687	2,469,734
Benzol	221.546	221.211
Calcium carbide	2 177 323	3,384,816
Copper sulphate	2,009,234	705.542
Lime:		
Acetate of	174,855	2,807,977
Chloride of (bleaching powder)	1,813,346	2,564,039
Chlorate of potash	69 307	187.152
	Value	Value
Total sodas	$1,492 707	$ 2,525,098
Total chemicals	9 681,692	18,885,433
Total dyes and dyestuffs	880,247	3,635 518
Medicinal and pharmaceutical preparations	1.218.409	1,944,111

Some of the import figures, as compiled by the Bureau of Foreign and Domestic Commerce, are as follows:

		Lb.	Lb.
Acids (except coal-tar acids):			
Oxalic	duty	none	377,523
All other	free	1,750,815	2,011,696
	duty	118,430	515,936
Chemical and medicinal compounds:			
Alkalis, alkaloids and preparations, mixtures of	duty	280.495	670,889
Medicinal preparations	duty	42,055	70,160
		Value	Value
Total coal-tar products		$ 388,399	$ 532,311
Total gums		1,849,377	5,704,581
Total chemicals, drugs, dyes, etc.:			
Free		4.174,504	13,352.532
Duty		3,315,930	7,277,911

Re-exported chemicals, as compiled by the Bureau of Foreign and Domestic Commerce, are:

	March, 1919	March, 1920
Acids:	Lb.	Lb.
Carbolic	1,904	None
Oxalic	None	23,756
All other	7,883	236,111
Extracts and decoctions for tanning:		
Quebracho	36 583	1.170,130
All other	2,341	511,900
Gums:		
Camphor, crude, natural	None	435
Camphor, refined and synthetic	2,350	27,842
Copal, dammar and hauri	315,311	228,989
Gambier, or terra japonica	13,042	4,199
Indigo, natural or synthetic	None	66,109
Iodine, crude or resublimed	1,549	None
Licorice root	2,056	4,902
Opium, containing 9 per cent and over of morphia	1,550	38,744
Carbonate of potash	139,784	1,200
Nitrate of soda	3,083	477
	Value	Value
Total chemicals	$ 566,045	$ 1,200,878

Alcohol as Motor Fuel

Scarcity and high price of petrol have caused the British Government to seek a substitute motor fuel. Among the many possibilities, alcohol from vegetable matter seems most promising. Extensive new laboratories and a special staff of assistants under the direction of Prof. H. B. Dixon are being provided to study this important problem.

Sulphur and Phosphorus Investigation

A second statement of progress has been issued by the Joint Committee on Investigation of Phosphorus and Sulphur in Steel, whose activities have already been mentioned in these columns.*

The committee on statistics has completed a bibliography of the literature. It has also made a survey of used material in the shop of two large Eastern railroads and has secured certain high-phosphorus and high-sulphur material that has been in service, including some connecting rods, a car axle, a crankpin, some parts from a high-sulphur locomotive firebox, and some high-sulphur channels. These will be analyzed and tested by the committee on tests.

A considerable quantity of rivet steel was rolled under observation at the Duquesne works of the Carnegie Steel Co. In all, thirteen ingots (18 x 20 x 72 in. —6,400 lb.) of varying sulphur content, each from a separate heat, were rolled into billets (4 x 4 in. x 4 ft. —220 lb.). In order to eliminate any variable that might be introduced by piping or segregation, it was decided to discard 40 per cent of the steel from the top of each ingot. The next six billets after the top discard, numbered 1 to 6 in sequence, were taken for the purposes of this investigation and each billet was properly stamped with the heat and billet number. Billets 1, 2, 3 and 4 from each ingot were rolled into $\frac{3}{4}$-in. rounds, each billet yielding eight bars 9 ft. 8 in. in length; billets 5 and 6 from each of the ingots were held in reserve. In the attempt to produce a heat high in sulphur, there was obtained the unusually high analysis of 0.17 per cent.

Approximately one-half of the material was shipped to Watertown Arsenal, the U. S. Navy Experiment Station at Annapolis, and the Bureau of Standards, for the various mechanical tests. The remainder was made into rivets at the Pennsylvania Railroad Co. shops at Altoona, and the Champion Rivet Co., Cleveland, Ohio The rivets were made into two types of head, namely, cone and button, and of $2\frac{3}{4}$-in., $3\frac{1}{2}$-in. and 6-in. lengths. Temperature readings of the various bars were taken with an optical pyrometer.

After careful review of all desirable tests and in the light of comments and suggestions, the committee on tests has prepared a schedule covering tension, fatigue, impact, hardness, bend, torsion and shear tests and certain tests for forgeability. Certain "fabrication" tests are also contemplated, which are particularly applicable to the rivet material furnished, such as cold and quench bends, hot flattening, upsetting and tests on the shearing strength of riveted joints.

Proposed Consolidation of Geological Survey and Bureau of Mines

A consolidation of the Geological Survey and the Bureau of Mines is proposed in a bill which has been introduced by Senator Henderson of Nevada, the ranking member of the Committee on Mines and Mining. The consolidated bureaus are to be known as the Division of Mines and Geology and are to be administered directly by an Assistant Secretary of the Interior who "shall be technically qualified by experience and education" for the position.

The bill specifies that the Assistant Secretary in charge of the division is to receive a salary of $10,000.

*CHEM. & MET. ENG., vol. 21, p. 556 (Oct. 29-Nov. 5, 1919); vol. 22, p. 297 (Feb. 18, 1920).

Chem. & Met. to Make Its Own Paper

The McGraw-Hill Co., Inc., together with the United Publishers Corporation, in an effort to solve the shortage in paper, has bought the Newton Falls Paper Mill at Newton Falls, N. Y. This mill, which now manufactures wrapping stock, will turn out magazine stock in the future. Each company holds a half interest in the property, which is valued at approximately $2,500,000.

Philosophical Society of Washington

The May 8 meeting of the Philosophical Society of Washington included a paper by F. B. Silsbee on "Physics of the High-Tension Magneto" and by C. Nusbaum on "The Magnetic Reluctivity Relationship as a Criterion of the Structure of a Eutectoid Carbon Steel." The latter paper is the first of a series of reports which are being prepared as a result of extensive investigations now in progress at the Bureau of Standards studying the correlation of the magnetic properties and physical properties with the composition and prior heat treatment of carbon and special steels.

Personal

Dr. RAYMOND F. BACON, director of the Mellon Institute of Industrial Research of the University of Pittsburgh, who during 1918 was a Colonel in the Chemical Warfare Service, serving as chief of the technical division of the Chemical Warfare Service, A. E. F., has been awarded a citation by General Pershing for exceptionally meritorious and conspicuous services in France.

L. D. BOWMAN, of the Vanadium Alloys Steel Co., delivered a short paper entitled "Some Notes on Annealing" before the regular meeting of the Pittsburgh Chapter of the American Steel Treaters' Society and the Steel Treaters' Research Society on Monday, May 17.

Dr. FREDERIC DANNERTH, who has been retained by the C. Kenyon Co., Brooklyn, N. Y., as consulting chemical engineer, has recently accepted an invitation to become head of the company's new laboratories. He is now planning and organizing the new department and upon completion will assume charge of an extensive program of research and development.

N. E. DORSEY, physicist in charge of the radium and X-ray section of the Bureau of Standards, has submitted his resignation, to take effect at an early date—not later than July 1. Dr. Dorsey has not perfected all of his plans definitely as yet, but he expects to open consulting offices during the latter part of the summer or early fall, specializing in the application of physics to medical practice, particularly X-ray and radium application.

KARL EILERS, recently of the directorate of the American Smelting & Refining Co., has opened private offices at 233 Broadway, New York City.

A. C. FIELDNER, the supervising chemist of the Pittsburgh station of the Bureau of Mines, is conferring with New York and New Jersey state officials in connection with plans for the proposed vehicular tunnel under the Hudson River. He also conferred last week with officials of the Bureau in Washington.

E. D. GORDON, of the weights and measures division of the Bureau of Standards, has resigned to take a position as sales-engineer with the General Automatic Scale Co. of St. Louis. Mr. Gordon will be engaged in both development and special problem work for this company, which contemplates a still further extension of its lines of scales.

N. E. HEHNER, a chemist who has been in the service of the Bureau of Mines, has resigned to enter private employment.

HENRY HOWARD, formerly vice-president of the Merrimac Chemical Co., Boston, Mass., is now associated with the Grasselli Chemical Co. at Cleveland, Ohio.

Dr. C. E. KENNETH MEES, director of the research laboratories of Eastman Kodak Co., landed in England, April 27. While there he will deliver the following lectures before various scientific bodies: "Some Photographic Phenomena in Relation to Astronomy," "Some Results of Recent Investigations on the Theory of Development," "Photography From the Air," "Reaction of the Eye to Light," "A Photographic Research Laboratory," "The Production and Supply of Synthetic Organic Chemicals in the United States," "Rochester and the Kodak Works," "Scientific Research and Industrial Production" and "The Theory of Tone Reproduction With a Graphic Method for the Solution of Problems."

A. G. PETERKIN, formerly assistant general manufacturing manager of the chemical department of The Barrett Co., is now manufacturing manager of the Frankfort plant of the same company.

R. E. H. POMEROY has resigned as smelter superintendent of the Nevada Consolidated Copper Co., and will associate himself with the Bonnot Co., of Canton, Ohio, as chief engineer of its pulverized coal department.

Dr. GEORGE D. VAN EPPS, formerly non-ferrous and oil chemist for the Continental Motors Corp., Muskegon, Mich., is now analytical chemist for the Citro Chemical Co., Maywood, N. J.

C. L. WISWALL, formerly of the Hercules Powder Co., recently accepted a position as production engineer with the Vulcan Detinning Co., Sewaren, N. J.

A. L. WRIGHT, formerly consulting mechanical engineer with the nitrate division of the Ordnance Department, is doing consulting engineering work in Chicago.

E. L. YOUNG has been appointed assistant general manager of the Sunnyside Mining & Milling Co.

Obituary

ARTHUR BENEDICT BELLOWS, first vice-president of the Pittsburgh Testing Laboratory, Pittsburgh, Pa., died Saturday, April 17, 1920.

ARTHUR H. HIORNS, the founder of the Birmingham (England) Metallurgical Society and for forty years head of the metallurgical department of the Birmingham Technical School, died Saturday, April 17, at Water Orton, England.

Prof. A. K. HUNTINGTON, professor of metallurgy at King's College University since 1879, died suddenly on April 17. His appointment terminated in October last year and his colleagues state that his severance from active work had had marked effect upon him. During the war he was engaged in highly specialized work with high explosives for the Admiralty.

JOHN WESLEY HYATT, inventor of the Hyatt roller bearing, died recently of heart disease in his eighty-third year at his residence, Windermere Terrace, Short Hills, N. J. He was born at Starkey, N. Y., and received merely a common school education followed by one year at Eddytown Seminary. Moving to Illinois as a youth, he gave all his time to inventing. Next to the roller-bearing device the most widely known of his inventions is the material called celluloid. His brother, the late I. Smith Hyatt, shared in the discovery of the process of its manufacture. The following list of other patents shows the extraordinary range of his inventive talent: Knife sharpener, new method of making dominoes and checkers, the Hyatt billiard ball (including the machinery for making it), water-purifying

systems, lockstitch sewing machine, machine for squeezing juice from sugar cane, new method of solidifying hard woods for use in bowling balls, golf stick heads and mallets.

Dr. RUDOLPH MESSEL, of London, past-president and for many years foreign secretary of the Society of Chemical Industry, died April 20. His researches with Winkler and others into the manufacture of oleum are classical and were developed commercially under his guidance. Dr. Messel was in his seventy-third year.

Current Market Reports

The Non-Ferrous Metal Market

New York, May 17, 1920.—Conditions are little changed since last week.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	10.00
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	55.75
Lead, New York, spot	8.70
Lead, E. St. Louis, spot	8.40
Zinc, spot, New York	8.62½
Zinc, spot, E. St. Louis	7.60

OTHER METALS

Silver	oz.	$99.75
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	2.70@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	110@115
Iridium	oz.	300.00
Palladium	oz.	105@115
Mercury	75 lb.	95.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper bottoms	38.50
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless high brass tubing	30.50

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	21.75@22.75
Aluminum, sheet scrap	21.25@22.50
Copper, heavy machinery comp	13.50@14.00
Copper, heavy and wire	13.50@13.75
Copper, light and bottoms	12.25@12.75
Copper, heavy cut and crucible	14.75@15.00
Brass, heavy	7.50@ 8.00
Brass, light	7.00@ 7.50
No. 1 clean brass turnings	8.25@ 8.50
No. 1 comp. turnings	10.25@10.75
Lead, tea	5.25@ 5.40
Lead, heavy	7.00@ 7.25
Zinc, scrap	4.25@ 4.50

The Iron and Steel Market

Pittsburgh, Pa., May 14, 1920.

The rail strike has not extended, in general, rather having waned a trifle, but iron and steel operations, as affected by the rail strike, have not improved during the past week, having if anything grown somewhat poorer. The change arises from the increased scarcity of empties for loading, whether of coal, coke or intermediate or finished products. A great deal of material has been loaded without the cars getting through to destination, and even when deliveries are made the empties have more difficulty in getting back for fresh loadings than the original shipments had in getting through. A trainload of coke, for instance, is made up in the Connellsville region and is "personally conducted" through to a blast furnace, but when the cars are unloaded there are no facilities for taking back the trainload of empties.

STEEL PRODUCTION

The monthly report of the American Iron and Steel Institute, relating to steel ingot production, furnishes a convenient check. The thirty companies contributing to the monthly report produced 2,638,305 gross tons of steel ingots in April, against 3,299,049 tons (revised) in March. These companies made 84.03 per cent of the total steel ingot output in 1918. Allowing for producers not reporting, and counting the number of working days in the month and year, the rates per annum of steel ingot production for the whole industry appear to have been approximately as follows:

	Gross Tons		Gross Tons
January	40,700,000	March	45,200,000
February	44,200,000	April	37,550,000

Thus the rate in April was one-sixth less than the March rate, which was the highest since October, 1918. The month was not equally affected throughout by the rail strike, which began April 1 in Chicago, but hardly affected operations in Cleveland, the valleys and the Pittsburgh district until Monday, April 12, while toward the close of the month operations in the Chicago district had increased. Probably as high an estimate as could be justified for the present rate of production would be the average rate of April.

So much steel has accumulated at mills and in transit that the concern now is not so much about production as about distribution. March production was less than capacity by perhaps 10 or 15 per cent, production is 15 or 20 per cent below the March production, shipments are less than production and receipts by consumers are less than shipments.

A situation is presented that is difficult to analyze. Very little complaint is heard from consumers. The consumers are not exerting any great pressure upon mills to give them preference, and there is even less bidding in the open market for prompt deliveries, at the various premium prices that would be asked, than there was a few weeks ago. Possibly consumers feel it would be futile to attempt to improve their supplies by this means. Possibly many are operating by drawing upon stocks. Possibly it is a common feeling that there is no occasion for haste in making up finished products at the factories.

However the situation is viewed, it is difficult if not impossible to draw any auguries that a stronger steel market is in prospect for the near future. If the operations of consumers are greatly curtailed, then consumption is postponed, and the extra supplies of steel now accumulating, at mill and in transit, will make a larger supply for consumers than has been seen since the steel strike began. If, on the other hand, consumers are operating by drawing upon stocks, then those stocks must have been accumulated at some time, and the only conceivable time for such a process was last February and March, for certainly there were no stocks at the beginning of the year.

As to prospects of consumption, existing capacity is 40 to 50 per cent greater than capacity at the end of 1913, yet in neither of the calendar years 1913 or 1912, though those were the years of largest production before the war, was the actual production within 90 per cent of that capacity, 1912 having had a weak beginning and 1913 a weak ending. For engagement of the present capacity, therefore, a collection of favorable circumstances would appear to be absolutely requisite. The railroads, normally counted upon as large consumers of steel, are buying scarcely anything, and there is merely conjecture as to whether they will become free buyers if or when they receive a favorable settlement of the rate case now inaugurated before the Interstate Commerce Commission. As to large construction jobs, involving the use of steel, hitherto considered essential to there being a full demand for steel, there is not much of that and the immediate prospects are not promising.

BOOKINGS

The United States Steel Corporation reports unfilled obligations at the end of April at 10,359,747 tons. The corporation's rated capacity being about 52,500 tons per working day, the unfilled tonnage would be equal to 7.7 months of operation at capacity, although of course the orders are not uniformly distributed in the different products. The April increase in unfilled obligations was 467,672 tons, against increases of 389,994 tons in March, 216,640 tons in February and 1,020,075 tons in January. April

bookings nevertheless fell short of those in March, since the shipments were less than 96 per cent of capacity in March and 60 per cent of capacity in April. The increase in unfilled obligations in March represented 28 per cent of capacity, the April increase representing 34 per cent of capacity. Adding these increases to the estimated shipments gives 124 per cent as the March bookings and 94 per cent as the April bookings.

When there was such a decrease in the bookings of the low seller, one may infer that there was a larger proportionate decrease in the bookings of the higher sellers, first the group of large independents that have been selling for delivery from two to four months ahead, at, say, $10 to $20 a ton above Steel Corporation or Industrial Board prices, and next the smaller independents that have been selling for delivery in, say, two to six weeks at still greater premiums. Market observation during April agreed with this inference. The independents have not been selling at capacity by any means, and when they have maintained their prices, as the majority have done, it has been at the expense of diminishing order books. Mills that could not permit this, having little tonnage ahead, have had to reduce prices, and thus there have been declines in prices for the earliest deliveries, though the delivery premiums are still large.

Chemical and Allied Industrial Markets

New York, May 14, 1920.

With transportation reported 10 per cent normal, these markets are in such a position that producers have been forced to cut their plant forces in half because of the lack of raw material and fuel, and it is only a question of weeks before they will have to close completely. Jobbers and brokers are in a bad way, as the only supplies within easy access of New York are the unimportant items for which there is small demand. One large drug house in Boston is operating a fleet of 5-ton trucks between that city and New Jersey, but the cost of transportation of this kind is figured on 1c. per lb. gross weight, which would make the cost prohibitive for general use.

General Chemicals

Glauber's salt went up 10c. per cwt. during the week, with still further tightening of supplies. This item was listed at $1.20@$1.35 a year ago, and current quotations range from $1.75@$2.05 per cwt. One factor in this item is reported thirty cars behind his contract and is refusing to consider any new business. Producers have firmly set the price on *carbon bisulphide* at 8@11c. per lb., with fairly good supply on hand at these figures. *Caustic soda* is still nominally quoted around $6.50 per cwt. for spot material; offers have been received from Japan below the present market for resale American material, but so far none of this material has arrived. All items on the *acid* list are decidedly firm; demand for *acetic* is still heavy, with 28 per cent listed at $3.50@$3.75 for car load and $3.80@$4.00 for less than carload, while glacial 99½ per cent holds firm at $16.50@$17.50 per cwt. *Hydrofluoric acid*, 52 per cent, continues in good demand at the recently fixed price of 12@14c. per lb., while *hydrochloric*, 20 deg., is still nominal at $3@$4 per cwt.

Coal-Tar Products

No improvement has been noted in this market during the week. Conditions as previously reported still prevail and there is very little material being offered on any of the items throughout the list. *Naphtha* has shown some indications of weakening, and it is said some material changed hands at 14c., but 15c. of last week still holds as an average price. *Alpha naphthylanine* came up during the period and is listed at 65@70c. per lb., against 50@60c. of the previous report. There is very little of this material being offered even at the new price. *Benzol*, water white, can be had for 27@36c. and 90 per cent is 25@31c. per gal. f.o.b. plant. *Toluol*, in practically the same position, suffering from shipping conditions, is listed at 28@32c. per gal. subject to delivery.

Naval Stores—Flotation Oils

Quotations on these items remain wholly nominal and the listed price will take effect upon arrival of material from the primary market. *Turpentine* came down slightly and is now quoted at $2.45 per gal., against $2.50 of last week. All grades of *rosin* have changed hands at prices ranging from $19 to $24 per 280 lb., but these prices will be broken shortly, as the Savannah market has already shown some signs of weakness. Practically the same thing holds true of the flotation oils, as material en route from the South is being held up, which upon arrival will relieve the present pressure.

Vegetable Oils

Dullness has been the predominating note of this market during the week. Buyers are not displaying any interest in future offerings due to the uncertainty of the transportation tangle. Business has been done in a small way on some of the items, but that is the best that can be said. *Linseed* is handicapped by the delivery problem. There has been increased activity on this item recently, but producers in the West are unable to ship any goods. Current quotations are firmly maintained at $1.72 per gal., raw, car lots; $1.67, raw, tank cars, and $1.75, boiled, car lots, with contracts subject to delivery.

Miscellaneous Materials

Like all other markets, there is very little material moving into this market. *Feldspar* remains unchanged with $13.50@$18, ground grade, f.o.b. New York State, still holding firm, while *barytes*, listed at $36@$40 for white floated, is in a wholly nominal position. *Fullers earth* is still scarce and $25@$30 for domestic and $35@$40 per ton for foreign is firmly maintained.

St. Louis, May 11, 1920.

The local production of heavy chemicals is curtailed due to manufacturers' inability to get raw material and supplies regularly on account of the railroad switchmen's strike. Railroad service is from 15 to 30 per cent normal. This situation has materially affected the chemical market and supply of practically all chemicals is very limited. No relief is expected until railroad service is back to normal. Prices are erratic and are based on supply available. The St. Louis district has had to depend almost entirely on local manufacturers to supply their needs.

Sulphuric Acid—Supply is practically limited to local production and stocks are low. The 60 deg. grade is quoted at $15 per ton and 66 deg. grade at $22 per ton. Oleum is quoted at $27 per ton.

Muriatic Acid—The demand exceeds the supply and quoted at $20@$22 per ton for the 18 deg. grade. The muriatic acid plant of the Monsanto Chemical Works, East St. Louis, was partially damaged by an explosion in a nearby oil refinery and production is temporarily curtailed.

Sodium Bisulphate—Supply limited and quoted at $4 per cwt.

Nitric Acid—Local supply practically exhausted and demands exceed local production.

Zinc Chloride—Available supply exhausted. Last quotations approximately $4.50 per cwt.

Zinc Oxide—Demand for this chemical is heavy and local output for second quarter practically all contracted for. Last quotation 9½@10c.

Phenol—There is a good demand for phenol, which is quoted at 12c. per lb. Supply is plentiful due to surplus which the Government is disposing of.

Caustic Soda—Supply is very limited, although several shipments have been received lately. It is quoted at 7c. per lb. 76 per cent test in carload lots.

Soda Ash and Silicate of Soda—Local supplies practically exhausted.

Hydrofluoric Acid—Local supplies practically exhausted.

Chicago, May 13, 1920.

Existing conditions in regard to transportation are such as to cause reports on Chicago market conditions in the chemical trade to be of almost purely local interest. While it is perhaps true that in general the railroad situation is

improving and that shipments are moving a little more freely now than two or three weeks ago, the chemical market has experienced but little relief. A great portion of the traffic in chemicals takes fifth or sixth class in freight classification and therefore receives but scant consideration in the present emergency. The effect has been practically to isolate Chicago from the rest of the country and to put each purchase purely on a basis of how much the buyer can afford to pay rather than go without the needed goods.

Stocks in most lines are probably lower than they have ever been before. It is now possible to procure shipments in limited extent from manufacturing points to Chicago and from Chicago to most destinations. Direct shipments from points outside of Chicago, through Chicago to a third city as the point of destination, are still impossible. This works as a severe handicap on direct shipments.

The tendency of buyers to stay out of the market unless their needs are absolutely essential to the conduct of their business, which was noted two weeks ago, continues. The consuming trade recognizes the fact that present conditions are such as to make it purely a sellers' market, and they are therefore reluctant to enter the buying field. This tendency has prevented any general skyrocketing of prices, though in practically all cases spot market is considerably above the figure asked for goods on contract for future delivery. Collections are, of course, tight. The greatly lengthened period of time consumed by goods in transit has tended to make payments slow all along the line and is amounting to a severe burden on both the dealer and the manufacturer.

The shortage of spot stock is most severely felt in the coal-tar products and in the alkalis.

Heavy Chemicals

Previously noted conditions tending to keep the prices of various grades of *alcohol* at a very high level have become accentuated by the difficulty of manufacturers securing raw materials, particularly molasses. The current market quotation on *ethyl* grade of $5@$5.50 per gal. is purely nominal. Actual transactions of the past two weeks have been very small in quantity and have ranged in price all the way from $6 to $10 per gal. *Methyl* grade is just about as scarce as ethyl, and while the ruling quotation is about $3 per gal. for 190 proof, spot goods are moving at a considerably higher figure. *Denatured*, not so scarce as the others, is quoted slightly higher than in the past, $1.05 being today's quotation. *Formaldehyde* is in no better supply, and the price remains constant at about 65c. per lb. Manufacturers are pretty well sold up on future production capacity and are becoming reluctant to make new contracts.

A more insistent demand is felt for alkali products than for any other line. Raw materials are hard to get, containers are scarce, and the goods themselves are hard to move after production and packing is completed. *Bleaching powder* continues to rise in price, with present quotation 4@5c. per lb., f.o.b. cars at factory. *Soda ash* is in very light supply and most manufacturers report their product sold up for the remainder of the year. Nominal quotation remains at 4½c. per lb., with spots bringing as high as 5c. This week's transactions in *caustic soda* have ranged from 6¼c. to 7c. per lb., and contracts for future business are being placed at 7c. per lb. in cars f.o.b. works. Conditions on *salsoda* are unchanged, ruling price being $1.35 per cwt. f.o.b. factory and $1.60 per cwt. out of Chicago stock.

The *glycerine* market continues very strong, quotation on c.p. grade being 26c. per lb. Purchases of this commodity in the past few weeks have been so heavy as apparently to assure a figure at least this high for some time to come. *Aqua ammonia*, reported last week as selling at 10c. out of stock, has lately been run up as high as 11c. This is wholly on account of the difficulty of obtaining material, as manufacturers are still quoting 8¼@8½c. per lb. on contracts. The last quotation of 16c. per lb. for white granulated *salammoniac* holds good, but deliveries at that or any other figure are hard to get. Demand is very light, consumers recognizing the difficulty of procuring shipment. Liquid *chlorine* remains very firm and manufacturers show no anxiety to close contracts at the prevailing figure of 8@8½c. per lb. *Sodium nitrite* seems to be in better supply, with the price unchanged at 26c. per lb. Actual transactions in all of these commodities are very light.

The scant movement of acids, particularly *sulphuric*, is causing stagnation in many lines of the chemical industry. Prices show much more strength than they have for some time past, but the market has not been stampeded by the present conditions which are recognized to be only temporary. *Sulphuric* acid, 66 deg., is quoted for early delivery at $24 per ton and for immediate delivery, that is, as soon as shipment is possible, at $25 per ton. Increases in the price of raw material have affected *acetic* acid, increasing the current quotation on 28 per cent to $3.75 per cwt., and on 56 per cent to $8.40 @ $8.50 per cwt. Almost no actual transactions are taking place in *muriatic* acid, on which quotation is 34c. per lb. for 22 deg. *Nitric* has recovered from past depression and is now quoted at 7½c. per lb. for 42 deg., and *oxalic*, with almost no supply visible, is tightly held at 56c. per lb.

Coal-Tar Products

The coal-tar product market seems to be the most seriously affected of all chemical lines by the present strike situation. Recovery had not been complete from the derangement occasioned by the coal and steel strikes when the present trouble started, and the situation today seems more serious, so far as production is concerned, than ever before. Supplies of crudes are on a hand-to-mouth basis and prices at which goods are actually changing hands vary widely. *Benzol* is bringing about 30c. per gal. for spots with no change recorded on prices of contract orders. Makers have practically no supply of *solvent naphtha* on hand and what few current transactions are being recorded are at about 32c. Small supplies of *naphthaline* are available, current prices being, for balls 18c. per lb.; flakes, 17c. per lb. *Toluol* is also difficult to get and current price ranges from 29c. to 31c. per gal. No price changes of moment are recorded in coal-tar acids, the quotation on *benzoic* being 75c. per gal. for technical and 90c. per gal. for c.p. *Salicylic* is quoted at 50c. per gal. for technical, and 55c. per gal for c.p. The supply of intermediates is so short as to render any quotations impossible. *Aniline oil* and *aniline salts* both remain in heavy demand, with prices ranging from 40c. upward on the oil and from 50c. upward on the salts.

Vegetable Oils

The condition noted last week of no supplies and likewise no buyers continues in effect. Local price on *linseed oil* in barrels remains unchanged at $2.05 per gal., but the carload price has fallen off somewhat. This quotation ranges from $1.65 to $1.70 per gal. Demand is very light.

Prices are weak on all the other oils. *Soya bean* is quoted in sellers' tanks, f.o.b. Coast, at 13½c. per gal. and in barrels, f.o.b. Chicago, at 18½c. Crude *cottonseed oil* under light demand is a shade off to 16c. Prime summer yellow remains firm at 18c. and refined deodorized in barrels still brings 22½c. *Cocoanut oil* is down a little to a present quotation in sellers' tanks, f.o.b. Coast, of about 16½c. No market seems to exist on corn oil, the nominal quotation for prime grade in tanks being 15¼ @ 16c. per lb.

Flotation Oils—Naval Stores

Present price on turpentine should probably be about $2.30 per gal. To this, on local sales, is being added the cost of trucking from various railroad points from ten to thirty miles from Chicago. This has caused the current figure for turpentine in barrels to be placed at $2.56 per gal. Reacting to a feeling that the transportation difficulties were going to be shortlived, on May 3 the price was dropped from the previous quotation of $2.57 per gal. to $2.25 per gal. The resulting renewal of buying and the prolongation of the rail trouble forced the price back to the present figure in one week. *Pine oil* remains high, *.933 pure steam distilled* now standing at $1.80 per gal. and *pure destructively distilled* at $1.70 per gal., these prices being for barrels. *Pine-tar oil* holds the previously quoted price of 42c. To a great extent these prices are nominal, there being practically no supply.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.65 – $0.75
Acetone	lb.	$0.19 – $0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.25
Acetic, 56 per cent	cwt.	6.50 – 7.00	8.75 – 9.00
Acetic, glacial, 99½ per cent., carboy	cwt.	15.50 – 16.00	16.50 – 17.50
Boric, crystals	lb.	14¼ – 15½	15½ – 16½
Boric, powder	lb.	14½ – 15	15 – 16
Citric	lb.	.85 – .86	1.17 – 1.18
Hydrochloric (nominal)	cwt.	3.00 – 3.25	3.50 – 4.00
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.13 – .14
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04 – .05½	.06 – .07
Molybdic, C. P.	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)			
Nitric, 40 deg.	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg.	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.58 – .59
Phosphoric, Ortho, 50 per cent solution	lb.	.22 – .23	.24 – .25
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 18.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	21.00 – 25.00	—
Sulphuric, 66 deg., drums	ton	35.00 – 40.00	—
Sulphuric, 66 deg., carboys	ton	36.00 – 40.00	—
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P.	lb.	1.50 – 1.60	1.65 – 1.70
Tannic (tech.)	lb.	—	.60 – .90
Tartaric, crystals	lb.	—	.75 – .80
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.50 – 3.50	—
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.00 – 1.05
Alcohol, denatured, 190 proof (nominal)	gal.	—	.98 – 1.02
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08¾	.09 – .09½
Alum, chrome lump	lb.	.17 – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.03½ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.14 – .14½
Ammonium nitrate	lb.	.08¾ – .12	—
Ammonium sulphate	lb.	.07 – .08	.08½ –
Amylacetate	gal.	—	3.65 – 3.75
Arsenic, oxide, lumps (white arsenic)	lb.	—	.13½ – .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride (nominal)	ton	150.00–160.00	165.00 – 175.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.10 – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)			
Blue vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.85 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	—
Calcium carbide	lb.	.04½ – .04¾	.04¾ – .05½
Calcium chloride, fused, lump	ton	23.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.35 – 5.00
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08¾ – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Formaldehyde, 40 per cent (nominal)	lb.	.38 – .40	.60 – .80
Glauber's salt (see sodium sulphate)			
Glycerine	lb.	—	.24½ – .26
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	.14 – .14½	.15 – .18
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	—	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P.	100 lb.	3.50 – 3.55	3.60 – 4.25
Magnesium sulphate, commercial	100 lb.	—	3.25 – 3.60
Nickel salt, double	lb.	.14 –	.15 –
Nickel salt, single	lb.	.16 – .17	.17½ –
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.36 – .37	.40 – .46
Potassium bitartrate (cream of Tartar)	lb.	.53 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – .95
Potassium carbonate, U. S. P.	lb.	—	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28
Potassium chlorate, crystals	lb.	.14 – .16	.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.30 – .38
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.19 –	.21 –
Potassium permanganate	lb.	—	.65 – .95
Potassium prussiate, red	lb.	$0.90 – $1.00	$1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.38 – $0.41
Potassium sulphate (powdered)	ton	$225.00 – 240.00	—
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)			
Salt cake	ton	28.00 – 32.00	—
Silver cyanide (nominal)	oz.	—	1.25 –
Silver nitrate (nominal)	oz.	—	.74 – .76
Soda ash, light	100 lb.	—	3.50 – 3.60
Soda ash, dense	100 lb.	—	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09 – .10
Sodium bicarbonate	100 lb.	2.25 – 2.60	2.75 – 3.00
Sodium bichromate	lb.	.39 – .41	.42 – .43
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .07½
Sodium borate (borax)	lb.	.09 – .10	.10½ –
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	—	.12 – .14
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	5.00 – 6.00	7.00 – 7.50
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25 –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.22 – .24	.24 – .25
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03½ – .04¼	.04¼ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	.39 – .40	.40 – .41
Sodium prussiate, yellow	lb.	.23 – .27	.30 – .40
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.50 – 1.70	1.75 – 2.05
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½	.04 – .06
Strontium nitrate, crystals	lb.	.23 – .24	.25 – .26
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 – .—
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.13	.13½ – .17
Zinc cyanide	lb.	.49	.50 – .60
Zinc dust	lb.	.12½ – .12½	.13 – .15
Zinc oxide, U. S. P.	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities

Alpha naphthol, crude	lb.	$1.05 –	$1.15
Alpha naphthol, refined	lb.	1.40 –	1.60
Alpha naphthylamine	lb.	.65 –	.70
Aniline oil, drums extra	lb.	.34 –	.45
Aniline salts	lb.	.46 –	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90 –	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 –	2.10
Benzidine, base	lb.	1.35 –	1.40
Benzidine, sulphate	lb.	1.20 –	1.25
Benzoic acid, U. S. P.	lb.	.90 –	1.00
Benzoate of soda, U. S. P.	lb.	.80 –	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 –	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 –	.31
Benzyl chloride, 95-97%, refined	lb.	.35 –	.40
Benzyl chloride, tech.	lb.	.25 –	.35
Beta naphthol benzoate (nominal)	lb.	.50 –	.65
Beta naphthol, sublimed (nominal)	lb.	.70 –	.90
Beta naphthol, tech (nominal)	lb.	.45 –	.55
Beta naphthylamine, sublimed	lb.	2.25 –	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 –	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 –	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 –	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 –	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 –	.75
Dichlorbenzol	lb.	.08 –	.10
Diethylaniline	lb.	1.40 –	1.50
Dimethylaniline (nominal)	lb.	—	1.80
Dinitrobenzol	lb.	.30 –	.37
Dinitroclorbenzol	lb.	.30 –	.35
Dinitronaphthaline	lb.	.45 –	.55
Dinitrophenol	lb.	.40 –	.45
Dinitrotoluol	lb.	.40 –	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 –	.40
Diphenylamine (nominal)	lb.	.55 –	.65
H-acid (nominal)	lb.	2.25 –	2.50
Metaphenylenediamine	lb.	1.15 –	1.80
Monochlorbenzol	lb.	.12 –	.15
Monoethylaniline	lb.	1.70 –	1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	.15 –	—
Naphthaline, flake	lb.	.15 –	.17
Naphthaline, balls	lb.	.16 –	.18
Naphthionic acid, crude	lb.	.75 –	.85
Nitrobenzol	lb.	.14 –	.17
Nitronaphthaline	lb.	.40 –	.50
Nitrotoluol	lb.	.20 –	.30
Ortho-amidophenol	lb.	3.25 –	4.25
Orthodichlorbenzol	lb.	.15 –	.20
Orthonitrophenol	lb.	.80 –	1.25
Ortho-nitro-toluol	lb.	.35 –	.40
Ortho-toluidine	lb.	.35 –	.40
Para-amidophenol, base	lb.	2.50 –	2.50
Para-amidophenol, HCl	lb.	2.90 –	3.25
Paradichlorbenzol	lb.	.08 –	.12
Paranitraniline	lb.	1.75 –	1.85
Paranitrotoluol	lb.	1.15 –	1.20
Paraphenylenediamine	lb.	2.60 –	3.00
Paratoluidine	lb.	2.00 –	2.50
Phthalic anhydride	lb.	.65 –	.75
Picric acid, U. S. P., drums (dest.), (240 lb.)	lb.	.12 –	.25
Pyridin	gal.	1.60 –	2.50
Resorcin, technical	lb.	4.25 –	4.50
Resorcin, pure	lb.	6.25 –	6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.49 –	.52
Salicylic acid, U. S. P.	lb.	.55 –	.60
Salol	lb.	.96 –	1.00

Solvent naphtha, water-white, in drums, 100 gal..	gal.	$0.25 —	$0.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.28 —	.32
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36 —	$0.39
Beeswax, refined, light	lb.	.40 —	.41
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	.80 —	.88
Carnauba, No. 2, regular (nominal)	lb.	.60 —	.70
Carnauba, No. 3, North Country (nominal)	lb.	.45 —	.46
Japan	lb.	.21 —	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	..... —	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.09¾
Paraffine waxes, refined, 118-120 m.p.	lb.	..... —	.11½
Paraffine waxes, refined, 128-130 m.p.	lb.	..... —	.13½
Paraffine waxes, refined, 133-135 m.p.	lb.	.14 —	.15
Paraffine waxes, refined, 135-137 m.p.	lb.	.16 —	.16½
Stearic acid, single pressed	lb.	.26 —	.27
Stearic acid, double pressed	lb.	.32 —	.29
Stearic acid, triple pressed	lb.	.32 —	.33

NOTE—Quotations on paraffine waxes are nominal.

*Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.65
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

*(See New York market letter)

*Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$16.95 —	$18.75
Rosin E-I	280 lb.	18.75 —	19.00
Rosin K-N	280 lb.	19.00 —	21.00
Rosin W. G.-W. W	280 lb.	20.50 —	21.50
Wood rosin, bbl	280 lb.	15.50 —	18.50
Spirits of turpentine	gal.	..... —	2.45
Wood turpentine, steam dist.	gal.	2.35 —	2.40
Wood turpentine, dest. dist.	gal.	..... —	2.00
Pine tar pitch, bbl	200 lb.	8.40 —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl	500 lb	15.00 —	15.50
Rosin oil, first run	gal.	.92 —	.95
Rosin oil, second run	gal.	.94 —	.97
Rosin oil, third run	gal.	1.00 —	1.05
Rosin oil, fourth run	gal.	1.10 —	1.15

* (See New York market letter)

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Crude Rubber

Para—Upriver fine	lb.	$0.40½ —	$0.42
Upriver coarse	lb.	.29 —	.32
Upriver caucho ball	lb.	.30½ —	.33
Plantation—First latex crepe	lb.	.44 —	.45
Ribbed smoked sheets	lb.	.44½ —	....
Brown crepe, thin, clean	lb.	.42 —	....
Amber crepe No. 1	lb.	.40½ —	.41½

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.18½ —	$0.20
Castor oil, AA, in bbls	lb.	.20 —	.23
China wood oil, in bbls	lb.	.22 —	.23
Cocoanut oil, Ceylon grade, in bbls	lb.	.18¾ —	.18¾
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.19 —	.19½
Corn oil, crude, in bbls	lb.	.17½ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½ —	.16
Cottonseed oil, summer yellow	lb.	.19½ —	.20
Cottonseed oil, winter yellow	lb.	.21 —	.22
Linseed oil, raw, car lots	gal.	1.72 —	.....
Linseed oil, raw, tank cars	gal.	1.67 —	.....
Linseed oil, boiled, car lots	gal.	1.75 —	.....
Olive oil, commercial	gal.	2.75 —	3.00
Palm, Lagos	lb.	.13½ —	.14½
Palm, bright red	lb.	.14½ —	.17½
Palm, Niger	lb.	.12¾ —	.14
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.19 —	.20
Peanut oil, refined, in bbls	lb.	.24 —	.25
Rapeseed oil, refined in bbls	gal.	1.70 —	1.72
Rapeseed oil, blown, in bbls	gal.	1.80 —	1.82
Soya bean oil (Manchurian), in bbls N. Y.	lb.	.17 —	.18
Soya bean oil, tank cars, f.o.b. Pacific coast	lb.	.13¼ —	.14

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal	1.23 —	1.24
Blown Menhaden	gal.	1.34 —	1.36

† (See New York market letter)

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$35.00 —	$40.00
Barytes, off color	ton	20.00 —	25.00
Barytes, crude	ton	10.00 —	12.00
Blanc fixe, dry	lb.	.05½ —	.06½
Blanc fixe, pulp	ton	60.00 —	80.00
Casein	lb.	.15 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50 —	18.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite, crucible, 85% carbon content	lb.	..... —	.07½
Graphite, crucible, 86% carbon content	lb.	..... —	.08
Graphite, crucible, 87% carbon content	lb.	..... —	.08½
Graphite, crucible, 88% carbon content	lb.	..... —	.09
Graphite, crucible, 89% carbon content	lb.	..... —	.09½
Graphite, crucible, 90% carbon content	lb.	..... —	.10
Graphite, crucible, 91% carbon content	lb.	..... —	.10½
Graphite, crucible, 92% carbon content	lb.	..... —	.11
Graphite, crucible, plus 92%	lb.	..... —	.12½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	....
Shellac, orange, fine	nominal lb.	1.50 —	....
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	30.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn	gross ton	200.00 —	250.00
Spiegeleisen, 16-20% Mn	gross ton	73.00 —	75.00
Ferro-molybdenum, per lb. of Mo	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W...	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V....	lb.	6.50 —	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70 —	$0.85
Chrome ore, 48% and over	† unit	..... —	.....
Coke, foundry, f.o.b. ovens	net ton	12.00 —	14.00
Coke, furnace, f.o.b. ovens	net ton	11.00 —	12.00
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	14.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, Mex.	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00 —	65.00
Manganese ore, 45% Mn and over	unit	.80 —	.95
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium Ore	lb.	1.00 —	3.00
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.02 —	.....
Rutile, 95% TiO_2	lb.	.11 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Nominal †See New York Market Letter

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in.	100 lb.	$2.45@$4.00
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45@ 4.00
Tees, 3-in. and larger	100 lb.	2.45@ 4.00
Plates	100 lb.	2.65@ 4.00
Rivets, structural, ¾-in. and larger	100 lb.	4.50
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.60
Sheets, No. 28 black	100 lb.	4.35@ 6.50
Sheets, No. 10 blue annealed	100 lb.	3.55@ 6.00
Sheets, No. 28 galvanized	100 lb.	5.70@ 8.50

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Connecticut

HAMDEN—The Mt. Carmel Brass Fdry. Wks., Mt. Carmel, has awarded the contract for the construction of a 1-story, 25x115-ft. foundry at Mt. Carmel, to the Sperry Eng. Co., 82 Church St., New Haven. Estimated cost, $20,000.

MANSFIELD DEPOT — The Mansfield State Training School will soon award the contract for the construction of a 1-story, 40x50-ft. filter plant and a concrete dam. Estimated cost, $25,000. Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, engrs.

NEW HAVEN—The Fritzell Brass Fdry. Co., 33 Chestnut St., plans to build a 1-story, 60x150-ft. plant addition on Chestnut St. Estimated cost, $40,000. Fletcher, Thompson, Inc., 1089 Broad St., archts. and engrs.

WATERVILLE (Waterbury P. O.)—The Amer. Pin Co., Thomaston Ave., has awarded the contract for the construction of a 2-story, 40x101-ft. factory addition for the manufacture of brass goods, to the Torrington Bldg. Co., 197 Water St. Estimated cost, $35,000.

District of Columbia

WASHINGTON—The Dupont Fibre Silk Co., Dupont Bldg., Wilmington, Del., is having plans prepared for the construction of a 3-story factory here. Estimated cost, $750,000.

WASHINGTON—The General Purchasing Officer of the Panama Canal will receive bids until May 25 for furnishing 60,000 lb. of sodium nitrate dynamite, 45% nitroglycerin and 50,000 lb. of sodium nitrate dynamite, 60% nitroglycerin.

WASHINGTON — The Washington Gas & Light Co., 411 10th St., has purchased Analostan Island and plans to construct a gas plant on same. Estimated cost, from $2,000,000 to $3,000,000. J. S. McIlheny, chief engr.

Illinois

CHICAGO—The Illinois Malleable Iron Co., 1801 Diversity Bldg., is having plans prepared for the construction of a 1-story plant. Cahill & Douglas, 217 Water St., Milwaukee, engrs.

CHICAGO—The Charles McAdam Co., 3167 Cottage Grove Ave., will soon award the contract for the construction of a 1-story, 65x250-ft. factory for the manufacture of painters' supplies, on West 27th and Troy Sts. Estimated cost, $100,000. J. C. Llewellyn, 38 South Dearborn St., archt.

CHICAGO—The Ward Baking Co., 2608 Lexington Ave., plans to build a bakery at Irving Park Blvd. and Kilbourne Ave.

CHICAGO—The Western Felt Wks. plans to build extensions to its plant at 4115 Ogden Ave.

Iowa

ALBIA—The city has awarded the contract for the construction of a sewage disposal plant to A. Phelps & Son, Knoxville, at $36,828. C. Atchison, clk.

AMES—The city will receive bids until June 7 for the construction of a sewage disposal plant, consisting of pumping plant, Imhoff tank, sludge bed and trickling filters, etc. Noted March 10.

WELLSBURG—The town has awarded the contract for the construction of a sewage disposal plant, to Ward & Weighton, 516-17 Davidson Bldg., Sioux City, at $16,700.

Kentucky

BOWLING GREEN—The Amer. Producing & Refining Co. is in the market for machinery for an oil refinery.

LOUISVILLE — Avery & Sons have awarded the contract for the construction of a 2-story, 120x175-ft. paint shop and a 5-story shipping warehouse in connection with the number of proposed additions to the present plant, to the Natl. Concrete Constr. Co., Bd. Tr. Bldg. Estimated cost, $400,000.

Massachusetts

CAMBRIDGE—Henry Thayer & Co., 150 B'way, will build a 3-story, 40x80-ft. plant addition for the manufacture of chemicals. Estimated cost, $30,000. Work will be done by day labor.

EAST WALPOLE—Bird & Son, Inc., has awarded the contract for the construction of a 1-story, 30x310-ft. building for the manufacture of roofing and floor coverings on Water St., to A. A. Appleby, 449 Washington St., Norwood. Estimated cost, $40,000. Charlie T. Main, 201 Devonshire St., engr.

SOUTH BOSTON (Boston P. O.)—The Joseph Burnett Co., 36 India St., Boston, has awarded the contract for the construction of a 7-story, 80x160-ft. manufacturing plant on Fargo and D Sts., to the W. M. Bailey Co., 88 Broad St., Boston. Estimated cost, $400,000.

SPRINGFIELD—B. E. Geckler, archt., 335 St. James Ave., will soon award the contract for the construction of a 1-story, 55x65-ft. foundry addition on Birnie Ave., for the Brightwood Brass & Bronze Fdry., Birnie Ave. Estimated cost, $20,000.

WILLIMANSETT (Holyoke P. O.)—The Stevens Duryea Co., Chicopee Falls, has awarded the contract for the construction of three manufacturing buildings including a 1-story, 60x270-ft. heat treating building, to P. J. Kennedy Co., Inc., 464 Maple St., Holyoke. Estimated cost, $800,000.

WOLLASTON (Boston P. O.) — The Howard Chemical Co., c/o E. R. Simpson, engr., 176 Federal St., Boston, has awarded the contract for the construction of a 3-story, 55x120-ft. factory for the manufacture of chemicals, etc. on Old Colony Ave., to S. C. Sperry Co., 300 Main St., Cambridge. Estimated cost, $50,000. Noted April 21.

Michigan

DETROIT—A. J. Detlaff, East Lafayette Ave., has awarded the contract for the construction of a 1-story, 51x88-ft. foundry on Lafayette and Hastings Sts., to Otto Misch Co., Chamber of Commerce. Equipment for making and handling malleable castings will be installed in same. Estimated cost, $10,000. Noted May 4.

HOUGHTON—The Michigan College of Mines, College Ave., is having plans prepared for the construction of a 2-story chemical building. Two complete chemical laboratories will be installed in same. Estimated cost, $100,000. Herbst & Kuenzli, Caswell Block, Milwaukee, Wis., archts.

Minnesota

JORDAN—The Bd. Educ. will soon award the contract for the construction of a 3-story, 67x112-ft. high and grade school. A chemical laboratory will be installed in same. P. T. Hunziker, clk. K. T. Snyder, 739 Plymouth Bldg., Minneapolis, archt.

REXVILLE—The Bd. Educ. will receive bids until May 30 for the construction of an 80x240-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $300,000. Croft & Boerner, Palace Bldg., Minneapolis, archts. Noted April 14.

SPRING GROVE—The Bd. Educ. is having plans prepared for the construction of a 2-story, 40x90-ft. school. A chemical laboratory will be installed in same. Sund & Dunham, 312 Essex Bldg., Minneapolis, archts.

WAYZATA — The Bd. Educ. is having plans prepared for the construction of a 3-story, 136x148-ft. grade and high school. A chemical laboratory will be installed in same. Estimated cost, $150,000. Hewitt & Brown, 715 4th Ave. S., and Tyler & Chapman, 329 Andrus Bldg., Minneapolis, archts.

Missouri

KANSAS CITY — The Cass Products Refining Co., 17 Battery Pl., New York City, plans to build a 1-story factory. Estimated cost, $7,000,000.

New Hampshire

HANOVER — Dartmouth College has awarded the contract for the construction of a 1-story, 60x150-ft. chemical laboratory, to the Cummings Constr. Co., Woodsville. Estimated cost, $294,000.

New Jersey

HADDONFIELD — The city Borough Hall, has awarded the contract for the construction of a sewage disposal plant, to William Penn Corson, Camden, at $12,799. Noted April 21.

JERSEY CITY — The Amer. Butterine Co., Henderson St., has awarded the contract for the construction of a 5-story, 50x100-ft. factory to the Realty Associates, 162 Remsen St., Brooklyn.

NEWARK—J. Campbell & Co., 75 Hudson St., New York City, has awarded the contract for the construction of a 1-story, 91x223-ft. dye building and power house on Plum Point Lane, to J. Jewks & Sons, 676 Montgomery St., Jersey City.

TRENTON — The McFarland Fdry. & Machine Co., Mead St., plans to construct a large plant including a 1-story, 30x120-ft. foundry. Estimated cost, $23,000. N. A. K. Bugbee Co., 206 East Hanover St., engr.

TRENTON—The Trent Tile Co., Klagg Ave., has awarded the contract for the construction of a 1-story, 50x100-ft. addition to its plant, to J. W. Thompson, Broad St. Bank. Estimated cost, $12,000.

VINELAND—F. H. Bent, engr., 142 W. State St., Trenton, will receive bids for the construction of a sewerage system, including a septic tank, etc., at the Home for the Feeble Minded, here. Estimated cost, $15,000.

New York

BEAVER FALLS—The J. P. Lewis Co., paper manufacturers, will rebuild two buildings which were recently destroyed by fire, entailing a loss of $100,000.

NIAGARA FALLS—The Electric Smelting & Aluminum Co., Mill Track 9, plans to build a hollow tile factory addition on West Jackson St. Estimated cost, $10,000.

PYRITES—The De Grasse Paper Co. has awarded the contract for the construction of a 1-story, 60x208-ft. machine room addition to its present plant here, to Hodge & Foster, Flower Bldg., Watertown, at $100,000. Noted April 14.

North Carolina

GASTONIA — Glass & Authur has awarded the contract for the construction of a 1-story, 50x75-ft. foundry, to James McAllister. Estimated cost, $5,000.

NAVASSA—The Morris Fertilizer Co., Citizen and Southern Bank Bldg., Atlanta, Ga., has awarded the contract for the construction of a fertilizer factory, to A. Bentley & Sons, Jacksonville, Fla.

North Dakota

GRAND FORKS—The Industrial Comm. of North Dakota, Bismarck, will receive bids until May 29 for the construction of a reservoir and filter plant. C. A. Pillsbury Co., 2305 Oliver Ave. S., Minneapolis, Minn., engr.

Ohio

ASHLAND—The Alboy Co. will soon award the contract for the construction of a 2-story, 200x200-ft. factory for metal stamping. Estimated cost, $150,000. Dercum & Beer, 4500 Euclid Ave., Cleveland, archts.

CLEVELAND—The Holan Mfg. Co., 3809 Clark Ave., has awarded the contract for the construction of a 1-story, 43x164-ft. drying kiln and a 44x150-ft. mill at 5809 Parkbrook Rd., to F. J. Jirka, 4216 Warren St. Estimated cost, $100,000.

DELAWARE—The Delaware Water Co. plans to build a 2-story filter plant.

WOOSTER—The Akron Brass Mfg. Co. has awarded the contract for the construction of a 1-story, 50x185-ft. foundry and machine shop, to J. S. Smythe, Wooster. Estimated cost, $26,000.

Pennsylvania

PHILADELPHIA — The Atlantic Refining Co., 1211 Chestnut St., plans to construct an oil manufacturing plant addition on Snyder Ave., west of 29th St.

WASHINGTON—The Hazel Atlas Glass Co. is building a 1- and 2-story, 100x368-ft. glass factory at its plant here. Estimated cost. $500,000.

Rhode Island

CENTRAL FALLS (Pawtucket P. O.)— The United Nets Corp., 229 4th Ave., New York City, has awarded the contract for the construction of a dyehouse and bleachery on High St., to the Central Const. Co., Pawtucket. Estimated cost, $20,000. Noted May 4.

South Carolina

BENNETTSVILLE—The Mailboro Fertilizer Co. plans to build an 80x200-ft. fertilizer factory.

CAYCE—The Seminole Fertilizer & Oil Co., Jacksonville, Fla., plans to build a fertilizer plant.

CHESTER—The Baldwin Cotton Mills has awarded the contract for the construction of a sewage disposal plant to Tucker & Horton, Charlotte, N. C.

Virginia

RICHMOND—The Standard Paper Mfg. Co., Hull and Canal Sts., is building a factory for the manufacture of blotting paper. Estimated cost, $150,000. J. H. Wallace & Co., 5 Beekman St., New York City, archt. and engr.

Wisconsin

HORICON—The Columbus Canning Co., c/o C. L. Davidson, supt., has awarded the contract for the construction of a 2-story, 96x108-ft. canning factory on Main St., to F. J. Pluckhahn, Juneau. Estimated cost, $40,000.

MILWAUKEE—H. A. Poppert Mfg. Co., 505 Cedar St., has awarded the contract for the construction of a 26x52-ft. foundry on 5th St., to Byrne Bros., 2112 Burleigh St. Foundry equipment will be installed in same. Estimated cost, $5,000.

TOMAHAWK — The Pride Pulp and Paper Co. plans to build a paper mill. C. B. Pride, pres.

Wyoming

LARAMIE — The Standard Oil Co., Casper, is building a Burton Process pressure plant here. The plant will consist of principally ten 8x40-ft. pressure stills and necessary storage equipment and will handle distillates for the Midwest Refining Co.

Quebec

MONTREAL — The Congoleum Co. of Canada has awarded the contract for the construction of a 70x118-ft. building on St. Patricks St., to the Atlas Constr. Co., 37 Belmont St. Estimated cost, $105,000.

Ontario

PETERBORO—The city plans to build a sewage disposal station and pumping plant. Estimated cost, $50,000. R. H. Parsons, City Hall, engr.

PORT CREDIT—The village plans to construct a waterworks system. Plans include a chlorination system and the installation of mechanical filters, etc. Estimated cost, $80,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, engr.

LONDON—The W. T. Rawleigh Co., 55-65 Liberty St., Freeport, Ill., will receive bids about June 1 for the construction of factory buildings for the manufacture of pure food products on Adelaide St. Estimated cost, $300,000.

NEWMARKET—The city will soon award the contract for the construction of a sewer and activated sludge plant. Estimated cost, $65,000. E. A. James Co., Ltd., Toronto St., Toronto, engrs. Noted Jan. 7.

SUDBURY—The High School Bd. will soon award the contract for the construction of a 3-story school. Chemical and physical laboratory equipment will be installed in same. Estimated cost, $200,000. P. J. O'Gorman, archt. Noted March 17.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold a regular meeting June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS will meet in St. Louis May 27 to 29.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE INDUSTRIAL RELATIONS ASSOCIATION OF AMERICA plans to hold its annual convention in the Auditorium Theater, Chicago, Ill., May 19, 20 and 21.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NEW JERSEY CHEMICAL SOCIETY will hold a regular meeting and ladies' day Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J.

THE SOCIETY OF CHEMICAL INDUSTRY, American Section, will hold a meeting, May 21, at the Chemists' Club.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

Industrial Notes

THE WILSON-MAEULEN CO., New York City, has appointed Harry Goldsen, a practical instrument man, who knows the company's electrical pyrometers thoroughly, both from the manufacturing and service sides, as its new representative in the Pittsburgh district. He will have charge of both sales and service in that territory.

THE CELITE PRODUCTS CO., New York City, announces the appointment of Lyle Stockton Abbott as head of the Eastern sales department. Mr. Abbott succeeds H. A. Mannshardt, resigned.

THE FOUNDATION CO., New York City, announces that Edwin J. Beugler has become associated with it as vice-president in charge of engineering. Announcement is also made of the appointment of Joseph H. O'Brien as chief engineer.

THE HARRISON SAFETY BOILER WORKS, which has been carried on for many years as a co-partnership by Joseph S. Lovering Wharton, William S. Hollowell and John C. Jones, has been incorporated under the laws of Pennsylvania, charter perpetual, as the H. S. B. W.-Cochrane Corp. with the following officers and board of directors: Joseph S. Lovering Wharton, president; John C. Jones, vice-president and general manager; William S. Hollowell, secretary and treasurer; Horace E. Sibson, general sales manager, and Alexander B. Wallen, general works manager. The corporation takes over, as of date Jan. 2, 1920, the entire business of the former firm, acquiring its assets and assuming its liabilities.

YORK, REGAN & BURKE has been organized as a partnership with headquarters at 1323 North Clark St., Chicago, Ill., for the purpose of general consulting work as architect and engineer, embracing concrete engineering, buildings, bridges, concrete steel structures, industrial plants and other civil engineering work.

THE ELECTRIC FURNACE CONSTRUCTION Co., Philadelphia, makes several announcements: First, the following new orders for Greaves-Etchells electric furnaces: Wayne Steel & Iron Co., Croghan, N. Y., 1-ton furnace; Stora Kopparbergs Bergslags Aktiebolaget, Domnarfvet, Sweden, one 20-ton for steel ingots; Soc. Métallurgique de la Loire, St. Etienne, France, two 10-ton for steel ingots; S. A. C. Electriques de Charleroi, Belgium, one ½-ton for castings; Carlisle Steel Co., Sheffield, one ½-ton for tool steel; Sproat Marley & Co., Newcastle, England, one 1-ton for steel castings. Second, the successful starting up of the Greaves-Etchells electric furnaces at the following companies: Dodge Steel Castings Co., Philadelphia; American Radiator Co., Buffalo, N. Y.; Hammond Steel Co., Syracuse, N. Y.; Charles Bertolus, Bellegarde, France; Fonderie Ambrogie Necchi, Milan, Italy. Third, the following appointments of agents and representatives for the Greaves-Etchells electric furnaces: H. M. Smith, 39 Schofield Bldg., Cleveland, Ohio; A. S. Lindstrom, 519 California St., San Francisco, Cal.; McCrum & Gillem, 1011 Empire Bldg., Birmingham, Ala.; D. P. Morisseau, General Welding & Supply Co., Wainwright Bldg., St. Louis, Mo.

Manufacturers' Catalogs

WILLIAM R. PERRIN & Co., Chicago, Ill., is issuing a new filter press circular.

LEEDS & NORTHRUP Co., Philadelphia, Pa., calls attention to a pamphlet, Catalog No. 90, entitled "The Hump Method for the Heat Treatment of Steel," which describes a radically new way of hardening steel. Accurate measurement of temperatures and the independent determination of transformation points are rendered unnecessary. The work is heated in an electric furnace in contact with, or near to, a thermocouple. A recording instrument draws upon a large scale chart a curve of the electromotive force developed by the thermocouple. While the work is passing through the transformation or decalescence point, the rise in temperature is arrested, producing a decided jog or "hump" in the line. The operator allows the work to remain in the furnace a definite number of minutes after this hump appears and then quenches. The results claimed are entire uniformity of heat treatment, including grain size, hardness and tensile strength, together with freedom from distortion, breakage, decarbonization and scale. In addition, there are certain advantages due to the use of electric furnaces, such as cleanliness, low upkeep charges, ability to locate the heat treating department in the machine shop where the material can be treated in the direct course of manufacture, thus reducing handling charges and bringing all operations under the supervision of one man. A number of large concerns are using this method for hardening tools and dies and for the quantity production of automobile gears, races for ball bearings, etc. The total cost of operation, including labor and electric current is said to be less than that of fuel-fired furnaces, where quantity rates for current can be obtained, while the quality of the product is improved and standardized.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES S. LAPOLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, May 26, 1920 *Number* 21

Congress and the Air Nitrate Projects

THE special House Committee of War-Time Expenditures on Air Nitrate Projects by the Government has made its majority and minority reports, as recounted at considerable length on our news pages. This conforms to Congressional tradition, which is the same as that of country lawyers. The Speaker appointed a majority of his own party and a minority of the opposition to the committee, and its members straightway established themselves as attorneys for their respective parties. The people were hardly represented.

The principal recommendation of the majority related to the big Muscle Shoals works and proposed that it be leased and converted into a fertilizer plant for the sale of products direct to farmers with the right of the Government to take it over in time of threatened war.

This is a recommendation in regard to the general welfare. It might very probably be the report that any majority would have made, whether it consisted of Republican or Democratic conservative politicians who shy at anything that smacks of Government control of a specialized industry. But immediately a minority member registered a protest against the report, not on the ground that another alternative was better, but on the ground that it was an invasion of the function of another committee of the House. This was twaddle and it was overruled, but whether it was overruled because it was twaddle or because it was registered by a Democrat, while the Speaker is a Republican, is a secret that will probably always remain hidden in the Speaker's breast—and it is doubtful if he could reveal the truth about it if he tried.

Then the majority condemned the Government's entire war-time program and charged reckless waste and extravagance. They say the blame rests on President WILSON and BERNARD M. BARUCH, Mr. BARUCH being the moving spirit of the war-time project. The assertion, however, has no significance whatever, because, if Mr. WILSON had been a Republican, the same majority would have praised him for doing exactly what he did and admired Mr. BARUCH even beyond his real deserts. And the Democratic minority would have found no merit in it. As it was they found no fault. The majority vote of censure is not a register of opinion; it is merely a register of political tropism.

Then, to put the Administration into a hole, the majority proposed that no further sums be paid to the Air Nitrates Corporation, on the ground that it failed to perform its contract; the institution of civil suits was recommended for recovery of damages, and it was urged that the whole question of pay (i.e., the payment of debts incurred by the Government) be "threshed out" in the Court of Claims. Threshed out is the right expression. The chance of collecting a debt against the Government in the Court of Claims with governmental counter-suits pending is a weary process. If the liquidation can be completed within twenty years it will be speedy work. Members of the majority may strut and shout until they are blue in the face about their integrity of purpose, but they cannot prevent it from appearing that they were willing to cause the Government to default in its obligations rather than miss the chance to embarrass the opposition. There was no effort to serve the people by either side that a careful reader can discover. They did what they had to do to avoid blame for themselves, and devoted the major portion of their efforts to get their opponents into trouble. The whole thing is sickening.

Suppose a commission of engineers were selected to build a smelter, not because of their merit as engineers but to provide a body of men unevenly divided between persons with red hair and those with black. Suppose whatever men of one complexion did the others declared to be wrong and that the whole caboodle of them were more interested in fixing blame on the opposition than in getting the smelter built. What kind of a smelter would result? Then suppose after it was built its operations were carried on by just this sort of "party government." When would dividends begin?

Here we are with the threat of madness over civilization confronting a great part of the world, and the trouble is contagious. And we have not enough strong men of character in Congress to shame their fellows into a sense of their obligations to the people. Nobody wants to know how incompetent the other side is. Everybody knows both sides are incompetent. There is no use in telling us so any more. We do not want the choice of the lesser evil. What we want is the greater good, and vituperation will not bring it to light. What a pity that the men we have elected to represent us cannot understand this!

National Organization Of Engineering Societies

DOUBTLESS all national, regional and local engineering societies have some time since received proper notification from the Joint Conference Committee of the Civil, Mining, Mechanical and Electrical Engineers of the organization meeting to be held at Washington, D. C., on June 3. Therefore it is unnecessary to dwell upon the importance of this item of news, but it is well for engineers in general to think carefully upon the issues which impel the present movement toward a national organization.

It may be said that the Joint Conference Committee is an outcome of a slow accumulation of sentiment in the ranks of the American Society of Civil Engineers,

which after years of growth took visible form in the appointment of a numerous committee on development, to consider ways and means whereby the individual engineer could get more direct advantage in a human rather than a technical way from his engineering society. Other engineering societies took similar action for a variety of reasons which would be tedious to relate, but in all of these committees there was a well-expressed idea that some inclusive organization would be necessary to express properly the engineers' desire for service and influence on such public affairs as they are qualified to speak of with authority, and to consider the welfare of the profession of engineering in its broad general aspects.

Hence the Joint Conference Committee, delegated from committees on development from the four national societies, met and formulated a plan of organization which was duly reported back to the parent institutions. These societies, by appropriate action, approved the plan in principle, and appointed delegates to the forthcoming conference, apparently, however, without power to bind their parent societies to such action as may be taken at Washington.

In fact, the development activities within the Civil Engineers were responsible for a very recent letter ballot, wherein the membership by decisive majorities called for such action as would increase the engineer's influence in public affairs, yet by a small majority rejected the plan advised by the Joint Conference Committee. Briefly, this proposed organization is not intended to be (in the words of one of its sponsors) "a super-society of engineers. It will have no membership of individuals, but will be composed entirely of delegates representing organizations already in existence. In its object it does not encroach on the province of any engineering organization at present in existence."

This last statement may fairly be questioned, as well as doubt expressed as to whether the method of representation will appeal to all engineers any more favorably than it did to the Civils. It may be pointed out that the new organization is not a society, but a federation. The ultimate member will be well represented only in case his particular society is peculiarly responsive to his needs. If memory serves correctly, not so long ago an appeal to American engineers for funds for Engineering Council (in itself an organization having no membership of individuals, but composed entirely of delegates) met with extremely meager response. On the other hand, during the last year the American Association of Engineers increased its membership from 4,000 to 17,000, and received $170,000 for investment in active work of the organization, which indeed seems to include the avowed purposes of both the poverty-stricken Engineering Council and the proposed new federation.

Unquestionably the spirit of unrest is stirring engineers as well as it is any other group of individuals in the present-day world. It is calling for engineering societies which shall justify their existence by service to the individual rather than for their officials. Engineers are worthy of a more influential voice in our public activities, and some organization will spring up to satisfy this demand. But in view of the history of Engineering Council, the Civil Engineers' letter-ballot, and the phenomenal growth of the A.A.E., it can be plainly concluded that the successful society will not be composed of delegates, but rather of individuals.

Inquisitive Ignorance In the Foundry

OF COURSE we younger metallurgists had an inkling of it in our own minds, without immodest self-confidence. Yet it sounded good to hear the gray-headed expert ("expert" is the proper term), the seasoned consultant with his kindly eyes, repeat in all seriousness, "The educated young man now in the foundry is its salvation."

The hearer was feeling pessimistic that morning, and mentioned the fact that perhaps twenty-five years ago there was a great furore to put a chemist into the foundry. No foundry was complete without either a rack of test tubes or a file of analysis reports. Yet even today relatively few of the foundries which delude themselves with "chemical control" really appreciate what "chemical control" means. If the analyses are not laid away to rest alongside innumerable of their brothers on file, no serious effort is made by the melter to see that the charges are actually and carefully weighed. So why should the few technical men going into the foundries be so important?

"I'll grant you that the foundry is full of rule-of-thumb methods, and has a strong tendency to revert to type," said the older man. "When I first worked in a locomotive shop I well remember no one could cast engine cylinders but the HARE boys. If they were both sick, well, there were no cylinders made until they returned. They had their favorite cheeks, and their own peculiar sand. All the molders knew these, but did not know the feel of the sand when it was properly mixed, they would ram it just a bit too hard, or the gaggers would not be bent at the exact crook, or the cope would not be vented just so nor would the HARE boys ever tell just how they determined when the iron was exactly right. They were acknowledged the best molders on engine cylinders, and they intended to remain so.

"That works still remains, and the HARE boys are no longer molding cylinders, yet better engines than ever are turned out every month, and at a tremendous rate, despite the old-timers!

"About ten years ago the management decided to rebuild the rambling assemblage of miscellaneous shops into one consistent manufacturing establishment capable of turning out their steadily increasing business. They employed some real engineers, who studied the requirements of that particular concern, and in the end provided a modern plant containing all the mechanical features the heart could desire. The foundry was an inspiration!

"Naturally, but unfortunately, BILL RIDDLE, who had been foreman of the old foundry for thirty years, was continued in charge of the new plant. The bigger job was too much for him, and in order to be on the safe side, he saw to it that the workmen made car wheels exactly the same in 1910 as they were made in 1885. Of course, expected output did not materialize, nor could anyone tell RIDDLE anything or help him. The way he had done since youth was safe and good enough, and he was going to run the whole plant himself, since he was in charge!

"Finally the manager asked me if I could suggest a way out of their trouble, and I told them that they should select three or four of their best and keenest young men, and impose them upon BILL as assistants. Of course BILL would make a terrible fuss, and lead the

boys a dog's life for a while, but he must be given to understand that all were to work together rather than pull apart.

"In a year or so BILL RIDDLE retired, it is said with dire predictions of the fell consequences. Yet the best of the boys is now superintendent, and the plant is steadily improving and exceeding the designer's predictions. So you can see I have at least one good reason for my abiding and instinctive faith in the genius and capacity of the inquisitive young men coming into the foundry, who do not know so much about the correct way to do things that they are not afraid to put some of their foolish inspirations to trial!"

Inefficient Distribution of Labor

THERE is a "shortage of labor" in the United States. One may say that is a curious if not impossible situation, for if everybody is working and everybody is consuming it cannot make a great deal of difference how many there are all told, whether 50,000,000 or 100,000,000. If there is a shortage of workers why not an equal shortage of consumers, and there you are! It was a different thing at various times in the past when the entire population were consumers or would-be consumers, but through some mischance all could not get jobs, hence could not get the wherewithal to purchase things for consumption.

Large corporations are usually efficiently managed these days, but a large corporation is not well managed merely through having the proper total number of employees. It is in a bad way if it does not have a capable president, and the president's office is in a bad way if it does not have a proper supply of capable office boys. Each job must be properly filled, and the efficiency is not what it should be if there are men who are doing work that is beneath their ability. Everyone should have the opportunity to do the best work he is capable of doing.

The United States is not thus aligned as to its working forces. There is a very inefficient distribution of labor, using the term "labor" in its broadest sense. Thousands of school teachers have resigned from positions where they were very useful, in order to take positions as stenographers and clerks. Janitors and street sweepers get pay far in excess of the proportions formerly obtaining. Men able to do better things are engaged at common labor, but as they don't like that kind of work the common labor has been going to higher and higher premiums. Railroad work has been disorganized by workmen receiving higher pay than the foremen who direct their work.

The way we have been muddling along is that if there is not enough common labor we pay a disproportionately high price for common labor, and if there is still not enough, the more skilled crafts reduce their performance to strike a balance.

When immigration has been shut off for years it is natural that there should be a shortage of common labor, and as each finished product, whether a dwelling house, a skycraper, a steel rail or a bushel of potatoes, requires its certain percentage of unskilled labor and of skilled labor there is a deficiency in production. If skilled workers were working as well as formerly, there would not be enough work for them to do, on account of the lack of the proper proportion of common labor, but they endeavor to bridge the gap by doing less in a day. This may seem well enough to them, although the high cost of living is making some of them think, but in any event it is not efficient. Should competition among skilled workers arise, as there has been competition in the past, it would be found that not enough work could be given them, by reason of the scarcity of men to do the common labor.

The scarcity of common labor is due, of course, to the failure of immigration, and immigration needs to be stimulated, whereas the literacy test, enacted by Congress at the behest of organized labor after successive Presidential vetoes, is one thing that curtails immigration. The country is suffering from lack of common labor, and skilled labor is suffering. Some time it may suffer still more. The question is whether it realizes, or can be brought to realize, its mistake, in opposing immigration. If we had no plumbers and found it much more costly to train plumbers than to allow plumbers from abroad to come into the country, it would certainly be advantageous to bring them in.

It used to be complained that the foreign-born workmen saved up their money and sent it abroad to friends and relatives, or even carried it out of the country with them. We were under the painful necessity of exporting goods to equalize this and other portions of the "unseen balance of trade." Nowadays we bribe men to do common laboring work by paying them high wages and instead of saving their money they buy silk shirts, hence the high cost of living. The silk shirts do not do them any particular good and the man who feels he is really entitled to wear silk shirts is disgruntled.

"Technically and Commercially Successful"

AN ANNOUNCEMENT of a co-operative agreement which has been perfected by the Bureau of Mines with certain individuals for the study of lignite coking and briquetting has been made public. The agreement puts special emphasis upon the desire that there be established "a technically and commercially successful business." Both parties are to be congratulated that there is such definite recognition of two essential elements in any investigational plan.

There is a great deal needed to be known about lignite and its properties, about the products, solid, liquid and gaseous, which result from its carbonization, and about the possibilities of briquetting lignite and lignite chars. It is to be hoped that many of these uncertainties will be cleared up and valuable information afforded our engineering talent for future development of this important fuel resource that today lies practically unexplored and untried.

However, the business side of any such process is just as important to the engineer as the science and technology, and it is very satisfying therefore to find that the two elements so important in the development of this new industry are placed upon a par in the program of work announced. One cannot expect that both elements will be wholly illuminated by such a limited expenditure as the $300,000 which will be invested under this co-operative agreement. However, the very limited knowledge now available in this field should be greatly extended, and the possibility of further future development made much more promising.

Readers' Views and Comments

Engineering Conference on Public Service

To the Editor of Chemical & Metallurgical Engineering

SIR:—On page 910 of your May 12 issue you entirely misinterpret the Notice to Engineering Societies. The Organizing Conference, meeting in Washington, June 3 and 4, is not a meeting of the Joint Conference Committee, but is a meeting of representatives of all national and local engineering and technical societies to organize the representative national body which shall embody the "public service" element of all American engineers. The Joint Conference Committee was authorized by the four large engineering societies to issue this call for a conference to organize this body along the lines of the Joint Conference Committee's report to the four large engineering societies.

JOSEPH W. RICHARDS,
Acting Secretary, Joint Conference Committee.

Bethlehem, Pa.

To the Engineers of America

To the Editor of Chemical & Metallurgical Engineering

SIR:—None of the undersigned has been active in "politics" heretofore; nor are we now! But we believe that our country needs just one kind of a man to guide its fortunes during the next four years.

He should be a man understanding the underlying causes of the present nation-wide unrest—the economic as well as the social causes; a man who has administered large affairs successfully, handled vast sums economically and honestly; has employed laborers with sympathy and success; one having executive experience; who has made his way up from humble beginnings and therefore understands the psychology of the man who works with his hands; one who has the courage to combat squarely, whether in the board-rooms of corporations or in the councils of ignorant or vicious "Soviets."

We need a man not only "favoring" economy in the National Administration, but an avowed advocate thereof, with the knowledge gained from experience of how a budget system is prepared and also how it should *work*; in other words, a sane and tried "efficiency expert."

America needs a man who has seen and knows actual conditions overseas and who can guide our international relations with firmness and sympathy, justice and honor; a man who has met face to face and understands those who lead the councils and influence the policies of European nations, new and old; who has had not only the grace to say "Yes," but the courage to say "No!" when necessary, not only to our late enemies, but to some others abroad who would take advantage of American sympathy or generosity—yes, and to some of the few here who would "profiteer."

Some of us know and respect one or more of the men who are seeking in an honorable way to secure the Presidential nomination, and others who are also favorably thought of; *but has anyone of them the first-hand knowledge of our national and international problems that are in the undisputed possession of Herbert Hoover?* We think not!

We believe it is possible that he can be nominated, even without a political machine behind him; that the American people can constitute themselves a "Committee of the Whole" whose choice will be triumphant, *provided the "vox populi" can be made audible!*

How can this be done? By bringing it about that the people shall not only speak out what we believe is in their hearts but that their voice shall be *heard.*

We are members of one or another of the great Engineering Societies of America, but we have neither asked nor do we expect these organizations to act as *such.* But if each engineer, before whom this letter appears, will constitute himself a committee of one, each in his own locality, to spread the well-known facts of Herbert Hoover's career, personality and attainments and *to bring to the delegates of his own state the knowledge of his neighbors' demand* that Hoover shall be the nominee, this result will surely be attained. No one knows better than the political leaders of all parties that if nominated *he is sure to be elected.*

Will the American engineers help to bring this about?

For further information write to the Engineers' Hoover Committee, 480 Lexington Ave., New York.

ALBERT R. LEDOUX, New York
CHARLES F. RAND, New York
HOWARD E. COFFIN, Michigan
J. VIPOND DAVIES, New York
CHARLES T. MAIN, Massachusetts
HUNTER MCDONALD, Tennessee
B. B. THAYER, New York
J. G. WHITE, New York

An Accounting Mystery

To the Editor of Chemical & Metallurgical Engineering

SIR:—In the issue of April 21 you express regret that the House and Senate had declined to grant a fund to the Bureau of Standards for the preparation and distribution of standard samples. Later, you say that the work was really self-supporting. If it was self-supporting, why is a fund necessary for its continuance? Why can the Bureau not continue to distribute samples and show a profit from it? If it was not self-supporting, why continue to state that it was?

A. A. N.

It is no wonder that A. A. N. is somewhat mystified at the Government accounting system which does not permit a self-supporting fund to be such in effect as well as in name.

With reference to the standard sample fund of the Bureau of Standards, the fund requested is $5,000. The fees last year were $6,000 in cash and $4,000 or more additional in credits for work done for state and Federal departments that do not pay cash. These funds, however, are not available to the Bureau of Standards but go into the Treasury, to the credit of the United States. Therefore, it makes no difference how much money the Bureau takes in in fees, it has absolutely none of it to spend for continuing the work. As a consequence, it might be more nearly correct to say that the work was self-supporting as far as the Government was concerned, but as far as the Bureau of Standards is involved any expenditures it makes cannot be recovered from income, no matter what the fee may be in size or character. [EDITOR.]

Corrosive Action of Soils on Iron and Lead

An Outline of Field and Laboratory Tests on Electrolysis of Metal Parts Buried in Many Soils, Together With a Brief Summary of the Experimental Results and Derived Conclusions

By L. A. STENGER

ONE of the features of industrial conditions little noticed by the average person is the multiplicity of pipe lines, cables, conduits and various other metallic structures found in the subsoils of cities. These structures, with the exception of earthenware sewers and conduits and bituminized fiber conduits, are constructed from cast or wrought iron, steel and lead. The iron and lead are used for water pipes, iron is used for electrical conduits and gas pipes, and lead, usually containing 2 per cent of tin, is used as a protective covering for electric power and telephone cables. Rails of street railways may be included with these structures, also steel foundations of buildings and steel tunnel linings.

Usually these pipes, etc., are placed in the soil with the idea that they will not be affected, at least to the point of destruction, by any corrosive agencies. Attempts are sometimes made to paint or coat the metallic surfaces for protection, more often not.

An enormous amount of work has been done investigating the causes of corrosion of iron and lead in air and the methods for their adequate protection. Comparatively little has been done investigating and preventing corrosion of these metals in soils.

There have been several theories advanced to explain the corrosion of iron. These are the electrolytic, the carbon dioxide or acid, the hydrogen peroxide, the oxidation and the biological or bacterial. From the results of work on this subject, together with a study of the publications of Whitney, Cushman, Gardner, Walker and many others on corrosion in general, the present author believes that practically all corrosion, of both iron and lead, is electrolytic in action.

Corrosive Action of Soil

The general study of the subject was begun with field observations of underground structures in different places. Extensive work of this type was done at Havana, Cuba, in 1911, by S. T. Todd, of the General Electric Co., and the writer. At that time a new sewer system was being installed, the excavations for which offered a rare opportunity for observing the many piping systems buried in the ground. There it was found the corrosive action of the soil on iron was severe. The most damage was done to the smaller iron gas and water service pipes. From reliable information from several sources, it was found their life was from three to seven years, for either wrought iron or steel pipes. A poorly galvanized pipe would corrode as badly as a black pipe. A good heavy galvanized coat was an effective protection. Corrosive action was very marked also on cast iron pipe. Careful work was done to find leakage electric currents where this corrosion occurred. None was found. The street railway rails carry practically no current, the double trolley system being in use. The rails of two electric lines entering the city carried current; these were the only sources of leakage current in the city, and, owing to the good soil conductivity, damage from that current would be localized closely to the lower potential points of the tracks. No damage had been reported from this cause. Furthermore, corrosion had been common in that city before electricity had been used at all, therefore it is absolutely certain the pipes were corroded by reactions between soil constituents and the metal.

In Indiana there was laid in 1891 an 8-in. steel gas pipe with screwed wrought iron couplings. This pipe extended from the Grant County gas fields to Crawfordsville, where it ended about one-half mile from an electric railway. This pipe was taken up in 1911. It was corroded in local areas over the pipe, at many places through the walls, and generally over the whole length of the line. It was buried 3 to 5 ft. deep, lying in moist yellow clay soil. This corrosion was also due to reactions between soil constituents and iron.

In Pierre, S. D., cast iron water pipes have been replaced on account of damage due to soil corrosion only. Small iron service pipes were corroded to leakage in six years. The subsoil there is a heavy clay

Cast iron and steel pipes have been found in Minneapolis and St. Paul, corroded to destruction in black peat soil, cinder fills and clay. These soils were found to be actively corrosive.

Commercial lead is very long lived under ordinary circumstances. However, in Havana it was found that lead covers of some insulated electric cables laid in earthenware conduits were destroyed in three years. This occurred where silt had leaked into the conduits, and where, at times, water ran through them. The lead water service pipes buried in clay were in an excellent state of preservation, and all observations and information indicated that they were undamaged.

Corrosion Is Electrolytic or Auto-Electrolytic

Consideration of these facts and others leads to the classification of corrosive effects into two types. One, called electrolysis, is the resultant of an outside generated electrical current flowing from the metal by an electrolytic conduction path. The other has been termed auto-electrolysis; it is electrochemical in nature, and nearly all corrosive effects on subsoil structures, not caused from electrolysis, are produced by it. These two types are to be clearly differentiated, although it has been found that their effects are similar, and as they are so nearly related, any study of corrosion should include consideration of each, especially when corrosion causes are under investigation.

Localized corrosive action on iron, commonly called pitting, may easily destroy gas or water pipes, as a leak is caused in a comparatively short time. The

electrolytic theory may be applied to explain such corrosion. Iron has a high solution tension, which causes iron ions to leave its surface under electrolytic conditions, as in moist soils. This ionic travel sets up an electric current. If there is a particle of material electronegative to iron and in contact with it, the current will be directed and will flow from the iron through the adjacent soil to the electronegative area back to the iron. The result will be iron going into solution and becoming oxidized to hydrated iron rust, which is insoluble, porous and an electric conductor. The hydrogen formed by this electrolysis is oxidized to water. If free hydrogen were formed, as in rapid action, the current would be reduced or stopped by insulation due to the gas film on the electronegative area; that is, the miniature battery would be polarized. But it is found by experiment that all the hydrogen is oxidized, and no gas is evolved, and that the action is continuous until the iron is all removed in the immediate vicinity and a pit results. This action is then auto-electrolysis. Any bare iron structure in soil is subject to auto-electrolysis, as the soil will always be more or less an electrolyte, as it contains soluble salts, or acid ions, and moisture.

On account of the number of variable factors found affecting corrosion rates, it becomes rather difficult to isolate and to study them effectively. Considering the metal alone, prominent factors affecting its corrosion rates are constitution, properties of components, segregations, foreign substances including gases, states of strain, solution tension and conditions of surface.

External factors involving the soils and conditions outside of and in contact with the metal are moisture content, gases, composition, electrical conductivity and components. The latter may be chemically corrosive, electronegative to the metal and catalytic in action. Also porosity or density, homogeneity, concentrations, bacterial conditions, temperature and pressure are to be included.

Potential Explorations

At the beginning of some laboratory work done by the writer under direction of Prof. E. E. Nicholson at the University of Minnesota, some experiments were carried out, electrolyzing cast iron and sheet steel in solutions. They show that the iron goes into solution at a rate of 1.042 g. per amp.-hr., approximately. This is with a valence of two. Further work was then done using several irons in different soils, to compare all effects under the various conditions, and to find the corrosion rates both by electrolysis and auto-electrolysis. For electrolysis in soils many tests were run, using different soils and iron, steel and lead anodes. Tests were made on iron anodes with scaled, smooth, or polished surfaces. Various voltages and current strengths were used. After deducting for the corrosion due to auto-electrolysis as determined under the same conditions without any applied electric current, the efficiency of electrolysis was determined. From all results, about two-thirds of the iron anodes having an electrolysis corrosion efficiency under 100 per cent gave an average of 81 per cent efficiency. The remaining 33 per cent of anodes at 100 per cent efficiency and over gave an average of 110 per cent. Lead anodes gave an efficiency of from 80 to 150 per cent. From these results no law connecting any of the variable factors with a definite electrolysis efficiency was noted.

Electrical or galvanic phenomena found in connection with auto-electrolysis were studied. Two identical electrodes of copper (platinum could have also been used) were made, and covered with pads of cotton cloth or filter paper. These terminals were connected to a suitable electrometer. Wetting the pads with dilute acid and placing them on an iron surface, an electromotive force was produced. The resulting current was caused by the iron ions passing into solution at a faster rate in one electrolyte than in the other. The effect is also observed after using soil under the terminals instead of pure acid electrolyte. The energy generated is dependent on various factors, and the voltage is due primarily to the solution tension of the metal.

Current Strength Studied

Studies were made of these potentials and the resulting current strengths. A Weston 15-volt voltmeter is a suitable instrument to use for measurement of voltage with electrodes as described about 1 in. in diameter. This instrument does not indicate the full voltage generated, on account of the limited current flow. A special inclined capillary Lippman electrometer was constructed for this work and found excellent. It takes no current and indicates potential up to 0.8 volt accurately. A Weston milliammeter may be used to measure the current. In making such electrical surveys on bright pure iron, usually the electrode put down first is found to be electropositive. The current flow would be from the iron under it. Using ordinary moist clay as electrolyte and two similar copper terminals, placing one clay first on pure bright iron, and in a few seconds the other in another place on the same piece of iron, closing the circuit with the copper terminals through the Lippman electrometer, voltage up to 0.1 was indicated. The copper terminals may be reversed, also reversing the electrometer, to determine if there is any voltage due to dissimilarity between them—there should be none. Care should be used to avoid contact between terminals and iron.

With this method, using moist soils as electrolytes, potentials were measured between points on many kinds and conditions of irons found in commercial use. On clean ordinary surfaces would be found 0 to 0.1 volt, clean iron to mill scale 0.3 to 0.5, clean iron to copper 0.8 to 1.0, clean iron to carbon 0.8 to 1.0, clean iron to red rust 0.3 volt. The clean iron would be electropositive in all cases; current would leave it and cause corrosion.

Causes of Auto-Electrolysis

The destructive effects of auto-electrolysis depend upon the electronegative material to a considerable degree. If it is a copper coating with a flaw exposing iron, then under auto-electrolytic conditions a hole will be corroded through the iron in a surprisingly short time. A superficial corrosion will expose the graphitic carbon in cast iron; an area is thus electronegative and the iron ions are removed through the porous electrolyte-saturated soft material, characteristic of corroded cast iron. Mill scale, if thick and unbroken, is a good protection to iron, but if broken becomes a source of danger, since it is electronegative. In soils where the electrolytic conditions are not favorable for corrosion, as in clean sand, action may be suspended indefinitely, only a small amount of rust forming.

Corrosion of Purest Ingot Iron

Pitting will occur in polished, pure irons (analysis 1) in a clean well-mixed clay, due to the same causes

with no apparent electronegative areas on the iron itself to direct or localize the reaction. This may be due to either or both the following causes: slight differences in the iron itself, or concentration cells set up in the clay. Using the Lippman electrometer with electrodes of similar metal, preferably small platinum wires, surveys over a piece of moist clay showed potentials of 0.01 to 0.02 volt between different points. Attempts were made in this way to locate the low potential points on a smooth clay surface. Then a polished, pure iron plate was placed on it. Allowing action to continue a few days, the iron was examined to see if the corroded areas had any definite relation to these low points. Fair correspondence was obtained on one specimen, but others did not give definite results. These potentials are very difficult to locate, but it is probable they aid in starting local actions on the iron surface, producing red rust in small amount. This is electronegative, and action then becomes definite, and pitting proceeds.

A special corrosion cell was used to duplicate conditions of underground structures for further experiments on auto-electrolysis measurements. Three-inch bituminized fiber conduit was cut in sections about 3 in. long and filled with soil, in which was placed the iron plate. Sheet rubber disks placed in the ends made them air- and moisture-tight, and paraffined wooden disks over these completed the cell. With this arrangement, the specimen could be subjected to pressure. Sets were made up to determine the effects of different pressures and temperatures encountered in practice.

Corrosion of Lead

Lead, having a very low solution tension, is not so susceptible to auto-electrolysis as is iron. External conditions will produce corrosion, however, in a somewhat different manner. If two soils are in contact with a metal, one of which contains a substance subject to a change of valence, we may expect an electrical current flow. This current will enter the metal as part of its circuit, and leave it again, in the near proximity of the bi-electrolytic soil, causing corrosion of the cathode areas. Examples of lead corrosion of this type are given in a paper by E. H. Schofield, Minneapolis, Minn., and the writer, *Electric Railway Journal*, 1914, p. 1092.

TABLE I. ANALYSES OF IRONS.

No.	1 Per Cent	3 Per Cent	4 Per Cent	5 Per Cent	6 Per Cent	7 Per C.
Graphitic Carbon..	....	....	....	2.20	3.23	....
Combined Carbon .	....	....	....	.73	.41	....
Total Carbon.....	0.02	0.200	0.060	2.93	3.64	0.153
Si.....	.003	.003	tr.	3.070	1.62	....
S.....	.005	.041	.019	.051	.133	....
Mn.....	.011	.432	.365	.283	.324	....
P.....	.000	.010	.027	.500	.458	....
Cu.....	.000	.170	.000	tr.	tr.	.233

1. Pure ingot iron No. 16 sheet.
3. No. 16 sheet.
4. No. 22 sheet.
5. From 6-in. cast iron pipe.
6. Cast iron, cast in ½ x ⅛in. stripe, broken 2 in. long, for test in soils.
7. No. 20 sheet.

Lead is also liable to corrosion from other conditions. Pipes leaving moist cement floors often corrode near the floor line. Cable covers lying in cement ducts and lead pipes in mortar walls are also destroyed. If water from condensation or other sources is allowed to collect or run down or around a lead structure under conditions when soluble salts are present, there will be formed a concentration cell. The electromotive force set up is caused by different velocities of different ions, which would be found in any surroundings of a pipe in cement or soil. The more dilute solution would be the fresh moisture supply; the more concentrated solution would be near the metal surface in the surrounding medium. Common specific instances of this type of corrosive action are seen at the bases of iron poles at the ground line. It occurs also if the pole is set in cement. This is a plausible explanation of the corrosion of the lead cable covers at Havana, previously mentioned. The bottom side of the cover lay in silt, electrolytically more concentrated. The dilute solution would be from condensation and the water flowing intermittently in the conduit, in contact with the upper surface of the lead.

The complete report of this investigation necessarily

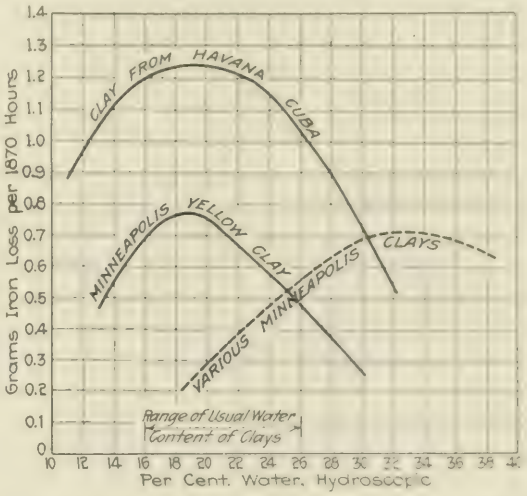


CHART SHOWING VARIATION OF AUTO-ELECTROLYSIS WITH MOISTURE CONTENT OF SOILS

Solid lines for cast iron No. 6. Broken line for both scaled and clean steel No. 3.

carries much detail which need not be included in this review. Tests on approximately 150 soil samples collected in the different cities mentioned, and the fact that many types of iron and lead specimens were treated in these soils, will give an idea of the scope of the work. Some representative results are given in Tables I and II. The influence of the moisture content of clays is shown in the chart, but this also shows that the electrolytic nature is variable in the different clays. Analyses of several soils were made, and it was found that the combined sulphates and chlorides had the greater influence in increasing corrosion. Although the amounts of these components are small in an average soil, and perhaps not over 0.5 per cent in the most active clays, yet their action is remittent and continuous, and corrosion proceeds without renewing the supply of acid ions.

An engineering crime often committed is that of placing iron pipes in cinders. Cinders have carbon particles, sulphates, and carry much moisture. This furnishes a most excellent example for illustration of the electrolytic theory of corrosion, as there is at once formed numerous localized electric batteries, where the iron is the positive and corroded element, carbon the electronegative pole, and the sulphates dissociate and form a very active electrolyte. As a result, the iron pipe is certain to leak, sometimes within a year.

Conclusions

Some other conclusions derived from these experiments may be stated as follows:

Electrolysis of underground structures may be caused

by certain definite conditions, which may be determined by electrical measurements and a study of the environments.

The electrolytic theory is applicable to corrosion of underground iron and lead structures.

In comparing the corrosive resistance of different types of irons and steels, a careful study should be made of the conditions under which the metals are to be used, and tests conducted under these conditions. Conclusions should not be based on a few experiments, but many tests should be conducted and studied. A good factor for comparison is the "corrosion rate per unit area corroded per year." This factor varies with different metals and with different external conditions, as shown in Table II. Iron specimens should be treated at least 400 hours or longer if possible. The moisture content of the soils in the cell should be maintained constant. The corroded areas usually are definite on the cleaned test plate and may be measured by planimeter.

From experiments performed, and corrosion rates found, the probable life of an iron structure in given soils may be predetermined. The weight of $\frac{1}{8}$-in. iron 1 sq.in. in area is 15.8 g. Assuming corrosion forms

TABLE II. IRON LOST FROM CORROSIVE ACTION OF NATURAL SOILS

Soils	Cast Iron (Anal. 6) As Cast A	Cast Iron (Anal. 6) As Cast B	Cast Iron (Anal. 6) Polished A	Cast Iron (Anal. 6) Polished B	Mild Steel (Anal. 3) With Mill Scale A	Mild Steel (Anal. 3) With Mill Scale B	Mild Steel (Anal. 3) Polished A	Mild Steel (Anal. 3) Polished B	99.94% (Anal. 1) Ingot Polished Sheet A	99.94% (Anal. 1) Ingot Polished Sheet B
Clay 21.5% water	2.02	1.18	1.36	0.90	0.83 1.17	0.41 0.51	0.992	0.34	0.47	0.12
Black Peat 39.4% Water	2.75	1.05	3.44	2.65	2.22 1.70	2.47 0.57	2.82	1.76	2.82	1.47
Mixed 27.8% Water	1.48 1.34	1.18 0.64	2.41	1.60	1.29 0.84 1.06	0.807 0.45 0.59	1.69	0.70	1.17	0.47
Loam....	1.51	0.66			0.97	0.52				
4" pipe in clay and black peat	171 171	5.18 5.18								

Column A, grams per year lost from plates; column B, grams lost per year per square inch of corroded area. Area of plates 4.8 to 5.5 sq.in. Plates underlined treated 1.07 years; all others 0.23 year. The 4-in. cast iron pipe, 41.5 in. long, was treated 0.85 year. Cells in glass beakers. Large pipe in wooden cell. Loss by water evaporation determined by weighing cells at intervals and replaced by adding pure water.

a conical pit, the metal removed weighs 5.2 g. Referring to Table III, the scaled mild steel specimen in clay showed a yearly corrosion rate per square inch of corroded area of 0.51 g. As $\frac{5.2}{0.51}$ is 10.0 years, this is the probable life of a mild steel black iron pipe with $\frac{1}{8}$-in. wall, buried in an average moist clay soil.

The ordinary coatings, mill scale, poor grades of galvanizing, casting skin and tar dips on cast iron have little value as protection against auto-electrolysis, and in cases accelerate it. Tar dips lengthen the life of cast iron by delaying the action, but the coating will soon fail in spots.

The longer life of cast iron is due to its greater wall thickness.

Corrosion rates of iron are little affected by temperature changes within the range usually found about water pipes.

Corrosion rates are appreciably increased by pressures within the range of pressures met in practice due to depths of burial.

TABLE III. AUTO-ELECTROLYSIS IN DIFFERENT SOILS

Clay A, St. Paul	0.0198
Dark gray clay, Pierre, South Dakota	0.0613
Yellow clay, Indiana	0.0915
Light gray clay, Havana, Cuba	0.0295
Yellow clay, Havana, Cuba	0.3240
Blue clay, Minneapolis	0.0597
Peat D, St. Paul	0.2300

Ingot iron, analysis 1, 1.3x2.5-in. polished plates. Grams iron lost after treating 528 hours in fiber cells. Water content approximately the natural percentage.

Admitting or excluding air from a test cell has no appreciable effect on corrosion rates.

The life of underground iron structures could be greatly prolonged by placing a few inches of sand around them, especially in clay, cinders and moist electrolytically active soils.

Denver, Col.

Industrial Courts in Great Britain

In response to questions asked in Parliament on March 3, 1920, Sir Robert Horne, British Minister of Labor, stated that the Industrial Court established by the industrial courts act, which received the royal assent on Nov. 20, 1919, had been duly set up. The president of the court is Sir William MacKenzie, Violet Markham and Cecile Matheson representing the women.

The court is a standing arbitration tribunal, the provision of which was one of the recommendations of the Committee on Relations between Employers and Employees, better known as the Whitley Committee. It is the desire of the government that trade disputes should be settled as far as possible by negotiation between employers' associations and trade unions. In cases where agreement is impossible recourse can be had to the Industrial Court, provided consent of both parties to the dispute is forthcoming. One of the advantages of reference to a standing court is that the experience of the members of the court in dealing with difficulties in other trades is placed at the disposal of the parties to a particular dispute.

The Minister of Labor went on to say that since Nov. 20, 1919, 208 differences have been referred to the court. These have been heard mostly in London, but the court has also sat in Glasgow, Dublin, Belfast, Liverpool, Manchester, Sheffield, and elsewhere in its ordinary form, by which three members of the court—a chairman, a representative of the employers, and a representative of the employees—constitute the court, while a certain number of cases have been dealt with in different parts of the country by single members of the court. The differences have chiefly concerned questions of wages, but many other industrial matters have come before the court. The court has settled the general wage arrangements for the Scottish building trade, gas undertakings throughout Great Britain, the spelter trade, the clay industry, the bobbin and shuttle making industry, the seed-crushing and oil-milling industry, and the organ-building trade, and wages of women employed in railway shops.

The court has at present before it claims for national increases of wages in the engineering, shipbuilding, and explosives trades, together with the wages of railway shopmen. "As far as I am in a position to judge," Sir Robert concluded, "the court appears to have commended itself to both employers and employees. It is recognized to be an impartial and independent tribunal, and I think that it will continue to serve a most useful purpose in the national life."

A Comparative Test Upon High-Speed Steels—IV

Chemical Composition, Microstructure, and Manufacturing Methods Which Distinguish the Really Superior Brands—It Is Perfectly Feasible for the Metallurgist in the Smaller Shops to Determine the Tool Best Suited for His Requirements*

By A. J. Langhammer, M.E.†

After the test had been completed and the winners decided upon, there was still one point to be determined of fascinating interest from an industrial engineering standpoint.

Why did steels with an almost ideal chemical composition and good microstructure fail utterly? It was believed that an inspection tour of the various plants making tool steel would possibly shed some light on the matter. Happily, the writer was able to take this trip, and though it was impossible to visit all of the mills whose product was tested, due to limited time, yet a representative group was inspected. The principal points investigated were the organization, shop and laboratory equipment, personnel, plant laycut, manufacturing methods, inspection methods and the raw materials used.

Good High-Speed Steel Is Strictly a Quality Product

Coming into the steel plants in this manner with a fresh viewpoint and having access to all departments, it was relatively easy to detect deficiencies or, better still, to ascertain why some brands simply *had to be* of superior quality. A well-balanced organization, modern, high-grade equipment, properly planned and executed work, experienced and careful workmen, together with the best only of raw materials and expert supervision, cannot help but be reflected in the product. Then, too, there are elements of refinement (analogous in a way to that of polishing and buffing the domes of cylinder heads on a very high-grade motor) that some steel manufacturers do not incorporate in their product. As a matter of fact, whenever the policy was such that everything was sacrificed for quality and no product except such as met the established standard was shipped, an excellent steel was produced.

The above-stated general conditions are, of course, essential in the manufacture of a good steel. It is felt, however, that there are some additional important factors that will bear special mention, and for this reason they are listed below.

Raw Materials

A good iron as basic material is invaluable. Especially is this apparent where the refinement of the iron is controlled by the tool steel mill. The same is of course true of the other alloys, though in this case there are relatively few mills that control the production of the bulk of their raw metal. This latter feature is very desirable, especially when a market scarcity exists in the rarer elements. The chemical composition of the iron, both before and after refinement, should be held to close limits and frequent examinations made for the presence of slag and other inclusions.

Melting

Furnace construction and condition, grade of crucibles, correct mixture and temperature control are vital factors in melting practice. In pouring, the best practice is to eliminate the ladle and pour the ingot direct from individual crucibles. Each ingot, then, after annealing, should be analyzed and graded. If a steel mill makes various grades, it thereby effects quite a saving in costs over the "one-grade mill." Rigid inspection for surface defects should follow naturally.

Forging

Uniformly slow pre-heating and accurate temperature control for the forging operation are essential. Hammers of sufficient size or capacity should be used and in the same way the ingot must be of large enough cross-section to permit a sufficient reduction in area. When an ingot is worked in the rolling mills, the various factors must be controlled and a high standard set. Subsequent chipping or grinding is then followed by another inspection.

Miscellaneous

In the mixing of the alloy, especially where the electric furnace is used, there is an excellent opportunity for the introduction of "elixirs" (if that term may be used) such as uranium, and quite a bit of work is being done to this end. An advantage that few modern high-speed steels possess in any marked degree is that of being able to withstand the high heat in hardening without scaling. Needless to say, this is of prime importance in the manufacture of taps, hobs, form tools, etc., especially where the hardening is done in an open fire and not by packing.

Discussion of Results

Perhaps the most interesting data of the whole test are those presented on the two graph sheets, Figs. 5 and 6, reproduced herewith. Quite a few factors are brought out clearly, two of which appear of extreme importance, and which should be classed as essential requisites when a test of this nature is planned. They are the *number of specimen tools* used per braid and the *time limit on which failure should occur*. By an inspection of the graphs, it is at once obvious that no two tools of any one brand (of the same bar, heat treatment and subjected to identical working conditions) gave the same results. In most cases a wide variation is found, indicating that at least four and possibly six tools must be used if the results of a test are to be reliable. It is

*For Parts I, II and III, see Chem. & Met. Eng., vol. 22, Nos. 18, 19 and 20, May 5, 12 and 19, pp. 829, 889, and 939.

†Industrial engineer, Thompson & Black, engineers and accountants, New York and Detroit.
Formerly mechanical engineer, Packard Motor Car Co.

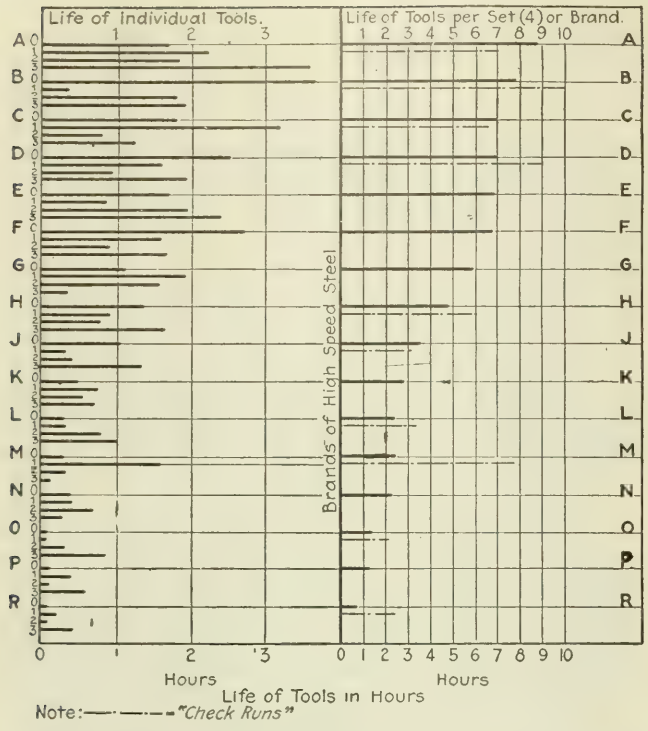


FIG. 5. CURVE SHEET OF FIRST RUN

Turning Liberty motor cylinders 5½ in. diameter. Tool with $\frac{1}{16}$-in. radius nose; cutting speed, 35 ft.; feed, 0.054 in.; depth, $\frac{5}{32}$ in.

felt that this is a point of great importance, because conclusions are often based on the performance of one tool only and the above results indicate that such a test really means very little. When but one tool is used, the results may flatter a brand or do it great injustice with equal equanimity and in either case the consumer is the loser. The steel company, too, in such an instance does not have the proper opportunity to show the quality of its product.

The other point of importance brought out in the graphs is that apparently when a tool is not forced or put to heavy duty, a mediocre steel may show up almost as well as a good brand. As the average plant probably does not exact a high duty from the high-speed tools in use, this fact explains why an inferior or even a poor brand may give fairly satisfactory results. Attention is invited to the fact that a superior steel will demonstrate its worth regardless of the duty exacted. For example, see steel B and D in both graphs. In the first run it will be remembered the cutting speed was 35 ft., the depth of cut $\frac{5}{32}$ in. and the feed 0.054 in., while in the second run the other factors remained the same except that the feed was increased to 0.090 in. A steel which is less excellent but still may be classed as "good" does not always fare so well, as is shown, for instance, by brand K. At this point it will probably be well to consider the exactly opposite performance of brand A, which finished as the leader in the first run, and in only the sixth position in the second run.

In the heat-treatment chart it will be noticed that this steel was treated with cyanide while at the high heat, the resulting "case" probably aiding the steel materially in the first run. After failing while cutting and then being reground (the case being removed in grinding) the beneficial effect of the case hardening was removed and the steel was graded as "good" steel only and not as a "superior" brand. While it appears that the cyanide treatment possibly aids a tool to some extent, its application should not be encouraged because it provides for non-uniformity, causes gasification and gives off dense, obnoxious fumes at the high heat, and distracts the attention of the tool hardener to a most undesirable extent. It is also to be noticed, from an examination of Table IV, page 941, that the nose of tool number 1 of brand B broke during the first run, thereby preventing this brand from finishing as the leader in this run also, to which position it unquestionably is entitled.

Check Runs

Attention is directed to the "check runs" indicated on both graphs. These additional runs were conducted to check the results of the leaders primarily, but as long as a check run was being made it was decided to include some of the other brands where the possibility of accidental performance such as broken tools indicated that they might be entitled to a higher standing. Steels of exceptionally promising analysis were also included in the check run. On every case a different bar of steel was procured from a standard supply; tools were then made up and put through the test like the first batch. It is to be noticed that the sequence as established by the original runs was not altered except in the case of brand M, which steel moved up to third position. This was to be expected because experience with brands C and J, previously occupying that position in the first and second runs respectively, had indicated that both steels were very non-uniform. Besides, they gave a lot of trouble in hardening. The rest of the check runs resulted in relatively unimportant changes in standing except that in nearly every case the "life" was greater than that of the original results. This fact seemed to indicate that brands D and B would at least duplicate the performance exhibited during the test

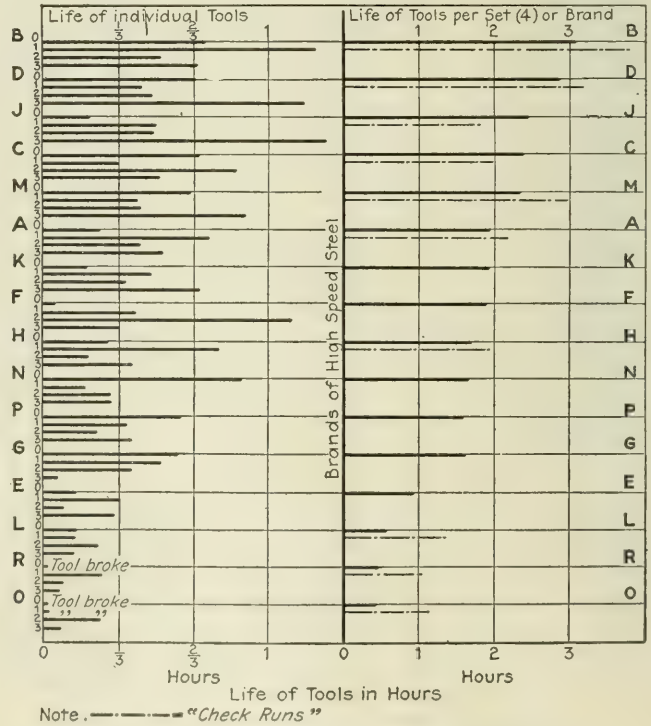


FIG. 6. CURVE SHEET OF SECOND RUN

Turning Liberty motor cylinders 5½ in. diameter. Tool with $\frac{3}{4}$-in. radius nose; cutting speed, 35 ft.; feed, 0.090 in.; depth, $\frac{5}{32}$ in.

at any time and probably would average even better. Brand M, on the other hand, showed a marked improvement in the check run, in which feature it far surpassed brands J and C and was awarded third place for this reason.

It is to be noted that one of these two "superior" steels, i.e., D and B, was in use at the Packard factory previous to the test. As a matter of fact the particular brand in question had been adopted as the factory standard for all Packard-made cutting tools. It should be further emphasized that unlike many large factories, tool steels are here specified by the mechanical department—which department is solely responsible for all machine and tool equipment used in the plant—rather than the purchasing department. This condition reflects credit on the head of the manufacturing department and his staff from the standpoint of industrial engineering.

Comparative Ratings by Other Large Consumers

It was thought expedient about this time to compare these results with those obtained by other large manufacturers. In Table VIII are given data collected with this end in view, the notation in each case being identical with the same symbols as were used in the test. The firms represented are composed of six large automotive manufacturers and three important tool companies. It will be noticed that three of the eight concerns represented buy their steel on the basis of results shown in actual test runs, one company on the basis of analysis only, and the four others on the basis of popular opinion. Note the fact that in the three cases where a cutting test was conducted, brand B was the winner. Further, in one of these instances brands M and D finished second and third respectively; in another, brand D was second and M fourth; while in the third case no mention is made of the other brands, besides B, that were in the test. These data were much appreciated because they verified the findings given in the Packard test to determine the correct choice of really superior steels and also presented some interesting facts about the brands as a whole.

Costs as Affected by a Superior Brand of Tool Steel

Automobile manufacturers usually make but a small percentage of the cutting tools required in their plant. Whenever possible, a standard tool is used, for example milling cutters, end mills, counterbores, hollow mills, reamers, taps, dies, twist drills, etc., and these are secured from companies which specialize in their manufacture. In the same way there are concerns which specialize in the manufacture of special cutting tools, and they in turn satisfy the requirements of the automobile manufacturer. This distribution then obviously effects the greatest economy that can be achieved and also tends to make a uniformly good product. However, some tools must always be made in an automobile manufacturer's own plant, and the annual cost of high-speed steel for this purpose (as it comes from the steel mills) in a factory employing 10,000 men is about $125,000. A plant employing 20,000 men requires about $250,000 worth of high-speed steel, and larger or smaller factories are affected in the same proportion. The cost of the finished tools made from the first amount of steel ($125,000 worth) would be approximately $375,000.

So far, though, these figures show only relative values of the tools. As pointed out in a foregoing paragraph, the tool made from a poor steel may break during hardening, or if it gets into the machine shop it will then give extremely poor results in performance. During rush periods, assuming no excess finished goods in stock, such tool trouble, when occurring on major units like cylinders, crankcases or crankshafts, means that just so many less motors or finished cars can be shipped on that day and production cost is increased accordingly. All of these costs, however, are chargeable to the poor quality of high-speed steel that has been used. It is difficult to say to just what extent manufacturing costs will be affected, but aside entirely from the losses in indirect labor, material and burden that occur when a finished tool of poor steel breaks in hardening, the writer feels that a superior high-speed steel will easily decrease the direct labor cost from 5 to 10 per cent.

TABLE VIII.

Brands of high-speed steel being used by six large automotive manufacturers and three tool companies, and the sequence of their ratings in each case

Name of Co. or Manufacturer	Brands Being Used	Brands Tried	First Choice	Brands in Sequence of Desirability	Undesirable	Remarks
a	B H A J R D M	B C H N A O R D M	B	B D H M A J R	None	These classifications are the results of an actual cutting test.
b	R G B C	R,O G B C,N	R	Non-committal	N O	No test had been conducted in years
d	B C	B C	B	B	None	In a test recently completed, B proved superior to all others and will be used exclusively
e	J L C W	J L C W	J, W & L	Non-committal	None	All high speed steel is bought on the basis of analyses
f	F J L B C	F J,M L,X L,B C	Non-committal	Non-committal	H N X*	Analysis is specified but used as an indicator only
g	D B E M R Y*	D,Y B,J H M,C R,O N	B	B M D H Y* R	C O N J	Standard analyses as specified by the steel maker is requested. Classification is made on the basis of actual cutting tests.
h	C N D A	C N D H	A and H	Non-committal	None	Classification based on opinion only
j	F O N M	F N O M	Non-committal	Non-committal	None	No test had been conducted for five years
m	C N O R	C N O R	C and N	C N O R	None	Classification based on what most of the executive heads of departments thought about the brand

*N and Y are brands of steel that were not represented in the test; they are obviously of inferior quality.

To give a better perspective of the cost and number of tools required to carry out a gasoline motor manufacturing program, the following figures are quoted from the text book of lectures used in the "Advanced Training School"[1] of the Packard Motor Car Co.:

"The total number of tools made by the Packard Motor Car Co. for the Liberty '12' airplane motor was 1,796,910. The cost of the perishable tools only was $1,466,540. Standard tools, such as drills, reamers, counterbores, taps and dies, cost approximately $700,000.

"We used 48,000 special tools for machining the connecting rods, 42,862 of which were perishable tools. For the large cutters which were used for straddle

[1] Edited by D. G. Stanbrough, general superintendent, Packard Motor Car Co.

TABLE II. COMPOSITION AND HEAT TREATMENTS OF TOOL STEELS TESTED

Brand	Chemical Composition * Carbon	Tungsten	Vanadium	Nickel	Chromium	Cobalt	Uranium	Heat Treatment: Preheating	Hardening	Quenching Medium	Drawing Temperature	Remarks on Heat Treatment
A	0.79	12.8	1.74	0.10	3.78	None	None	All tools slowly preheated to 1550-1600 F.	The temperature in the hardening furnace was maintained at practically 2300 F. The tools were withdrawn and quenched when the condition of sweating was satisfactory to the expert representing the steel company which produced the brand being hardened.	Oil	1050	Cyanide on tip of tools during hardening.
B	0.64	16.9	0.92	0.10	2.42	None	None			Lead at 1050 F.	1100	"B" tools withstood the high heat very well.
C	0.40	18.00	0.51	Tr.	3.53	None	0.11			Lead and kerosene.	1050	Tools 0 and 1 quenched in lead. Tools 2 and 3 quenched in kerosene.
D	0.62	14.86	1.05	Tr.	3.59	None	0.10			Lead at 1050 F.	1100	One-half of tool immersed in lead. Relatively short heat.
E	0.49	17.35	0.23	Tr.	2.78	None	0.14			Lead	1100	
F †	0.67	19.70	0.99	0.21	3.78	None	None			Oil and lead	1100	Tools 0 and 1 quenched in lead.
..	0.65	15.79	0.49	0.24	3.44	None	None				.....	Tools 2 and 3 quenched in oil.
G	0.62	18.26	0.75	Tr.	3.70	None	None			Oil	1050	
H	0.66	18.30	0.45	None	4.17	None	None			Lead at 1050 F.	1075	
J	0.68	18.12	0.48	Tr.	2.63	None	0.10			Oil and lead	1050	Tools 0 and 3 were immersed half way in oil; then they were placed on the floor and thus drawn.
K	0.59	13.34	0.95	Tr.	3.64	None	0.15			Oil	1075	
L	0.76	21.92	1.05	None	5.27	None	None			Lead at 1050 F.	1050	
M	0.69	16.95	0.75	0.18	3.09	None	None			Oil and kerosene	1100	Tool 2 quenched in oil. Tools 0, 1 and 3 quenched in kerosene. "M" tools withstood the high heat very well.
N	0.66	13.55	2.20	0.10	3.59	None	None			Oil	1050	
O	0.67	13.50	0.99	0.20	4.30	None	None			Oil and lead	1100	For tool 0 only. Tools 1, 2 and 3 were not drawn.
P	0.38	15.27	0.05	0.20	2.85	None	0.14			Lead	1100	Blistered on heating.
R	0.65	17.08	0.58	0.20	2.78	None	0.10			Oil and lead	1075	Tools 0 and 2 were quenched in lead. Tools 1 and 3 were quenched in oil.
13, 14‡	0.75	11.12	2.10	0.32	5.13	None	None				.....	

The samples for chemical analysis were obtained from the same section of the bar of which the tools were made.

The temperature of the lead bath used in quenching was maintained at a temperature of 105 F. The tools were immersed in the molten metal for about 3 min., and then allowed to cool in the air.

* Phosphorus and sulphur below 0.04 per cent in all cases.
† The second analysis under F gives that of a second bar obtained subsequently.
‡ This steel was not tested, but its microstructure is shown in Figs. 13 and 14.

milling the large ends of the connecting rods, there were 25,000 cutter blades costing $4 each. Eighteen hundred end mills were used for milling out the channel of the rod, and 4,100 doming tools for the cylinder."

It will be observed that the total cost of special and standard cutting tools required for producing the Liberty motor at the Packard Motor Car Co. was $2,000,000 in round figures. One item alone, that of the cutter blades for straddle milling the large ends of the connecting rods, cost $100,000. The tremendous importance of using only the cream of superior grades of high-speed steel is, then, readily perceived, but we must not forget that these figures involve only indirect factory costs. As was pointed out repeatedly, the real inefficiency is not reflected in the tool costs but in the direct labor costs and in a degree far in excess of that indicated by the above figures.

Preferred Chemical Analysis

About the first factor usually determined when a test is to be conducted on a large scale is that of the chemical composition of the different brands. By an inspection of Table II reproduced herewith an astonishing and entirely unwarranted variation of the proportion of the elements well known today as requisite is disclosed. The carbon content varies from 0.38 to 0.79, tungsten from 12.8 to 21.92, vanadium from 0.05 to 2.20, chromium from 2.72 to 5.27. Phosphorus and sulphur were below 0.04 in all cases, while other elements were present in practically a "trace" only. Uranium was probably present in an appreciable quantity in brand D only, the other traces being due to difficultly separated impurities. It is to be noticed that no cobalt or molybdenum was used by any of the steel makers whose brand was represented in the test.

Quite a variation will be observed in the heat treatment of these tools. Table II also contains the details of the heat treatment and such notes on observations as were made. It will be observed that some of the tools of the same brand were treated differently, though this applied only to the kind of quenching medium used and variations in the drawing temperature. On the whole, however, such practice indicates an apparent uncertainty on the part of the steel makers as to which treatment is the best for general purposes or even for a specific requirement.

Regarding the desired chemical composition, the writer feels that the following analysis is probably the most desirable for modern high-speed steel. Alongside is also affixed the analysis of the best high-speed steel tested by Frederick W. Taylor when he wrote his classical monograph "On the Art of Cutting Metals." It shows that this master has apparently plumbed the depth of the art, so that the last fifteen years show little progress in new compositions. As a matter of fact, Taylor recommended an ideal composition, slightly different from the one listed as giving him the best results.

	Minimum	Maximum	Taylor's Best Steel
Carbon	0.62	0.68	0.67
Tungsten	17.00	18.20	18.0
anadium	0.85	1.05	0.29
Chromium	3.00	4.50	5.5
Silicon	0.20	0.30	0.04
Phosphorus	0.00	0.04	Low
Sulphur	0.00	0.04	Low
Other impurities	0.00	0.10	
Manganese	0.00	0.00	0.11

Of course, were a substituting element such as molybdenum, uranium or cobalt used, the composition will be varied accordingly.

Microstructure of Annealed Steels

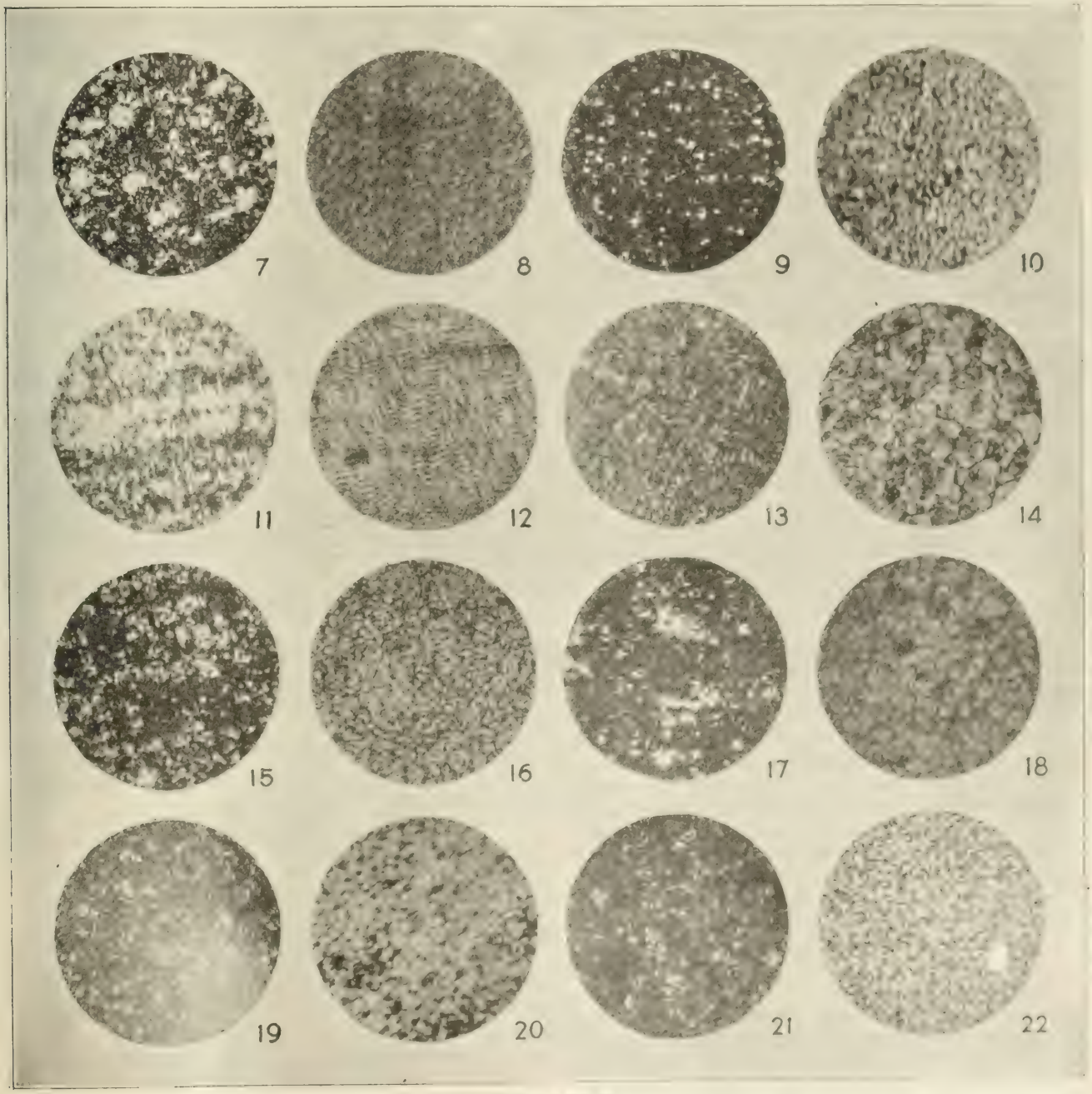
In order to determine the variation that might exist in the microstructure of the various brands of high-speed steel used in the test, specimens were examined

both in the condition in which they were received and also after hardening. It is understood, of course, that these specimens were made from the same section of the bar as were the test tools proper. The hardening of the samples used for microscopic examination was performed by an expert workman of wide experience in the hardening of high-speed steel. In every case the hardening specifications as quoted by the steel manufacturer were used. None of the samples was drawn, because it was desired only to investigate the structure resulting from the prescribed treatment at the high temperature.

Photomicrographs depicting the structure of seven different brands (both in the annealed state as received from the mills and after hardening) are shown in Figs. 7 to 22, all at 100 diameters.

In the case of brand F four exposures, 7 to 10, include a second pair made from a short piece cut from a bar secured from a different source. The cut of pictures as well as the analysis, Table II, shows clearly the wide variations that may be met in this brand.

An inspection of the odd-numbered microphotographs, showing the steel as it came from the mills, indicates that it was all in an annealed state; no trace is exhibited in any of the specimens of the original cellular ingot structure found in the newer cast high-speed steel. The microstructure therefore shows the presence of free carbides bedded in a sorbitic matrix. However, the quantity and the distribution of the carbides differ greatly in the various brands. The amount of free carbides, of course, depends on the composition and the rate of cooling. In the following brief discussion only the general characteristics exhibited in the different microphotographs will be noted.



FIGS. 7 TO 22

Microstructure at 100 diameters after nitric acid etching of same typical high-speed steels. Odd numbers are steels as received, even numbers the corresponding steels after hardening. Figs. 7, 8, 9 and 10 are of brand F. Figs. 11 and 12, brand A. Figs. 13 and 14, brand O, low W. Figs. 15 and 16, brand O. Figs. 17 and 18, brand E. Figs. 19 and 20, brand M. Figs. 21 and 22, brand H

Figs. 7 and 9, as remarked above, are of one brand (F) and therefore probably underwent the same cooling. However, the quantity of free carbides shown in Fig. 7 is much higher than that in Fig. 9. This difference is explained by the higher percentage of tungsten in the former case. In Fig. 11 it will be seen that the carbides are most conspicuous and the chemical analysis (brand L) shows the tungsten in this instance to be the highest of all steels tested. Again in Fig. 13, a bar of brand O in which the tungsten dropped to 11.12 per cent, little free carbide is found. Several of the specimens having good percentages of carbon and tungsten do not reveal corresponding amounts of the free carbides. Probably in such instances the rate of cooling was faster or perhaps the time at the annealing temperature was shorter.

In several instances the distribution of carbides is found to be quite non-uniform. This is brought out exceptionally well in Fig. 11 and Fig. 15. The carbides as depicted in these two cases are obviously more or less segregated into striations, whch indicates that the annealing was not sufficiently prolonged. An inspection of Fig. 12 discloses that even after hardening at the high temperature, this marked segregation of carbides still persists.

Microstructure of Hardened Steels

The exact nature of the physicochemical changes which take place in the hardening of high-speed steel are not yet fully known. Up to the present time no theory has been advanced which satisfactorily explains all the phenomena exhibited by the heating and cooling curves of this steel.[2]

However, it is known that for the best results in hardening, two requirements should be fulfilled. One of the requisites is that the carbides must first be taken into solution and then held in that state by a proper rate of cooling. The second requirement is that the solution of the carbides should be effected in such a manner that the resulting grain size is held to a minimum.

In carbon steel and in most alloy steels the preceding requirements are fulfilled at nearly the same temperatures. In other words, the carbides go into solution at about the same temperature, which also gives maximum grain refinement. This, however, is not true in high-speed steel. Here the temperature at which the carbides go into solution is far above the grain-refining temperature. Since both temperature and time are functions of the grain size, it is imperative that the tool, after thorough pre-heating, be brought rapidly to the high heat and held there for a minimum of time. Otherwise the grain structure will become too coarse and brittle, with consequent fragility. Some of the alloying elements in high-speed steel, tungsten in particular, tend to make grain growth more difficult, an influence on the grain size very beneficial to steel requiring high hardening temperature. On considering the variables which enter into the hardening process, and the difficulty with which they are controlled, the folly of drawing conclusions from tests made with a single tool is evident.

Examination of the photomicrographs of the hardened specimen shows quite a variation in the grain size. In most instances the nitric acid etching after hardening reveals polyhedral structure, part austenitic, part martensitic. The specimen shown in Fig. 14 shows the largest grain structure. Although the granulation in this instance is large as compared to some of the other specimens shown, still it is not uncommonly met with in commercial hardening. Perhaps in this case the large grain size was occasioned more by the high carbon and the low tungsten than by the temperature and time.

The microstructure of the hardened samples shows that little of the free carbides remained undissolved. Only in Figs. 10 and 14 are appreciable quantities of the carbides to be seen. Moderate amounts of undissolved carbide are believed not to have a detrimental effect on the cutting properties providing the tungsten and chromium contents are normal. Still, when the amount of the carbides is too great, as in Fig. 14, the solution will not be sufficiently complete to give good results.

Facts Brought Out in the Test

1. The chemical analysis of a high-speed steel may be used only as an indicator of its possible qualities.
2. Tools made of a medium grade of steel will work fairly satisfactorily when subjected to a relatively light duty.
3. No two tools of the same brand give exactly the same results, in a cutting test.
4. In conducting a test, no less than four specimen tools should be used.
5. To get the most efficient results from high-speed steel tools they must be operated under heavy duty, and no tests are reliable unless made with heavy cuts.
6. Test tools must be reground once, at least, and then again put through another run.
7. High-speed steel should be purchased only on the basis of performance.
8. A wide variation exists in the cutting qualities of the various brands of high-speed steel that are on the market today, and both indirect (material, labor and burden) and direct (labor and burden) costs are affected adversely when inferior steels are used.
9. Heat-treating practices of today leave wide room for improvement.
10. In hardening, the time factor is probably the important item needing investigation.
11. It is expected that a method of determining the efficiency of high-speed steel by means other than the service cutting test will be developed. Work with the X-ray and magnetic properties are quite hopeful in this direction.
12. It is believed that today the American manufacturers can produce a high-speed steel that is at least equal to the best European brands.

Application to the Small Shop

As was pointed out in the opening paragraph of this article, the proper choice of high-speed steel brands is of equal importance to the large manufacturer and the small shop. The writer is convinced that the time is not far distant when even the largest manufacturers will not only use a superior brand for the tools they make themselves but they will, in addition, prescribe the particular brand or a series of brands to "tool shops" that must be used in all the tools manufactured for them. This would apply to standard tools such as milling cutters, counterbores and twist drills, as well as for cutting tools of special design.

All tool steel will be specified by the mechanical

[2] See Sauveur, "Metallography and Heat Treatment."

superintendent, and the purchasing department will work in close co-ordination with that office. It naturally follows that a steel salesman with mechanical training and wide practical experience in manufacturing and steel making will be the successful salesman of the immediate future.

Now, then, what about the small machine shop? Obviously, such an institution cannot conduct a test in the elaborate manner described above. It can, however, conduct a thorough test in a small way, and the following suggestions may be helpful:

Some investigators have apparently concluded that a cutting test consisting of running a tool to destruction by "turning off the face" (that is to say, using the cross-feed and not longitudinal feed) of a bar yields accurate results. This, in my opinion, is erroneous. In the first place, at least two variables are introduced—cutting speed and material cut. It will easily be appreciated that under the proposed conditions the cutting speed varies so that at the center of the bar the duty is very low; as the periphery is approached it increases rapidly to an abnormal value. Now, if a tool approaches its breaking-down point while cutting anywhere near the periphery, failure occurs at once. If, on the other hand, a "weary" tool escapes failure at the periphery, it will continue to cut on its next travel out from the center until a high cutting speed is reached, when it will fail suddenly. However, had the previous cut been continued for a short time longer, possibly seconds only, failure would have inevitably occurred. The total life in such a case will vary widely, giving results entirely out of proportion to the facts. Variations in the material cut will also be encountered, as absolute homogeneity cannot be obtained for any great depth. There are other objections of a practical nature, but it is felt the above are sufficient to establish my positions.

The brands used in the small test can be of a limited number, therefore time spent in investigating a product before it is granted entry to the group to be tested is well spent indeed. Usually, two letters of inquiry per brand will be sufficient to classify it definitely. These letters would naturally be addressed to prominent users of high-speed steel who base their choice of brands on the results of actual cutting tests.

A thorough understanding of Taylor's thirteen fundamental variables and important factors brought out in this work, together with proper safeguarding of the human element, is, of course, essential. Stringent means must be employed to insure the correct heat treatment, and to avoid possible damage in hardening. As far as the material is concerned, a straight production job will give entire satisfaction so long as the necessary precautions are taken. A feed of $\frac{1}{16}$ in. or more, depth of cut $\frac{1}{8}$ in. or greater, time for failure of tool to occur twenty minutes to one-half hour, four test tools per brand, provision for at least one regrind, and a reliable record of all the data will round out the requirements. Finally, as much information as possible should be secured from reliable disinterested parties concerning the various brands of high-speed steel on the market.

APPRECIATION

It affords the writer particular pleasure to acknowledge his appreciation of the great assistance of his present and former associates, R. N. Brown, J. J. Long, E. P. Stenger, F. R. Weaver and M. Y. Kaptansky, who have contributed so much of value to this work.

Canada's Productive Power

The productive power of Canada during 1919 was greater than at any previous time in the history of the country, being in excess of $5,000,000,000, or approximately double that of five or six years ago. This total is made up of:

Manufactured goods	$4,015,000,000
Field crops	1,400,000,000
Live stock sold or slaughtered	750,000,000
Milk and dairy butter	165,000,000
Eggs	90,000,000
Fruits and vegetables	90,000,000
Wool	12,000,000
Fisheries	35,000,000
Forest products	175,000,000
Mining	160,000,000

The figures regarding the manufacturing industry are based upon the census covering 1917 and are in all probability under rather than over the mark as applied to current conditions, there having since then been substantial expansion in several branches of the industry. This is particularly true of such important industries as paper and pulp, automobiles, iron and steel, furniture, and textiles. There is also the shipbuilding industry, which has greatly expanded since 1917, as seen from the shipping report issued in the month of March by the Dominion Government, which shows that during the fiscal year 1919 the aggregate tonnage of the vessels built was 104,444 tons compared with 28,638 two years before.

The figures covering field crops, wool, fisheries, mining, and forest products are compiled from various official government returns. Those covering live stock, milk, dairy butter, eggs, fruits, and vegetables are based on the last regular census returns, with conservative estimated allowances for appreciation in market values. The factory output of butter and cheese or of condensed cream, milk, and powder is included under the classification of manufactured goods. Cheese and butter made in the factories of the Dominion now have an annual value, according to the figures of the Statistical Bureau at Ottawa, of $81,657,000, an increase of nearly $6,000,000, compared with 1917; while the output of condensed and evaporated milk and milk powder, as a result of the enormous expansion which has taken place during the last year or two, was recently estimated by the Dairy Commissioner to possess an annual value of $22,000,000.

Development of French Chemical Industries

The figures below give some idea of the increase in the productive capacity of France during the war in chemical substances other than fine chemicals. They are quoted from the *Board of Trade Journal* for April 1, 1920.

Products	1913 Production, Tons	1913 Consumption, Tons	1919 Production, Tons	1919 Consumption, Tons
Sulphuric acid, 58 deg.	1,160,000	1,172,500	2,500,000	1,500,000
Sulphuric acid, 66 deg.	58,000	58,000	1,200,000	
Oleum (fuming sulphuric acid)	6,000	6,000	900,000	25,000
Nitric acid	20,000	18,500	340,000	37,000
Sodium salts	625,000	506,000	800,000	650,000
Liquid chlorine	300		60,000	15,000
Bromine		100	500	700
Calcium carbide	32,000	28,000	100,000	
Caustic potash	7,500	8,000	100,000	
Caustic soda	75,000	90,000	200,000	150,000
Ammonium salts		9,500	250,000	250,000
Nitrate of lime			1,000,000	250,000
Natural phosphates	2,700,000	1,225,000	4,000,000	2,500,000
Superphosphates	1,965,000	1,960,000	2,500,000	2,500,000
Phosphorus	300	10	2,000	

Great strides, the *Journal* states, have also been made in the manufacture of synthetic products, an impetus having been given by the requirements of the war.

The Properties of Powders

AT THE meeting of the Faraday Society held jointly with the London Section of the Society of Chemical Industry on March 1, Dr. T. Martin Lowry, O.B.E., F.R.S., and F. C. Hemmings presented a paper on "The Properties of Powders," which embodied an investigation that had been carried out for the Scientific and Industrial Research Department under the auspices of a committee appointed by the Council of the Faraday Society.

The caking of salts is in general dependent on the presence of a solvent, usually water. The following cases have been studied:

Nitrates

In the case of ammonium nitrate, very hard caking follows the change of state which takes place at 32 deg. C., but this caking can be prevented by very thorough drying. Hard caking also follows upon mechanical disintegration of the warm salt, but this is also attributed to the influence of moisture released during disintegration. Ammonium nitrate crystallized from alcohol shows much less tendency to cake than when crystallized from water. Caking of ammonium nitrate due to mechanical working is only slight when the conditions are such that moisture can escape from the powder.

Sodium nitrate forms a very hard cake when stored in bulk, but this can be prevented by commercial drying, whereas it is precisely this process which gives rise to the most serious caking in ammonium nitrate. This difference is attributed to the polymorphism of ammonium nitrate, which has no analogy in the case of sodium nitrate.

Potassium nitrate, which is less soluble than either of the two preceding salts, may cake during storage, but apparently to a much smaller extent.

Other Anhydrous Compounds

Serious caking is reported to occur, not only in common salt and in soda ash, but also in potassium chlorate, potassium perchlorate, citric acid and tartaric acid. In the last four cases, caking frequently accompanies or follows the grinding of the dried crystals. This is probably due to the liberation of more moisture during grinding, and can be prevented by drying the compound during or after grinding, and packing in a dry condition.

Hydrated Salts

Caking of hydrated salts frequently gives rise to trouble, e.g., in the case of rochelle salt, borax, sodium phosphate and alum. These hydrates cannot be dealt with in the same way as anhydrous salts, since it is difficult to secure complete drying of the hydrate without partial decomposition. The view is advanced that mechanical working of a hydrated salt not merely releases included moisture, but may result in the breaking up of the hydrate similar to that which takes place when the salt is heated, just as the phenomena which accompany the formation of amorphous materials during cold-working may be compared with the effects produced by fusion. Grinding is found to be accompanied by a slight loss in weight which is recovered quickly from the air. It is not thought that this is sufficient to account for caking of the salt, which is attributed rather to recrystallization following on the disturbance of the normal distribution of water which results from the grinding of the salt, just as sodium sulphate may recrystallize in the normal form after being melted in its water of crystallization.

Loss of Sulphur Dioxide During Caking

Sodium bisulphite and sodium hydrosulphite cake on exposure to air, but this is a more complex change, since not only is water absorbed but sulphur dioxide is also liberated.

Contraction During Caking of Copper Sulphate

When powdered anhydrous copper sulphate is exposed to moist air it swells considerably during hydration, but the absorption of the final 1 per cent of water is accompanied both by caking and by strong contraction. The slight excess of water taken up by the blocks is quickly lost in a dry atmosphere when hydration and caking are complete. Caking and contraction in this case are believed to be due to the simultaneous presence of particles of the trihydrate and of water saturated with the pentahydrate, in which the trihydrate dissolves and crystallizes out again in the ordinary form. The caking of hydrated salts can be prevented by the presence of a small amount of a lower hydrate, which absorbs the traces of moisture which are so effective in producing caking in a salt which is almost fully hydrated.

Attention is directed to the disintegration which accompanies the change of state of ammonium nitrate when dried by heat and which is also observed in the dehydration of many hydrated salts. This disintegration may be used as a substitute for grinding, just as in the converse process of slaking lime by the addition of water.

Dissolution of Belgian Steel Cartel

Much interest has been aroused in industrial circles by the virtual dissolution of the steel producers' cartel (Comptoir des Aciéries Belges), which in prewar days was such an important factor in the Belgian steel industry and included such large works as the Cockerill, Providence. Ougrée, Athus-Grivegnée, Boël, Clabecq, Châtelineau, Espérance-Longdoz, and Thy-le-Château companies. The functions of the association were very important, including the fixing of prices for finished as well as semi-finished products, allocating orders among the various members and serving as intermediary between producers and purchasers at home and abroad. There is some talk of reorganizing the comptoir on former lines, but at least one important concern has announced its unwillingness to enter into a new combination.

The association, it appears, will continue to exist, but its functions are now confined to the receiving of orders, without authority to accept them for individual firms or to fix prices.

It is predicted that the organization will not last long in its present form, as its functions will tend to become purely formal. It is probably that the disorganized state of the Belgian metallurgical industry since the war has had much to do with the dissolution of this powerful syndicate. The dissolution of the cartel has not the same significance that it would have in a period of stabilized prices and normal production and demand.

The Fixed Nitrogen Research Laboratory

A Brief Statement With Illustrations of the Government Investigations Being Made on the Cyanamide, Haber and Arc Processes for Producing Fixed Nitrogen— National Aspects of the Problem

BY ARTHUR B. LAMB*

THE disposition of the experimental Haber plant at Sheffield and the huge cyanamide plant and water-power development at Muscle Shoals, Ala., has been a serious problem confronting the War Department since the conclusion of hostilities.

On the one hand, these plants must be maintained in a state of instant readiness and efficiency in order to afford the military security which was the chief motive for their erection. Again, they represent a great monetary investment which the Government cannot afford to abandon or neglect. Finally, their operation would furnish a supply of cheap nitrogen which would help, at least in some measure, to meet the ever-increasing fertilizer requirements of our country.

On the other hand, the present products of these plants—namely, lime-nitrogen, ammonia and ammonium nitrate—are not immediately salable in large amounts for fertilizer purposes, either because of their intrinsic disabilities or because of the unfamiliarity of our farmers with their use.

Research Laboratory Established

To study these latter problems and because the knowledge of the fixation of atmospheric nitrogen is of vital importance to the military and economic welfare of the nation, and for other reasons, Arthur Graham Glasgow, fixed nitrogen administrator, in the spring of 1919 established the Fixed Nitrogen Research Laboratory, under the supervision of the Nitrate Division of Ordnance, with Dr. Arthur B. Lamb as director and Dr. Richard C. Tolman and Dr. William C. Bray as associate directors. The present staff (April 15, 1920) consists of a total of 108 persons, 77 on the technical staff and 31 on the business staff.

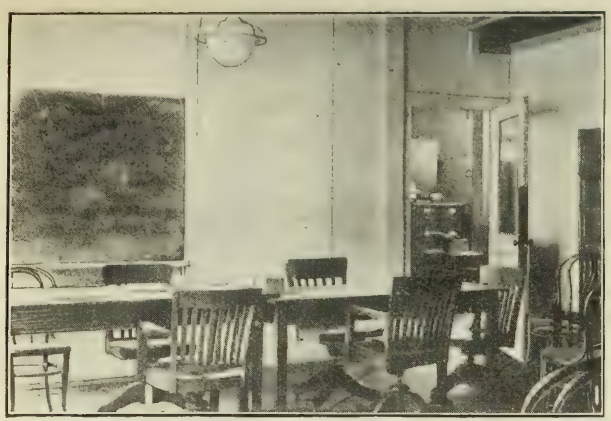
The laboratory is located at the American University, Washington, D. C., where it occupies a number of buildings, the largest of which is the Ohio Building, with a floor space of 50,000 sq.ft. These buildings, together with a large amount of scientific and technical equipment, were transferred to the laboratory from the Research Division, Chemical Warfare Service. Except for the limited technical and industrial facilities of the city of Washington, the laboratory is excellently located. The floor space is ample and the apparatus and equipment are unusually complete. Moreover, the location of the laboratory in Washington makes it possible to carry out important work in co-operation with the Department of Agriculture. Five men from the Bureau of Soils, including several who have had long experience in nitrogen investigation, are giving practically all their time to the work of the laboratory. Many tests on growing plants, both in pots and on $\frac{1}{20}$-acre and $\frac{1}{40}$-acre plots, are also being carried out in co-operation with the Bureau of Plant Industry.

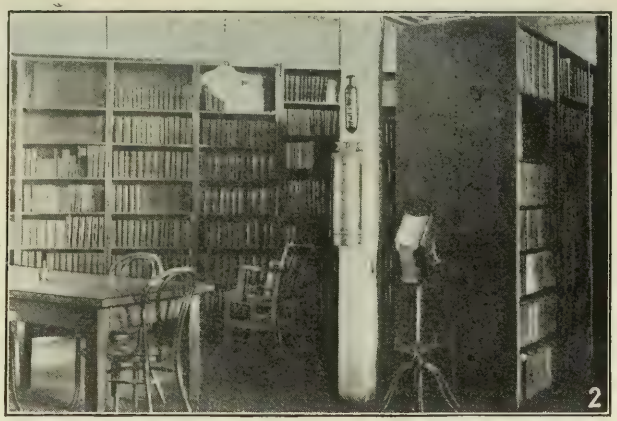
The smaller, partially completed Haber plant, U. S. N. P. No. 1, at Sheffield, Ala., never operated on a commercial basis; the large cyanamide plant, U. S. N. P. No. 2, was practically complete when the armistice was signed, and although now closed down, has been in full operation and has produced thousands of tons of product. Every part of it is well designed and functions successfully, and the whole is undoubtedly not only the best but the largest cyanamide plant in the world, with a capacity of either 220,000 tons of cyanamide or 110,000 tons of ammonium nitrate yearly.

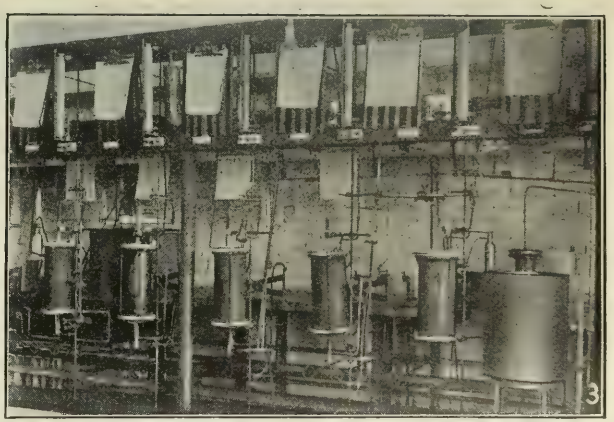
Utilization of Cyanamide

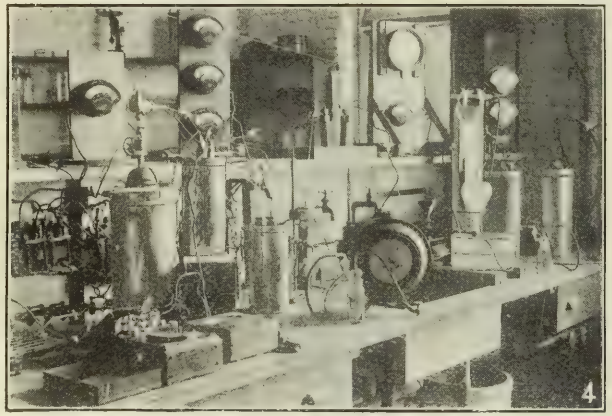
The first problem of the Fixed Nitrogen Research Laboratory has been to investigate methods for the agricultural utilization of the products of this plant. This is a problem with many angles, since cyanamide, the primary product, is a form of fixed nitrogen which at present has in America only a limited use in agriculture, and the many possible ways of increasing its use, as well as the many other forms of fixed nitrogen which can be made from it, must all be investigated. Researches along these lines have included such prob-

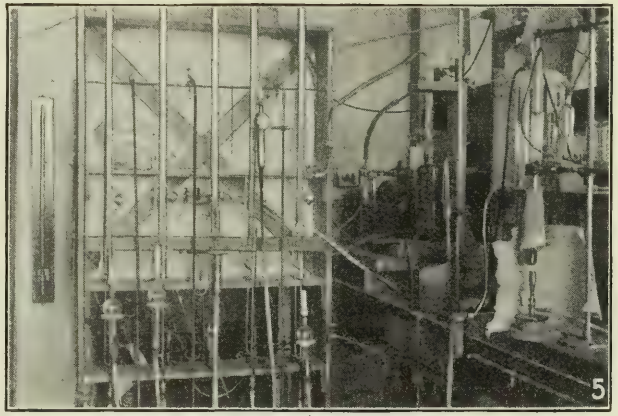
*Director, Fixed Nitrogen Research Laboratory.

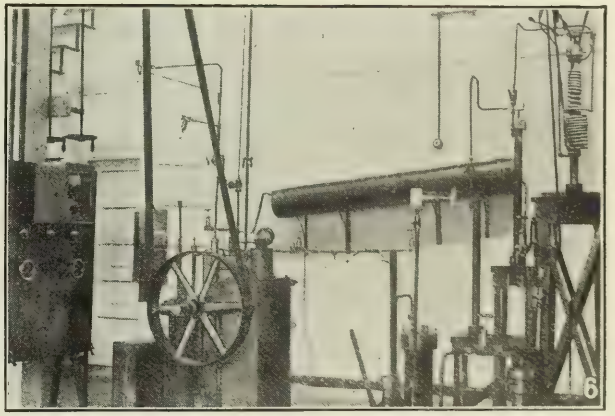


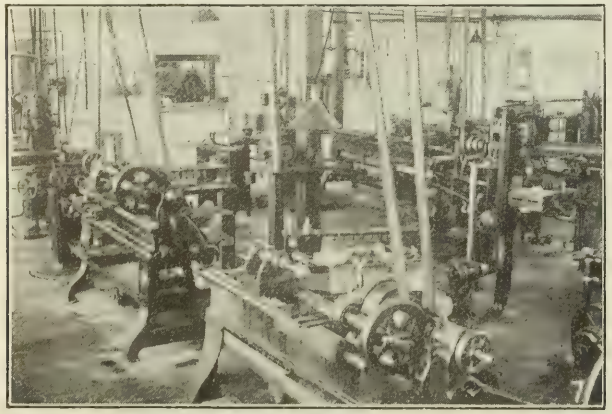


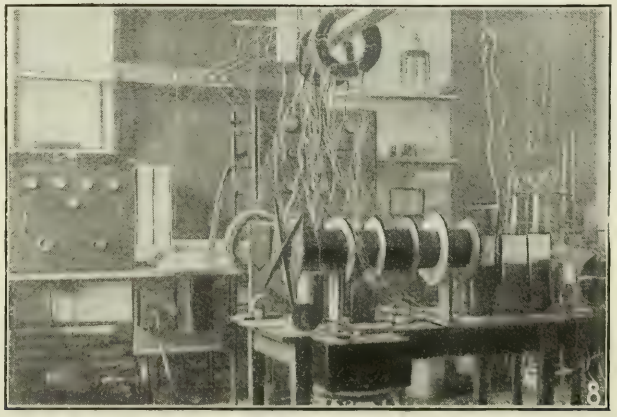












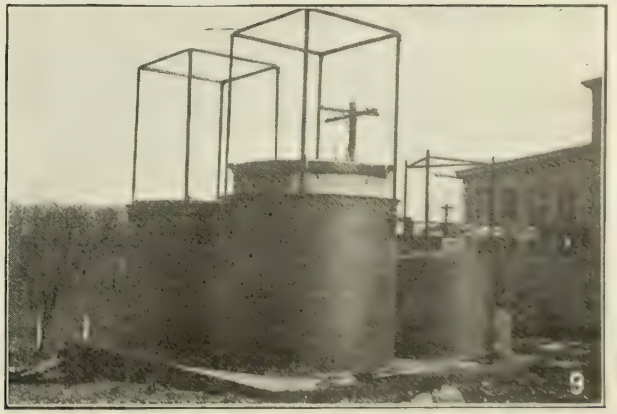


FIG. 1. Corner of conference room.
FIG. 4. Testing Haber catalyst, intermediate pressures.
FIG. 7. Corner of machine shop.

FIG. 2. Corner of the library.
FIG. 5. Adsorption measurements of catalysts.
FIG. 8. Corona discharge experiments.

FIG. 3. Testing Haber catalyst, atmospheric pressure.
FIG. 6. Ammonia absorption experiments.
FIG. 9. Gasometers for nitrogen and hydrogen.

lems as the oiling and hydrating of lime-nitrogen to reduce its undesirable properties, the granulation of cyanamide, the mixing of cyanamide with basic phosphates, the production from lime-nitrogen of a non-basic fertilizer containing urea, and the production from lime-nitrogen of ammonium sulphate, ammoniated superphosphate, ammonium phosphate, pure urea, ammonium nitrate and various double salts of ammonium nitrate. It is believed that such researches will make possible a decision as to the best methods by which this great plant at Muscle Shoals can best serve the peace-time needs of this country.

Development of N-H Catalyst

The other Government plant, U. S. N. P. No. 1, using the Haber process, has never operated satisfactorily. It represents, however, a much smaller investment than the cyanamide plant and can undoubtedly be made to operate with further study and research. The problem of the first importance in connection with it is the discovery of a robust and active catalyst for the reaction between nitrogen and hydrogen. The remodeling of the whole plant will be dependent on the ultimate choice of this catalyst. A further important problem in this redesign is the question of the best method of removing ammonia from the circulating system, and this is being investigated at the Fixed Nitrogen Research Laboratory by a group of investigators from the Bureau of Soils, working in co-operation with the staff of the laboratory. A third problem of considerable importance for the redesign of this plant is the study of those alloys of steel which are best adapted to withstand the high pressures, high temperatures and action of ammonia encountered in this process. Work along these lines is under way.

Arc Fixation Studied

Besides the above problems which are determined by the desirability of putting the two Government plants into operation, problems of less pressing importance are being studied, such as improvements in the methods of operating cyanamide plants, and the theory of the fixation of nitrogen by the electric arc. This latter process, although of considerable commercial importance where the very cheapest electrical power is available, is at present of importance in America only from a military point of view, because of the possibility

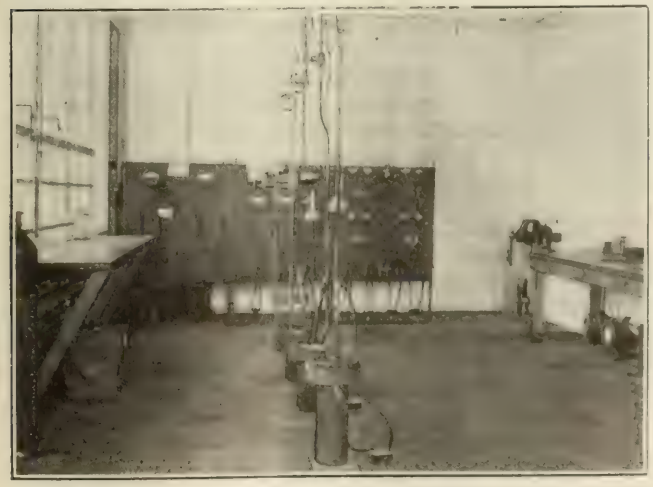


FIG. 10. TWO HABER CATALYST BOMBS AS FIRST INSTALLED

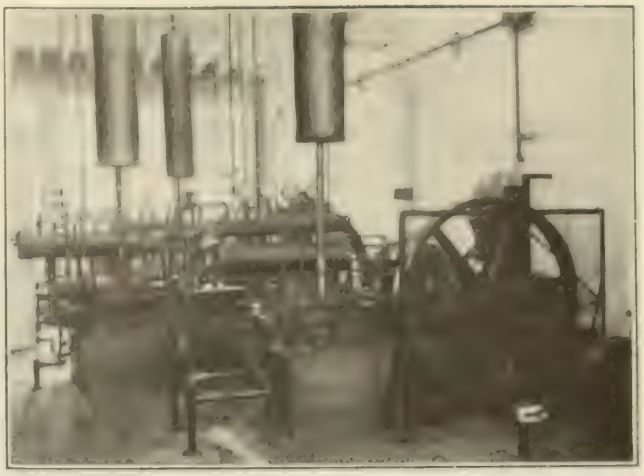


FIG. 11. COMPRESSORS FOR AMMONIA SYNTHESIS

of its rapid installation in time of emergency. A fundamental investigation of the relation between gaseous ionization and chemical reaction, however, may make this process also commercially important in America, and some work is now under way at this laboratory.

Research Situation in Germany

The activity of Germany on nitrogen research is certainly instructive. After years of extensive research and experimentation with governmental support a Haber plant with the very considerable output of over twenty tons of ammonia per day was erected at Oppau in 1913. At the outbreak of the war this was very greatly enlarged. Of all the buildings constructed at that time and in spite of their several years' successful experience with this process, the largest and finest was the Research Laboratory. It is 300 ft. long, 100 ft. wide and five stories high, and is entirely devoted to research. In August, 1919, although the plant was not operating, there were said to be seventy-five chemists at work in this building on research problems; during the war there were said to have been 250 chemists thus engaged.

The future of the Fixed Nitrogen Research Laboratory will presumably depend on legislation now pending in Congress. Senate Bill 3,390 and the corresponding bill before the House, besides providing for a self-sustaining Federal agency to operate the Government fixation plants, also specifically provides for research laboratories and experimental plants for the development of fixed-nitrogen production.

This important field of research certainly needs the resources, the scope and the disinterested point of view which the Government alone can provide.

Washington, D. C.

Industrial Experimental Laboratory in Mexico

On March 1 the Mexican Ministry of Industry, Commerce and Labor formally inaugurated an industrial experimental laboratory in connection with the commercial museum. The new laboratory is complete in every detail and is intended to offer opportunity for instruction in modern processes of manufacture to persons with small capital who are desirous of turning Mexican raw materials into manufactured products. There are in connection with the laboratory fully equipped machine shops, carpenter shops, and tin shops, with a corps of instructors for each different department.

Legal Notes

By Wellington Gustin

Contract Under War Provision Upheld

A contract, cancellation of which was due to the war, has been the subject of judicial interpretation and construction by the Supreme Court of Alabama. Whether the contract was subject to cancellation under the terms of the contract relating to war or whether such cancellation was a breach of contract was in issue between the parties, the Capital Fertilizer Co. vs. the Ashcroft-Wilkinson Co. (79 So., 484.)

The facts on which the action was founded are succinctly stated as follows: The plaintiff claimed $30,000 damages for breach of a contract entered into on May 25, 1914, by the terms of which the defendant sold to plaintiff 1,485 tons of potash, manure salts and kainit, for deliveries in November, 1914. In the second count of his complaint plaintiff claimed $3,500 for breach of a contract, entered into on July 11, 1914, for the sale of 200 tons of manure salts. Both contracts contain a clause providing: "It is understood that in case of war, rebellion or any interference by either the American or foreign government, strikes, accidents, epidemics or other contingencies happening to one or more of the mines or works furnishing or shipping the goods . . . then the seller has permission to cancel this contract."

War Set Up as Defense

In his defense the defendant set out that since the execution of the contracts one of the contingencies named as a ground for cancellation of the contract has happened, namely, that on Aug. 1, 1914, war broke out in Europe between the German Government and those of England, Russia and France, and, subsequently, on the seventh day of October, 1914, the defendant cancelled the contracts in writing.

The products of potash, manure salts and kainit were to be imported from foreign mines, by inference from the country of Germany. The contract provided for a differential duty or charge imposed by the United States or German Government, and that the foreign analyses furnished by the mines should be binding.

Contentions of the Parties

On the appeal from a judgment against it in the lower court the plaintiff contended that under the terms of the contract here in question the defendant could cancel the same only in the event of war which proximately prevented it from performing its contract; and that to construe the contract as giving the absolute right of cancellation in the event of war anywhere, without regard to its effect upon the ability of the seller to comply with its terms, would be both unusual and unreasonable. In opposition the defendant contended that the parties have, by the language used, created an absolute option to cancel the contract upon the happening of certain specified contingencies, one of them being "in case of war," and that the parties "meant what they said and said what they meant" when they placed this absolute option in the contract; that it means war—any war, anywhere; that in using the language plain and unambiguous, the parties have exercised the constitutional freedom of the contract, and they had the right to specify the event of any war anywhere as a signal for a right to cancel on the part of the seller."

The defendant strenuously insisted that the plain and unambiguous language of the absolute option given the seller in the contract was not open to construction—it was, however, urged that, if open to construction at all, it would only be to the extent of ascertaining what war was in contemplation of the parties when the contract was made. The furthest point in such a construction would be that the parties contemplated, by the language used, a war either in this country or Germany, from which country the products were to be obtained.

Court Construes Contract

The cancellation clause refers to rebellion, or any interference by either the American or a foreign government. Besides other alternatives the one here concerned is: "It is understood that in case of war . . . then the seller has permission to cancel this contract." Said the court: "We are of the opinion that this part of the cancellation clause here in question is properly construed as having reference to a war either in this country or in Germany, from which latter country it sufficiently appears the products were to be obtained."

This point being determined, the next point for consideration was that urged by the plaintiff that the war, within the meaning of the words in the cancellation clause, must be such that it becomes the proximate cause in preventing the seller from performing the terms of the contract.

Now there is a class of cases in which the language used in the contracts indicates that the contracts were made either subject to or contingent upon strikes, accidents or contingencies beyond the seller's control, and necessarily required construction to ascertain the meaning. But in the language quoted above the seller is given the absolute option to cancel the contract in case of war.

The court said that the effect of the war in Germany or in this country upon the ability of the seller to comply with the contract here was an unknown quantity, as well as its effect upon the transportation of goods, the risk incurred, the price of goods, and the freight rates; all of these in case of war are left in a state of uncertainty. It is not merely the question of ability to obtain the goods, but also the question of the great risk, in the happening of such events, both as to prices and freight rates. "We think, upon consideration, that the cancellation clause was not without some reason and business sagacity for its foundation, and that it was inserted for the seller's protection and with a sense of business prudence."

Contract Obligations Defined

In a cited case the court said: "The contracts of men are laws prescribed by themselves to govern their transactions with each other, which, as long as they interfere not with morality or with the interests of third persons, are conclusive obligations on the immediate parties to them."

It was a part of business sagacity that seller had the cancellation clause as to war, in the broad and sweeping terms "in case of war," so written in the contract. The right to cancel arose as soon as war occurred in Germany, whether such war was the proximate cause of any inability to perform on seller's part or not.

Diatomaceous or Infusorial Earth*

By W. C. Phalen†

DIATOMACEOUS earth is more commonly known as infusorial earth, and is sometimes referred to by its German name "kieselguhr." It is also, though erroneously, called tripoli. It is composed of the siliceous remains of minute aquatic plants known as diatoms, which are of minute proportions as a general rule, and have to be identified chiefly by aid of the microscope. The organic matter of these plants has long since disappeared from most of the deposits, but there are notable exceptions, as in California.

These low forms of plant life secrete silica much after the same manner as mollusks secrete lime and thus build up their shells. It is this part of the plant which makes up the formations found in nature. The siliceous parts accumulate on the bottoms of the bodies of water in which the plants lived, and in time attain considerable thickness, and become of economic importance. The diatoms may live in either fresh or salt water, and under varying conditions of depth, pressure and temperature. For example, they have been found in the depths of the Atlantic Ocean, and are known to occur in the warm springs of Yellowstone National Park, to cite two extremes of temperature, pressure and difference in the character of the water. The material is now in process of formation and although it has in times past been formed in very different epochs, it is especially abundant in the Tertiary, and most of the known beds of great thickness are of this age.

Chemical Composition

In chemical composition, diatomaceous earth is a hydrous silica or opal, but as a rule it contains a considerable quantity of earthy impurities. A very simple test, taken in connection with other distinguishing characteristics, is that when touched with hydrochloric acid it does not effervesce. Sometimes analyses from widely separated localities show great similarity of composition; as, for example, the first three analyses in the accompanying table.

ANALYSES OF DIATOMACEOUS EARTH

	1	2	3	4	5	6	7	8
SiO_2	80.53	80.66	81.53	75.68	65.62	86.92	72.50	86.89
Al_2O_3	5.89	3.84	3.43	9.88	.....	4.27	11.71	2.32
Fe_2O_3	1.03	.....	3.34	2.92	.....	.....	2.35	1.28
CaO	0.35	0.58	2.61	0.29	.....	1.60	0.32	0.43
MgO	.....	.....	.....	0.69	.....	Trace	0.83	Trace
K_2O	.....	.....	1.16	0.02	.....	2.48	1.88	3.58
Na_2O	.....	.....	1.43	0.08	.....	.....	.....	.....
H_2O	12.03*	14.01*	6.04*	9.21†	11.00	5.13	9.54	4.89
	99.83	99.09	99.54	98.77	.....	100.40	99.13	99.3

* Water and organic matter.
† Nitrogenous matter and moisture.
1. Lake Umbagog, New Hampshire.
2. Morris Co., New Jersey.
3. Pope's Creek, Md.
(Note: The above three analyses are quoted from Merrill, G. P., Non-Metallic Minerals, 2d Edition, 1910, p. 72.)
4. Darton, N. H., U. S. Geol. Sur. *Bull.* 483, p. 27, 1911.
5. Soft Diatomaceous Shale, Harris, Santa Barbara Co., California, W. T. Schaller, analyst.
6. Porcelain diatomaceous earth, Pt. Sal, Santa Barbara Co., California. Fairbanks, H. W., *Bull.* Dept. Geol. Sur., Univ. Calif. vol. 2, 1896, p. 12. sp. gr. 2.12.
7. Soft diatomaceous shale, Orcutt, Santa Barbara Co., California, W. T. Schaller, analyst, 1908.
8. Monterey, Monterey Co., California, A. C. Lawson and J. de la C. Posada, Dept. Geol., Univ. Calif., vol. 1, p. 25, sp. gr. 1.8 to 2.1.

Uses

The chief use of diatomaceous earth is as a cleanser and polisher, and for these purposes it is used in the form of a powder or mixed with soap. It is a most effective non-conductor of heat, and has been used alone or with various compounds in covering for boilers, steam pipe, furnaces and stoves, and in the manufacture of fireproof cements.

It has great absorbent qualities, as will be noted from the fact that its specific gravity, bulk for bulk, is only one-third that of water—namely, 0.33. Its absorbent quality makes it suitable for water filters. The statement has often been made in the literature that it has been used in the manufacture of dynamite, but I understand that its use for this purpose has long since been entirely supplanted by wood pulp, on account of the danger from particles of grit. Boiled with shellac, it is used in the manufacture of records for talking machines.

Its uses abroad have been more numerous than in the United States. It had been used in Europe for the absorption of liquid manures so as to make the latter conveniently available as a fertilizer. It has also been used in the manufacture of water-glass, in making cement, in tile glazing, artificial stone, ultramarine and other pigments of aniline and alizarine colors, paper filling, sealing wax, fireworks, hard rubber objects, matches, papier maché, as a container for liquid bromine and for miscellaneous minor purposes.

In California it has been used in the construction of buildings, advantage being taken of its property of being readily cut into any desired shape or size. In some of the California reports, it is referred to as shale. It is easily quarried, and the small blocks into which it may be cut are light in weight and placed easily in position. In powdered form the material has been used to a certain extent in California in the manufacture of plaster.

Preparation of Material

In preparing the earth for industrial use it is first roasted to expel as much water and organic matter as possible. It is then transferred to a furnace and heated to a moderately high temperature, but with the exercise of sufficient care so as not to destroy its porosity by overheating. It is then finely ground between rollers, sifted and sacked to prevent re-absorption of moisture. For certain purposes, it is only necessary to give it a prolonged drying at a high temperature prior to grinding and sifting.

In Santa Barbara County, California, the material is broken in open air quarries and as mined contains a considerable percentage of moisture. After forty to fifty days of drying in the dry atmosphere of southern California, the material still contains a small percentage, approximately 5 per cent, of moisture. Some of the material after air-drying is sawed into bricks or other shapes and dried in kilns. Such bricks are used for insulating purposes. The rest of the material is finely powdered in mills and sacked to be used for filtering. Quarrying is done by electrically driven channeling machines. Some of the California material contains 5 per cent of alumina, presumably in the form of clay, which acts as a binder. This material is adapted to the use of building blocks for interior fireproof walls, and contains about 85 per cent silica.

One of the deposits near Lompoc—namely, that of the Celite Products Co., formerly the Kieselguhr Company of America—comprises extensive beds of soft white earth in a very pure state, both thin and massive. These form a cap over the hills and overlie brown

*From Bureau of Mines Monthly Report on Investigations, March, 1920.
†Mineral technologist, Bureau of Mines.

siliceous shales and are conformable with them. The strike is east and west and the dip is 30 deg. south. This material is being quarried in open cuts. It is taken up in large blocks and air-dried in the quarry. It takes from forty to fifty days to reduce the water content, which ranges from 25 to 45 per cent by weight, to 5 per cent. It is then hauled by motor trucks to the plant at Lompoc, where it is ground to powder and transferred to the different warehouses by a pneumatic system. When blocks are required, the material is transported in its natural state direct from the quarry, sawed to the required sizes, and dried before shipment. The material, when dried, is utilized in making brick, tile and other refractory materials.

The quarry operations are readily carried out where transverse joints occur in the strata due to earth movements. Where these are not present to facilitate removal of the rock, it is necessary to loosen it slightly by means of powder before blocks can be removed from the quarry face.

On account of the quantity of absorbed surface water in the diatomaceous earth, it is necessary that it be split into convenient blocks for drying.

Deposits in the United States

That infusorial earth is a widely distributed commodity in the United States is evident from the descriptions given below. The localities outlined are doubtless far from being a complete list. They are given principally to indicate the widespread occurrences of the material.

Maine: A deposit of diatomaceous (infusorial) earth of unknown extent is reported to have been worked in South Beddington, Washington County. The material is said to be of pure white color and of unknown extent.

New Hampshire: Beds of diatomaceous earth are reported from the vicinity of Lake Umbagog. An analysis of this material is given above.

Massachusetts: Beds of infusorial earth are said to occur near South Framingham.

New York: Two deposits of infusorial earth are known in the State of New York—namely, at White Lake, Herkimer County, and at Cold Spring Harbor, on Long Island. It is likely that careful prospecting will reveal other deposits in some of the larger peat bogs and marshes of the State.[1]

New Jersey: Near Drakesville there occurs a deposit which covers a small acreage to a depth of 1 to 3 ft.

Maryland: Infusorial earth has been mined along Lyons Creek, a branch of the Patapsco River, separating Calvert and Anne Arundel Counties. The location is five miles west of Herring Bay, on the west shore of Chesapeake Bay. Deposits are also known extending from Fairhaven, on Herring Bay, to Pope Creek, on the Potomac River. It occurs at the base of the Calvert formation, which is Miocene (Tertiary).

Virginia: Diatomaceous earth occurs also in the Calvert formation of the Chesapeake group in the vicinity of Richmond, Va. The lower beds of the formation, chiefly those between 5 to 20 ft. from the base, contain diatom remains in sufficient quantity to entitle it to be termed diatomaceous earth. In weathering, the portions rich in diatom remains become nearly pure white. The material is of very fine texture, and is very light gray to white in color. Its lightness is characteristic, having a specific gravity of only 0.33, bulk for bulk. It outcrops especially in the valley of Shockoe Creek. The available material here is not so great in extent as at some other localities in Virginia and Maryland. The purer deposits are soft and clay-like, and when dug are very porous with a white or slightly yellowish tinge.

Florida: The Florida deposits of diatomaceous earth have been formed in fresh water, and are of comparatively recent date. A deposit located at Eustis, which has been worked to some extent, is in general appearance very much like the peat bogs of that section. The diatomaceous earth is in fact intimately mixed with peat or muck, and the material as taken from the bogs looks like peat of a grayish color. The method of treatment is to burn out the carbonaceous matter, leaving the siliceous material as a very fine white powder. The deposit in this bog has a thickness of 20 ft. or more.

About three miles east of Tavares, on the north side of Lake Dora, is a bog of the peat prairie type covering 100 acres. In 1901 a plant to treat the infusorial earth was erected on the north edge of this prairie a few hundred feet from the Sanford and Eustis division of what is now the Atlantic and Coast Line R.R. Besides the occurrence near Eustis, Lake County, a number of samples of similar material have come from Polk County.

It is reported that the Eustis product was at first shipped to England for use in making scouring soap.

New Mexico: Near Socorro there is stated to be a deposit of fine quality which outcrops in one place 1,500 ft. long and with a thickness of 6 ft.

Nevada: A deposit of diatomaceous earth is reported in a railroad cut west of Reno, Nev., with a thickness not less than 300 ft. and varying from a pure white to a pale buff or canary color.

Oregon: Near Linkville, Klamath County, there occurs a deposit of infusorial earth which has been traced a distance of ten miles, and along Lost River it shows a thickness of 40 ft.

Idaho: Beds of diatomaceous earth are known to occur in Idaho.

Washington: Beds of diatomaceous earth are known to occur near Seattle, Wash.

California: There are a number of deposits of infusorial earth in California. The most important thus far developed are in Santa Barbara, Monterey, Orange and San Luis Obispo Counties. The material in Santa Barbara County is of superior quality and has been worked on a commercial scale. Infusorial earth is also found in Fresno, Kern, Los Angeles, Plumas, San Benito, San Bernardino, San Joaquin, Shasta, Sonoma and Tehama Counties. During 1918 five quarries operating in Monterey and Santa Barbara Counties produced a total of 36,000 tons of this material, valued at $190,000. The most important deposit is that of the Celite Products Co., formerly the Kieselguhr Company of America, the name having been changed during the war. The quarry and mill of this company are at Lompoc, Santa Barbara County. This company has rapidly increased the scope of its dust operations, and it is reported that it expects to still further increase them. There is still another operation in the same vicinity by the name of La Salle Canyon quarry. Near Bradley, in Monterey County, there have been two small operations, and possibly a third. The deposits of northern Santa Barbara County have been described in great detail by Ralph Arnold and Robert Anderson in Part I of U. S. Geol. Sur. Bull. 315 (1906).

[1] Parsons, A. L.: "Peat, Its Formation, Uses, and Occurrence in New York," 57th Ann. Rept., N. Y. State Museum, vol. 1, sec. 1 (or 23d Ann. Rept. State Geologist, Part 1); 15-80-1905.

Reliability of Materials and Mechanism of Fractures*

The Focus of Impact Fracture Is Below the Surface Opposite the One Receiving the Blow, and the Metal or Amorphous Substance Splits Along Radiating Surfaces, Overlapping or Separated by Ripples Which Further Out Develop Into Major Fracture Planes

BY CHARLES DE FREMINVILLE†

RELIABILITY is the quality we desire in the metals we use, but it is very difficult to ascertain it through a short test. The reliability of materials is like the reliability of friends. Whatever brilliant qualities they may exhibit, their reliability is known only in the long run, so that in the case of an apparent failure, the qualities of a metal, like those of a friend, should not be questioned too quickly. It is not enough to know the intrinsic qualities of the metal; a very careful study of the circumstances under which the failure occurred must also be made, and it is this fact which has made the study of fractures and of the mechanism of fractures one of great interest to the author.

During the early days of the automobile industry the problem of resistance of materials began to be considered in a new light. The first motor cars that were built were designed with factors of safety then generally accepted for the resistance of medium-carbon steel. But the engineer soon came into contact with the sportsman and was tempted to put into the gearing a stress much greater than the one for which it had been made. One of the problems to be solved, therefore, was to secure a material which could safely be used for gears.

At that time steel makers had produced, among certain other new products, ternary steels, which showed brilliant promises of new qualities if the results of the laboratory tests to which they had been submitted could be taken as a proof of their reliability.

Viewing the question of material for motor cars in a general manner, the constituent parts appeared to belong to two distinct classes. The first included such parts as gears, crankshafts, connecting rods, etc., which had to withstand severe normal shocks. Also only a small amount of wear was allowable and the class of accidents to which they were liable was limited, being chiefly those of seizing or an encounter with stray nuts or bolts.

The parts of the second class did not have much stress imposed upon them in ordinary service, but they did have to meet with what can be termed "normal accidents," and were therefore expected to bend to a certain extent without ceasing to fulfill their duty. To this class belonged front axles and, more generally, all the parts connected with the steering mechanism. For these, the "normal accident" can happen very frequently. It is almost impossible to say that the wheel of a car will not come rather abruptly into contact with a curbstone, or even with the wheel of another car. In such case something must yield or break. It is of course but natural to hope that something will yield and that this yielding has been foreseen; also that it will take place on a piece easily seen and easily replaced, and that the material of which the piece is made will not cease to be reliable.

The impact test, to which attention was directed at that time in France by M. Considère and later by M. Frémont, seemed to be a very convenient method for ascertaining the characteristics of the parts of each class. The impact test, however, was devised primarily for soft steel and had to be adapted for very hard steel. But by making use of the impact test it was possible to select for the parts of the first class a grade of steel which only fractured after a very small amount of deformation, and this could be considered as a very excellent quality for the parts of this class.

The parts of the second class were expected to bend under the impact test to a very great extent, and it was easy to find wrought iron or mild steel possessing this characteristic, although the reliability of these materials for the use considered is a matter open to discussion. But here again the problem became complicated, because there were those who seemed reluctant to admit that some of the parts had to bend easily under certain circumstances and that a limited amount of toughness was not desirable, inasmuch as the steel maker pretended to have grades of steel uniting in a rare degree ductility with toughness.

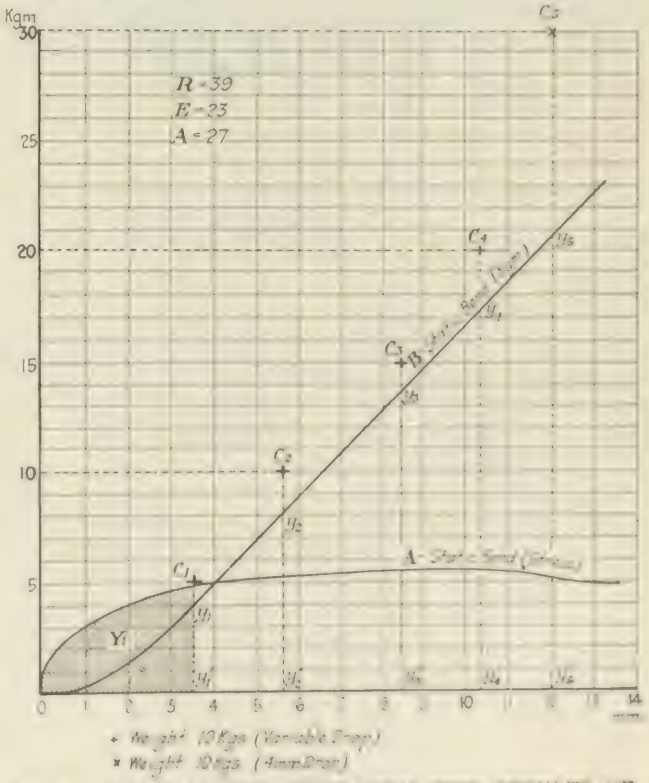


FIG. 1 DIAGRAM FOR COMPARING THE RESULTS OF STATIC BEND AND DROP BEND TESTS

*Presented at the annual meeting, New York, December, 1919, of the American Society of Mechanical Engineers, and printed in their *Journal*, April, 1920. A brief abstract of his address was given in CHEM. & MET. ENG., vol. 21, p. 613 (Nov. 12-19, 1919).

†Architectural and industrial engineer, Paris, France. Consulting engineer, Schneider Works. Hon.Mem.Am.Soc.M.E.

The tensile tests of these steels showed a high ultimate strength and a great elongation. The impact test showed that a considerable amount of energy had been absorbed by the test piece, which gave a great amount of distortion. It is evident that if it had been possible to have a diagram of the impact test, showing at every moment what was the amount of stress corresponding to a given deflection, the matter would have been made very much clearer. But since there was no machine that would give such a diagram, a substitute was found in a static bending machine registering the amount of energy taken in the deformation process. It was possible to ascertain that in all the cases which had to be investigated, the number of kilogram-meters absorbed was practically the same as in a quick bend or in a drop test. So far as the appearance of the fracture was concerned there was no perceptible difference in either case,

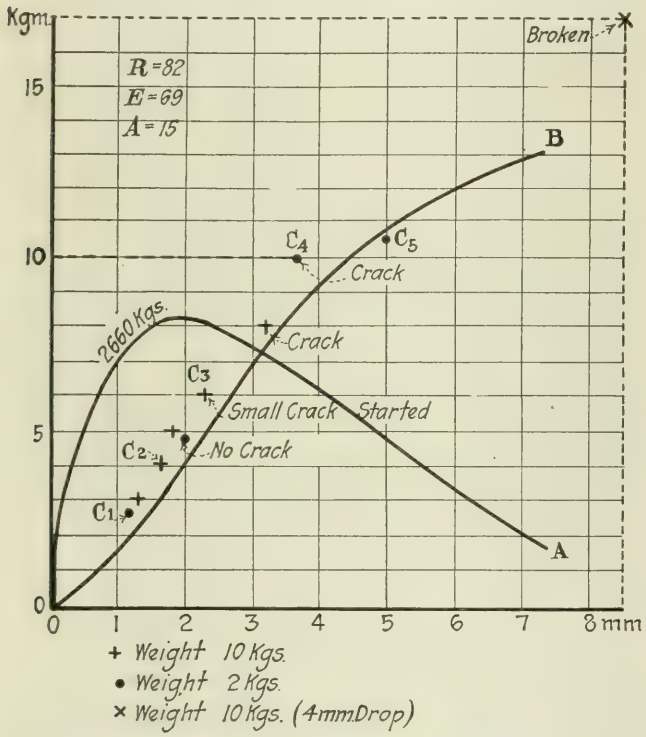


FIG. 2. DIAGRAM FOR COMPARING THE RESULTS OF STATIC BEND AND DROP BEND TESTS

which showed that the metal which seemed to possess ductility and toughness did not possess these characteristics to the extent believed.[1]

Figs. 1 and 2 are diagrams for comparing the results obtained by drop tests and quick-bend tests on notched test pieces. In these diagrams the ordinates of curves A are proportional to loads corresponding to deflections shown on the abscissa scale. In curves B (which are the integrals of curves A,—ordinates $y_1y'_1$, being proportional to surface Y_1, and so on) the amount of energy consumed in the bending test is given for each value of the deflection. The ordinates y'_1C_1, y'_2C_2, etc., are proportional to the amount of energy absorbed by the drop test for the same deflection, as measured in the bend test, and can be easily compared with $y_1y'_1$, $y_2y'_2$. The energy absorbed in the drop test appears to be only slightly greater than that absorbed in the quick-bend test, but the process has followed the same course in

[1]The author has recently learned that the same idea of interpreting a drop test by means of a diagram given by a static bend test has been successfully used in this country for testing rails, and he believes that it can be used in many instances.

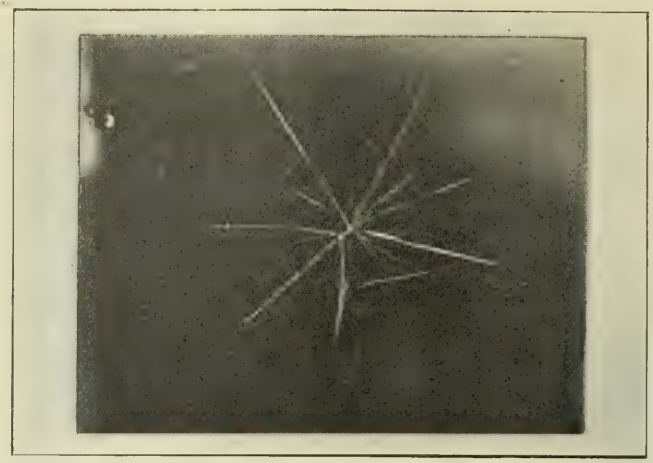


FIG. 3. RESULT OF SHARP SHOCK ON A GLASS VESSEL

both cases, and the difference may be attributed to errors in the experimental work.

Fig. 1 is a diagram of a test of wrought iron or mild steel in which the amount of stress necessary to obtain a given deflection remains constant over a long range. This is the type of material which can be expected to give good results for parts of the second class.

Fig. 2 is a diagram of a test of a steel with a certain amount of ductility, in which the energy consumed for a given deflection appears to be greater than in the case of Fig. 1, and which was offered for parts of the second class. It should be noted that in Fig. 2 curve A is absolutely different from curve A of Fig. 1, as it shows that a maximum amount of the energy is absorbed after a small deflection has been obtained. This maximum is the point where the piece begins to show a crack, which of course did not exist in the test piece whose diagram is shown in Fig. 1.

Parts of the second class made of this metal proved a decided failure. Even without experiencing the "normal accidents" which they were expected to withstand, they showed a great tendency to crack without the slightest deformation, which method of fracture has been called *fissillité* by the late M. Brustlein, of the Jacob Holtzer firm, Unieux, France.

By looking closely into the fracture of the broken test piece, which was supposed to possess ductility and toughness, it could be seen that most of the distortion,

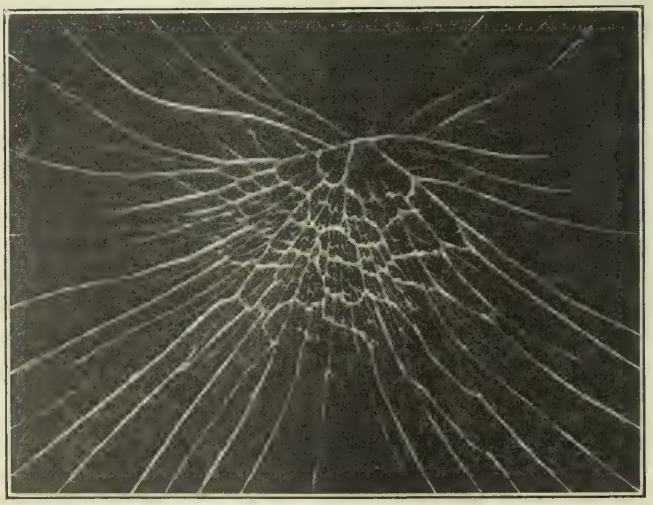


FIG. 4. DEVELOPMENT OF THE FRACTURE RESULTING FROM A SHOCK ON A THIN SHEET OF GLASS

or flowing of the metal, had taken place not before the fracture was started, but during the process of extension of the fracture, and this gave to the amount of energy recorded an altogether different meaning. In this case the failure of the material could be traced to a bad interpretation of the test, but other failures were encountered which could not be traced to the quality of

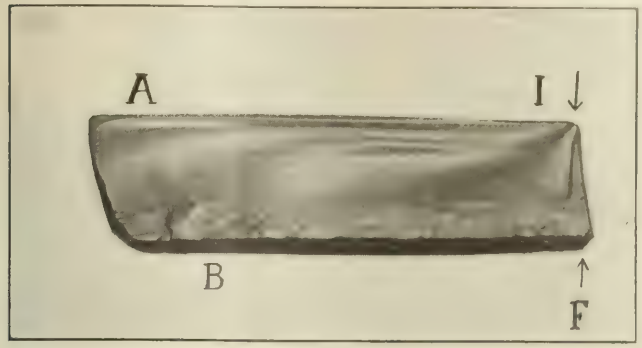


FIG. 5. FRACTURE SURFACE IN A SLAB OF GLASS

the metal used. Typical among these was the sudden snapping of levers, under conditions which could be specified but which were difficult to explain. The impact test, like others, could not give a clue as to reliability in certain circumstances.

The Study of Fractures

The uncertainties in the behavior of material, the propagation of a crack without any distortion of the piece, the sudden snapping of a rod without any perceptible alteration in the neighborhood, even the changes which were produced in brittleness under heat treatment, appeared to be difficult to account for, and it seemed to the author to be worth while to add to the theoretical views of the question by making, as far as possible, a thorough study of the fracture itself, which would tell, in some cases, the story of the failure.

It is frequently believed that fracture is a form of failure of such peculiar character as to escape all rules.

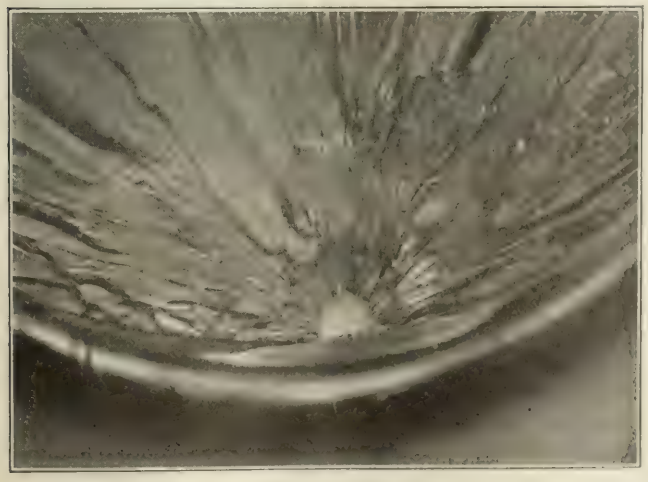


FIG. 6. SMALL SPLINTERING FOCUS GLASS

However, the attention of the author was first attracted by the very regular fractures of sandstone, which is used extensively in France for pavements, and which so resemble one another that they seem to be real diagrams of what has happened during the rupture. Moreover, a certain number of peculiarities of the fractures were found to be common to both sandstone and steel. It was also noticed that these same features were found in glass fractures, in which they could be observed with great accuracy; also that they were still easier to observe in Judea bitumen, where the breakage was produced very easily. A further study has shown that the fractures developed in an identical manner in these various materials.

It is not possible in the limited time at the disposal of the author to go thoroughly into the subject of the study of fractures, and as a result attention can only be called to some of the main features. Fig. 3 shows a fracture developed in a glass vessel by a sharp shock. In this should be noted the symmetry of the surfaces originated and the peculiar disposition of the starting points of these surfaces from both ends of a small line to which the surfaces are tangent. Fig. 4 shows the development of the fracture resulting from a similar

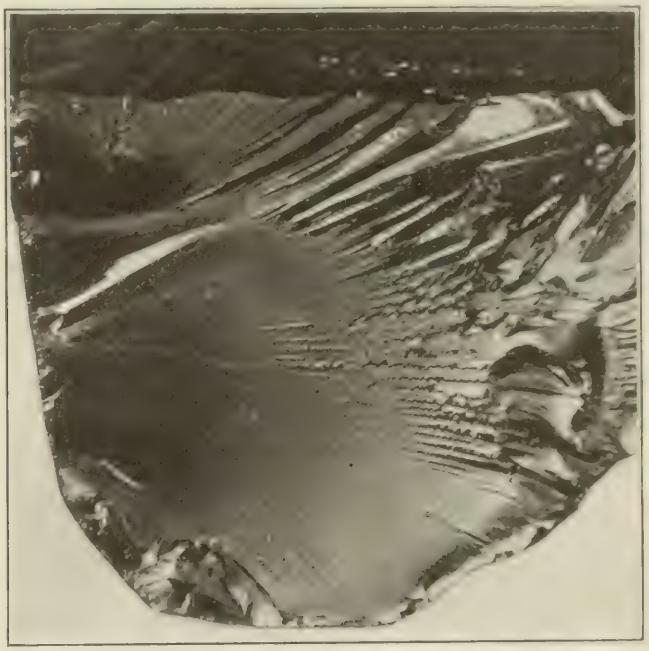


FIG. 7. FRACTURE IN JUDEA BITUMEN

shock in a thin sheet of glass. Here great symmetry is seen, the network also originates from a small line, and some of the surfaces extend entirely through the glass, some only partially.

Fig. 5 is taken from a slab of glass broken in the same manner. It shows one of the surfaces dividing the slab into pieces, which was also partially cut by other surfaces. In this particular case the blow was given at *I* on the top of the slab, and it will be seen that the small line, noted in the previous figures as the origin of all the cracks, is situated at *F* at the opposite side of the surface. It presents a very remarkable appearance and the general disposition of the surface induces us to believe that the fracture originated in that region.

Fig. 6 shows in great detail another specimen, which illustrates very clearly that there is a starting point of the fracture. Many such examples enable us to see that one of the main surfaces cutting the test sample has not expanded at one stretch, but is formed by surfaces overlapping each other like the blades of a fan. This is made still more evident by the fracture shown in Fig. 7. These surfaces overlap each other at distances often smaller than a hundredth of an inch, and by making use

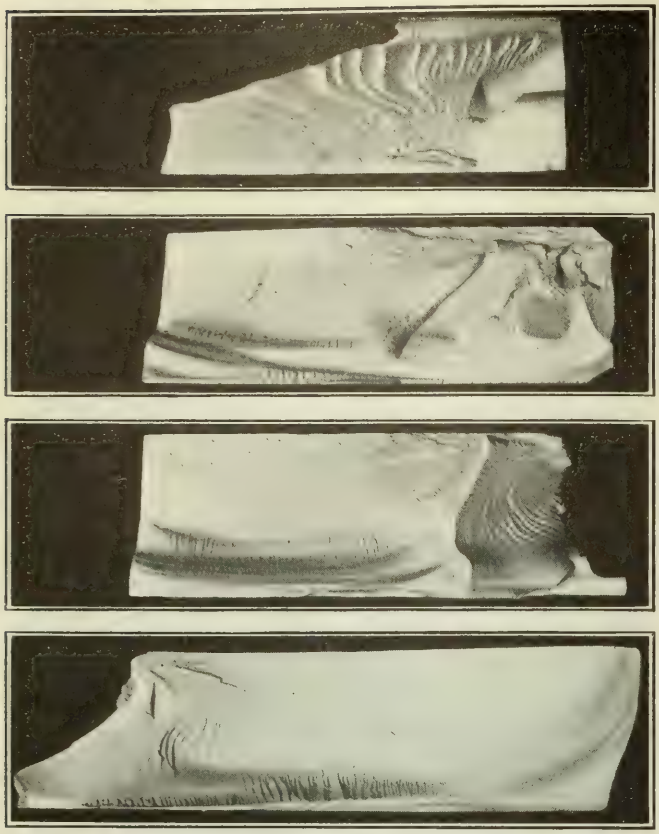


FIG. 8. FRACTURE IN TOOL STEEL

of the method called *recoupement* (recutting) by the geologists, it is possible to follow the successive order in which the various elements of the fractures have developed.

Fig. 9 shows in greater detail one of these surfaces, and enables us to point out some of its special features. Part of the surface is bright and part dull. A study of the bright part can be made from Fig. 7, which shows a standard fracture in Judea bitumen. It is very easy to

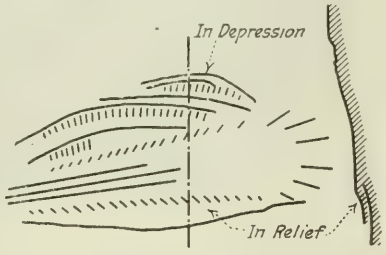


FIG. 9. SCHEME OF FRACTURE IN JUDEA BITUMEN

FIG. 10. RENTS FORMED UNDER THE MAIN SURFACE IN GLASS

follow the surfaces overlapping each other, as is shown by the scheme in Fig. 11. The general arrangement of the surfaces bears a very close resemblance to the surface of water as it runs in a culvert, passes over a dam, or expands in a shallow pond.

The same arrangements of fractures, overlapping surfaces, foci, etc., which are easily observed in glass and Judea bitumen are also met with in tool steel, as shown in Fig. 8.

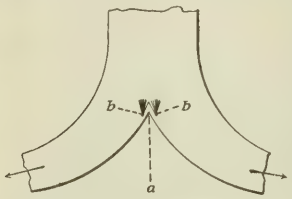


FIG. 11. SCHEME OF TEARING, WITH CRACKS THAT ACCOMPANY IT

We find that the dull part gives the impression that it has been rent or torn away, while the bright surface seems to have been carefully cut. Fig. 10 shows how the dull surface is originated by small rents coming from under the surface. If now we come back to the focus of Figs. 6, 7 and 8, and look for the point where it has been originated, we find that it also lies under the surface.

Fig. 11 shows what takes place in the tearing of a tough substance such as gelatine. The cracking (*bb*) travels ahead of the parting at *a* and prepares the way for its advance.

Fig. 12 is another and striking example of the tearing of a tough material. The parting at the edge of the

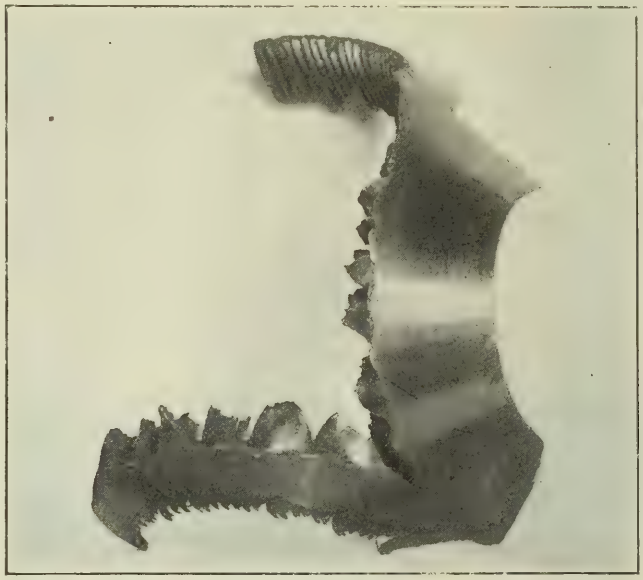


FIG. 12. STEEL CHIP

tool has been made possible by a "cracking" similar to that shown in Fig. 11. The sketch in Fig. 13 shows the scheme of the formation of the steel chip.

But how can a bright surface be produced? How can the cutting process be carried on without the subsurface cracking? How can surfaces be cut which run parallel within such small distance as the ones we have noted? The only explanation which seems to be satisfactory is that the cutting power is a vibratory motion of the surfaces of the fracture, so long as they do not join each other.

Stress and Strain

What are the conclusions to be drawn from this brief presentation of the mechanism of fractures? How can it pretend to be a contribution to the science of resistance of materials? In a general way, by showing the

succession of the phenomena which have taken place during the spreading of the fracture, it affords an experimental proof that the straining effects are more detrimental to the material than mere stress. This is in accordance with what has been shown by a purely mathematical study of the question.

In case of an impact fracture, be it in a piece of glass or in a piece of steel, we find the starting point of the fracture under the surface, although the maximum stress must certainly be located on the surface itself.

In the case of a piece subjected to tension only if a comparison is made with the fractures already considered it will show that fracture has originated along the axis of the test piece. (See Fig. 14.) The surface of the test piece itself sustains a very important stress, but without being subjected to the strains resulting from the contact of layers undergoing uneven stresses, flowing, so to speak, to give the reduction of area.

The predominance of the internal or straining action is no less striking in the case of a rent where the straining effect travels in advance of the stress which could be originated at the separating point. (See Fig. 11.) This condition should induce the metallurgist to pay more attention to the causes which produce straining; in other words, to the tensions which may exist in the pieces after being cast or forged. This is illustrated by the changes in brittleness which occur in glass undergoing heat treatment. The heat treatment does not bring about any change in its molecular arrangement, but the glass coming out of the furnace is very brittle, and after being properly annealed is so much less so that it is in the so-called unbreakable state; that is to say it can sustain shocks and bending to a much greater extent than ordinary glass.

FIG. 13. SCHEME OF STEEL CHIP

The first condition is one of very uneven tension; the second, one without tension; and the third, one which has a beneficial tension. This unevenness of tension also exists in steel, irrespective of the chemical or other changes in structure. An example of the effect of these internal tensions is given by Fig. 15, which shows a fracture in a rail. It is evident that the fracture was started in the neighborhood of the neutral axis, a fact which could not be accounted for if the piece had been under normal conditions; therefore the causes of a fracture of that kind must be traced to a tension most likely produced in the rolling mill. This case illustrates the mode of cutting which produces bright surfaces in glass, and which can only be explained by the presence of a vibratory motion of the surfaces when they are apart from one another.

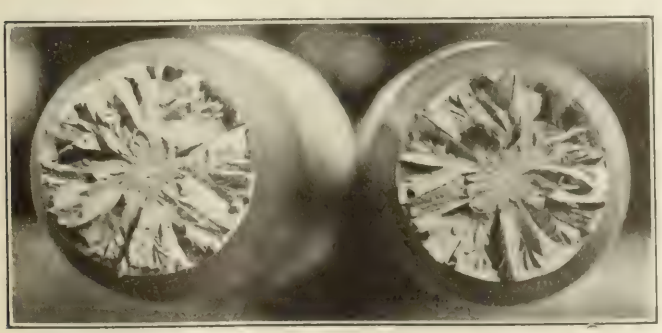


FIG. 14. TEST PIECE RUPTURED UNDER TENSION; FRACTURE ORIGINATED ALONG THE AXIS

FIG. 15. TENSION FRACTURE IN STEEL RAIL

In conclusion, the author trusts he has created the impression that a methodical study of fractures is of the greatest importance, especially as it leads to a knowledge of the causes of failures which cannot always be attributed to the intrinsic qualities of the metal itself.

United States Third in Visible Nitrate Supply

The Association of Producers of Nitrate has made public certain statistics concerning the consumption of this product, according to an Associated Press dispatch.

In the month of February there was on hand in Europe a stock of nitrate of 150,000 tons, and during this same month there was imported into Europe 237,000 tons. Of this total of 387,000 tons there was delivered to the consumer during February a total of 155,000 tons, which left on hand for the month of March a total of 232,000 tons.

The visible supply of nitrate reaches 2,102,000 tons, composed as follows: 1,252,000 from Chile, 492,000 in Europe, 277,000 in the United States and 81,000 in Japan and other countries.

To the 237,000 tons imported by foreign markets during February there should be added 12,500 tons transshipped in the United Kingdom. This gives a total for imports in February of 249,000 tons. The distribution of these imports was as follows: United Kingdom, 11,000; France, 90,000; Belgium, 21,500; Holland, 22,000; Spain and Portugal, 18,000; Italy, 39,000; Scandinavia, 31,000; Egypt, 7,500; Germany and Baltic ports, 9,000.

Production of Sandalwood and Sandalwood Oil in India

A report has been prepared showing the development of the sandalwood oil industry, which is practically a monopoly of the Mysore Government of India, and the distribution of this trade in previous years. The oil is used in the preparation of certain medicines, perfumes and scented soaps.

Australian Flax Industry*

THE Commonwealth Flax Industry Committee, which was established by the Australian Government on the recommendation of the Institute of Science and Industry, has recommended the government to continue the guaranty for raw flax. It is understood that the government does not intend to let this industry languish. Already the area under crop has been increased from 500 to 2,200 acres, and the Flax Committee anticipates that no less than 5,000 acres will be planted during next season.

Before the war Russia produced no less than 80 per cent of the world's output of flax fiber, and when the greater part of the Baltic provinces fell into German hands, as well as the flax-growing districts of Belgium, northern France and the Balkan Peninsula, the shortage of flax fiber among the allied nations for both military and commercial purposes became every day more and more acute. As a result of a meeting of agricultural scientists held in Melbourne in November, 1917, at the suggestion of the advisory council of science and industry a resolution was carried that the advisory council be asked to ascertain whether the British Government was prepared to purchase dewretted flax fiber from Australia in 1919; and, if so, in what quantities and at what price. Inquiries were instituted accordingly, with the result that the army council in England agreed to purchase the fiber from the 1918 flax crop at £170 ($827.30 at normal exchange) per ton c.i.f. The Commonwealth Government thereupon appointed a committee, under the war precautions regulations, for the control and development of the flax industry in Australia, at the same time guaranteeing all growers of fiber flax in 1918 £5 ($24.33) per ton for flax of specified standard.

Previous Efforts to Establish the Industry

For the past twenty years or more fiber flax has been grown on a limited scale in the Gippsland district of Victoria, and attempts have also been made at various times to introduce the cultivation into New South Wales and Tasmania, but without success. Owing to the scarcity and high value of labor and the low price at which flax fiber could be imported, the return the Australian farmer received for his flax did not prove sufficiently attractive to encourage its cultivation, and the few attempts made in recent years to establish the flax industry on a larger scale in Victoria ended so disastrously as to prejudice him still further against this crop. The bounties act, passed by the Commonwealth Government in 1907, provided for the payment of bounty of 10 per cent of the market value of all products from flax grown in Australia, but so little was this inducement availed of that when the act expired, in 1917, not more than 300 acres of flax were under cultivation.

It is more than likely that, in addition to the low returns for fiber and the comparatively high cost of labor, one reason for the retarded development of the flax industry in Australia was the difference in the climatic conditions as compared with those of the fiber-producing lands of Europe, and particularly with those of Ireland, in which country most of the farmers who have attempted flax cultivation in the commonwealth originally gained their experience of this crop. The system adopted in Australia is that of dewretting, the straw being spread over the paddocks in thin layers and the fermentation being brought about by the action of the dew and the sun. Again, in Ireland and in all the European flax-growing countries the custom is to pull the crop by hand, while in Australia it is cut with a reaper and binder. There appears to be no doubt that cutting is wasteful, besides being detrimental to the production of first-quality fiber; but the loss sustained by the Australian grower through the adoption of this method is probably more than compensated for by the greatly decreased cost of labor. Flax growers in Australia had had to learn by the practical experience of local economic and natural conditions, and the methods of cultivation and treatment that have proved successful in Europe may not be equally so in the commonwealth.

Work of the Flax Industry Committee

When the committee was appointed its first act was to requisition all the seed from the previous year's crop. In view of the limited quantity available, the committee decided, as far as growing flax on a commercial scale was concerned, to confine its efforts for 1918 to Gippsland, where it was known that flax could be grown with success, and where one or two flax mills were already in existence. The seed at the committee's disposal was grown in the Drouin district, and was of the variety know as "blue-flowering Riga," the descendant of a small consignment imported some years ago. The quantity available was sufficient to sow only about 1,400 acres, and for a time the advisability of obtaining a further supply from New Zealand was seriously considered. On examination of the samples admitted, however, some doubt arose as to the fiber-producing qualities of the imported seed, and it was decided to utilize only the acclimatized Victorian seed. The wisdom of this determination was proved subsequently by the results of experimental sowings of the New Zealand variety. At Drouin, at the same time and under similar conditions, an acre was sown with the New Zealand seed, and several acres with Victorian-grown seed; but whereas the latter produced one of the best crops in the district, the crop from the imported seed was of so little value as regards both fiber and seed that it was never harvested.

The 1918 Harvest

Owing to the exceptionally dry spring of 1918, the early anticipations of a record harvest were not realized, but nevertheless the average yield of flax was a satisfactory one. Appraisers were appointed at the time of harvesting to inspect and value each crop, and 1,800 tons were delivered for treatment at the various mills. As was inevitable in what was to many growers a new venture, the lack of the necessary experience militated in some cases against the best results being obtained, but the average price paid—£4 15s. ($23.12) per ton—is evidence of the comparatively high standard of the crop. The treatment of the flax at the mills was not completed before the end of 1919, but it was estimated that flax products to the value of approximately £23,000 ($112,000) would be obtained. It is more than likely that, with the experience gained in both the cultivation and treatment of 1918 flax, more profitable results will be obtained from succeeding crops.

*From the *Commonwealth Journal* of the Institute of Science and Industry.

As there was every indication of continued high prices for flax products, the flax committee had no hesitation in recommending the Commonwealth Government to extend the guaranty to the 1919 crop, to place the industry on a surer footing. At the same time, it was thought that, in view of the high returns received by farmers at present for other agricultural products, such as hay, potatoes and butter fat, the guaranty of £5 per ton was hardly sufficient, and an increase to £6 per ton was therefore recommended. The Commonwealth Government adopted the committee's recommendations, and subsequently an agreement was made with the Imperial Government for the purchase by the latter of the 1919 fiber on the same terms as previously given, viz., £170 per ton c.i.f.

The 1919 Crop

The area sown in 1919 was approximately 2,250 acres, an increase of 50 per cent on the acreage of 1918. The cultivation of flax has been introduced into several new localities, 700 acres having been sown in the Sale and Thorpdale districts, while in the western and central districts many farmers are growing this crop for the first time on a commercial scale. Provision will have to be made for the treatment of crops in those districts where milling facilities are not now existent, and the establishment of flax mills on a co-operative basis seems to offer the most satisfactory solution.

While fully assured that the flax industry can be established in the commonwealth on a sound and profitable basis, the flax committee considers that the most effective means of doing so would be a continuance of the present system of commonwealth control. A recommendation, therefore, has been made by the committee to the government that a guaranty of £5 per ton for standard flax be given to growers for a further period of three years, and the matter is now receiving ministerial consideration.

British Plate Glass Industry

Probably none of the war-time industries of Great Britain has shown greater development or more progress than that of glass making. Most of the country's imports of plate glass were from Belgium, but British glass manufacturers are now making a concerted effort to capture this branch of the glass industry from that country. It is estimated that an average of four Belgian ships fully laden with glass of various kinds arrive at the London wharves each week.

In 1914 there were only a few companies in Great Britain making plate glass or optical and chemical glassware. Although several had been established for many years, they were regarded as inefficient and their output was small in comparison with the requirements of the home market. The cutting off of German and Austrian supplies caused a great revival in this industry and many plants were extended on more modern and scientific lines.

English glass makers have been slow to do away with the hand-made method of production, but they realize that if they are to hold the home trade and to eventually successfully compete in foreign markets they must produce on a large scale, which is only possible by the use of machinery.

According to an interview with G. Peters, managing director of the Willesden Glass Works Co. (Ltd.), which was published in the *Daily Express*, his firm has a capacity of 10,000,000 sq.ft. of glass a week and production is at 40 per cent less than Belgian manufacturers. These works were established just before the signing of the armistice, and it is now claimed that it is the second largest sheet-glass factory in Great Britain. The initial cost of the plant was £100,000.

Mr. Peters also said: "There is a world shortage of glass, and we are out to take our share in supplying it. We are following the Belgian hand-blowing system at present, because no machinery has yet been found to give superior results. This, however, is sure to come, and we shall avail ourselves of every development in this direction. Twenty-five per cent of our workers are Belgians. We are training up British workmen for the future by taking on only British boys as apprentices. These boys start right away at 10 pence an hour. Skilled glass blowers can earn from £12 to £16 a week. They are all on piecework and the day is of eight hours."

Quicksilver Produced in 1919

The production of quicksilver in the United States in 1919 was 21,348 flasks, according to F. L. Ransome, of the United States Geological Survey, Department of the Interior. This was a decrease of 11,535 flasks, or about 35 per cent, from the output in 1918. These figures may be slightly revised when the final returns for the whole year are in.

The production by quarters, for 1919, according to the latest revised figures, was as follows:

	Flasks of 75 lb.
First quarter	6,125
Second quarter	4,059
Third quarter	5,413
Fourth quarter	5,751
	21,348

The output for the fourth quarter of the year shows an increase of 338 flasks, or about 6 per cent, over that for the third quarter.

Of the output for the fourth quarter 4,213 flasks were reported from California, 1,032 from Texas, 462 from Nevada, and 44 from Oregon. The proportion for the entire year was: California, 14,941 flasks; Texas, 5,183; Nevada, 821, and Oregon 403. No production was reported from Idaho or Arizona. The number of mines reported as productive during the fourth quarter was eighteen.

The quicksilver reported on hand at the mines or in transit to market at the end of the year amounted to about 4,000 flasks.

The average monthly prices of quicksilver per flask in San Francisco in 1919, as quoted in the *Mining and Scientific Press*, were as follows:

January	$103.75	July	$100.00
February	90.00	August	103.00
March	72.80	September	102.60
April	73.12	October	86.00
May	84.80	November	75.00
June	94.40	December	97.00

These figures give an average price of $90. This price should yield a profit to those operators whose mines are favorably situated and who have ore that averages 8 lb. or more of quicksilver to the ton. It evidently is not enough under present conditions, however, to furnish much incentive to the working of the lower grades of ore to which many of the mines have been reduced, or to encourage very active search for new ore bodies of so capricious a mineral commodity as quicksilver.

Synopsis of Recent Chemical & Metallurgical Literature

Influence of Artificial Carburation of Coal Gas on the Crystallization of Naphthalene in Gas Pipings.—Accumulation of naphthalene in the pipe lines, especially during the cold season, is a very troublesome problem in the gas industry. Cases occur quite often when as much as 1 kg. of naphthalene is deposited per meter of piping (⅔ lb. per ft.).

The methods to separate the naphthalene at the gas plant are based mainly on:

(1) Rapid cooling of the gas leaving the hydraulic main, a method first suggested by Emile Saint-Claire Deville. Thus, when rapidly cooling the gases from its average temperature when leaving the hydraulic main 60 deg. C. (140 deg. F.) to below 20 deg. C. (68 deg. F.) about nine-tenths of the napthalene is condensed with the tar.

(2) By washing the gas after leaving the gas purifiers with heavy oils. This is based on the same mechanical principle as that used to wash the gas with water for the separation of ammonia (method first suggested by Dr. Buels). By this method all the naphthalene contained in the gas can be separated.

After separating naphthalene the candle power of the gas is diminished. This would not be detrimental to the consumer when the gas is used only for heating purposes. When the main use of the gas is for lighting, it is best not to separate the naphthalene, but to hold it therein in gaseous form even at low temperatures. This can be realized by artificially carburating the gas with hydrocarbons derived from oil of coal tar.

CH. AB-DER-HALDEN has made experimental studies on the effect of artificial carburation, and the results of his work are described in the January, 1920, issue of *Chimie et Industrie*. Tables and diagrams are given, which show the influence of the oil used for carburation, and which lead to the following conclusions:

(1) When a coal gas saturated with naphthalene at a given temperature is artificially carburated, it can be cooled below this temperature without the naphthalene solidifying, as it is retained in the form of a gaseous solution by the carburating vapors.

(2) The efficiency of the treatment depends on the boiling point of the carburating agent and not on its chemical composition, and the best results are obtained with oils boiling between 80 and 90 deg. C.

(3) The cooling point of the treated gas up to which the napthalene will not solidify out depends on the quantity of the carburating agent used.

(4) The influence of carburating coal gas supersaturated in naphthalene is the more marked the greater the contents of the naphthalene in the original gas.

Some Properties of Sodium Nitrite.—Sodium nitrite plays an important role in the synthetic manufacture of HNO_3. C. MATIGNON and Miss C. MARCHAL have studied some of its properties. (*Comptes Rendus*, vol. 170, No. 4, pp. 232-233.) They worked on a very pure product, analyzing 99.9 per cent $NaNO_2$ and have found the following results:

Fusion point, 276 deg. C.

Heat of Solution. Sodium nitrite dissolves with comparative ease, the molecular heat of solution is —3.52 cal. at 20 deg. C.

Heat of Neutralization. This has been determined by adding a calculated quantity of sulphuric acid to a dilute solution of the nitrite, and was found to be 4.6 calories on the average.

Heat of Formation. The above values added to the heat of formation of the nitrous acid as determined by Berthelot:

$$N + O_2 + H + aq = HNO_2 \text{ solution} + 30.3 \text{ cal.}$$

and to the thermal constants of soda and sodium oxide give for the heat of formation of the solid nitrite 88.52 cal.

$$N \text{ gas} + O_2 \text{ gas} + Na \text{ solid} = NaNO_2 \text{ solid} + 88.52 \text{ cal.}$$

Action on Colored Reagents. The action of nitrous and nitric acid with phenolphthalein, cochineal, lacmoid, paranitrophenol, brazilian and iodeosine is the same. Helianthine is destroyed by nitrous acid.

Action of Oxygen. Sodium nitrite solution cannot be oxidized directly, even when maintaining the solution at 100 deg. C. in contact with oxygen under a pressure of 50 and 55 atm. for 5 to 6 hr. and with continuous agitation. The same negative results were obtained by the use of an oxidizing catalyzer, such as platinum black.

Comparative Study of Electrically and Coke Heated Blast Furnaces.—The relative expenditures of heat and the compositions of gases obtained in electrically and coke heated blast furnaces have been studied by MARCEL GUÉDRAS and described in the Jan. 20, 1920, issue of *Revue de Métallurgie*. Tables I and II give respectively the data of the heat expenditure in an electric furnace at Trolhättan, Sweden, and in a 90-ton furnace using coke.

TABLE I. HEAT SPENT IN AN ELECTRICALLY HEATED BLAST FURNACE PER METRIC TON OF PIG IRON

	Calories.
Reduction of 91.02 kg. Fe from Fe_2O_3	163,836
Reduction of 873.118 kg. Fe from Fe_3O_4	1,440,648
Reduction of 3.110 kg. Fe from FeO	725
Reduction of 0.160 kg. Mn from Mn_3O_4	315
Reduction of 4.270 kg. Mn from MnO	7,387
Reduction of 3.420 kg. Si from SiO_2	26,779
Reduction of 0.186 kg. P from P_2O_5	1,096
Heat of fusion of iron and slag	402,400
Heat of decomposition of carbonates	49,134
Heat of vaporization of 87.38 kg. H_2O, less cooling to 60 deg. C.	53,479
Tensile heat of dry gases from 10 to 60 deg. C.	
128.01 kg. CO_2 ... 1,280	
591.36 kg. CO ... 7,229	
10.54 kg. CH_4 ... 314	
3.73 kg. H ... 640	
	9,463
Total	2,155,262

TABLE II. HEAT SPENT IN A COKE-HEATED BLAST FURNACE PER METRIC TON OF PIG IRON

	Calories
Reduction of 950 kg. Fe from Fe_2O_3	1,792,650
Reduction of 10 kg. Si from SiO_2	78,300
Fusion of 1000 kg. pig iron	300,000
Fusion of 1452 kg. slag	726,000
Decomposition of 1,170 kg. carbonates	438,750
Vaporization and heating to 250 deg. C. of 96 kg. H_2O	74,736
Decomposition of H_2O contained in the air used	19,320
Heat entrained by the gases	47,374
Losses	450,000
Total	3,927,130

In the electrically heated furnace the quantity of heat furnished per metric ton of pig iron is 2,155,262 calories, of which 908,830 calories are obtained by burning 34.91 kg. C to CO_2 and 113.44 kg. C to CO, leaving a balance of 1,246,432 calories to be supplied by electric

energy, corresponding to 1,454 kw.-hr. In the blast furnace 1,100 kg. of coke is required per metric ton of pig iron. The tables show that the heat spent in the blast furnace is 1,771,863 calories more than in the electric furnace. Improvements in the electric furnace construction and operation will certainly increase this marked difference.

The composition of the gases from the blast furnaces is:

	Blast Furnace Per cent	Electric Furnace Per Cent
CO_2	18.60	14.12
CO	22.15	83.00
CH_4	0.62	0.54
H	0.08	1.86
N	58.55	0.48

Their calorific heat is, in blast furnace, 638 calories; in the electric furnace, 2,257 calories. The amount of gas produced per ton of pig iron is, in the blast furnace, 5,615 kg.; in the electric furnace, 737.9 kg.

Expressed in calories the total heat values of the gases in the two types of furnace are respectively 3,582,370 and 1,665,485 calories. This shows an apparent advantage for the blast furnace, but as a matter of fact the electric furnace gas is superior and more useful than that from the ordinary blast furnace.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Halogen Substitution Products. — Oxidation and reduction reactions in the gaseous phase, such as the substitution of a halogen in gaseous carbon compounds, may be carried out in an apparatus devised by WILLIAM KOEHLER of Cleveland, Ohio. The gases are passed separately through nozzles so arranged that the streams of gas converge at a point beyond the nozzles. Thorough mixing results and an electric spark or arc is provided at this point so that mixing and heating to the reaction temperature are accomplished simultaneously, thereby preventing premature explosions of the mixture. (1,332,730; March 2, 1920.)

Nitric Acid.—A mixture of niter cake and sodium nitrate is passed through an inclined rotating kiln which is heated in a furnace in such a manner that the lower portion of the retort is subjected to the highest temperature. A sharp-edged iron bar is placed lengthwise in the retort, so that it tumbles about as the retort revolves and prevents the mass from adhering to the sides. A slow current of air through the apparatus effects the oxidation of the lower oxides of nitrogen and maintains the flow of the gases through the condensers and absorbers. (1,332,195; THOMAS F. BANIGAN of Kenvil, N. J., assignor to Hercules Powder Co., March 2, 1920.)

Naphthalene-β-Sulphonic Acid.—Sulphuric acid of 75 per cent strength is preferable to concentrated or fuming acid for the production of naphthalene-β-sulphonic acid. When sulphonation is carried on with this acid at about 160 deg. C. for a period of from 1 to 1¾ hr., the product contains only 22½ to 26 per cent of the α-sulphonic acid and very small amounts of sulphones, disulphonic acids and gum-like insoluble carbonaceous residue. The β-acid is preferably extracted from the mass by the use of toluene according to the method described in U. S. patent 1,228,414 of June 5, 1917, also granted to the present inventor, LOUIS M. DENNIS of Ithaca, N. Y. (1,332,203; March 2, 1920.)

Copper-Lead Smelting Process.—Methods by which complex ores carrying copper, lead and zinc can be economically treated for the recovery of the metals are of particular interest at the present time. As a general proposition, coke is expensive at mining centers, whereas soft coal may be relatively cheap and electric energy is usually available at a reasonable price.

WOOLSEY MCA. JOHNSON, of Hartford, Conn., proposes to take advantage of these general facts in a process for the recovery of copper, lead and zinc. The basic and acidic components of the charge to be smelted are heated separately in rotary kilns, using coal or coal dust for fuel. These are fed separately to an electric furnace in which the reduction takes place in such proportion that a slag of approximately the following analysis will result: SiO_2, 40 per cent; CaO, 20 per cent; FeO, 30 per cent, and ZnO, 10 per cent. In this operation lead bullion and copper matte will be produced in the same manner as in a lead blast furnace. The slag and matte are passed through two electrically heated settling hearths. In the first settler matte will be tapped out at intervals, while the slag, partly freed from matte, will pass to the second settler, where some fine carbonaceous material will be added to reduce the ZnO, and any dissolved PbO or CuO. In case much lead is present and in case an extremely high temperature is used, it is necessary to collect the lead fume from the electric furnace in a suitable apparatus. Also, in cases where no lead is present in the ore, the ratio of CuO to Cu_2S is so proportioned that the reaction $2CuO + Cu_2S = 4Cu + SO_2$ takes place, producing copper bullion directly from the ore.

It is evident that by this process but small amounts of electricity are used and that it plays a rôle similar to that of small amounts of coke in pyritic smelting. By employing indirect methods of heating, fine ore or flotation concentrates can be smelted without dusting. A representative slag will contain, it is claimed, less than 0.1 per cent of copper and lead, and not more than half an ounce of silver with no gold. If proper precautions are taken the electrode consumption is not over 4 lb. per ton of ore treated. (1,333,720; March 16, 1920.)

Electric Furnace.—A patent covering the design of a revolvable electric furnace has been granted to WILLIAM K. BOOT. This furnace was described in CHEMICAL & METALLURGICAL ENGINEERING, vol. 21, p. 636, Nov. 12-19, 1919. (1,332,795; March 21, 1920; assigned to the Booth Electric Furnace Co., of Chicago, Ill.)

Recovery of Copper From Its Ores and Solutions.—H. LIVINGSTONE SULMAN and H. F. K. PICARD, of London, England, have been granted a patent on the above subject which is assigned to Minerals Separation, Ltd. One object of the invention is to precipitate copper from copper solutions obtained in metallurgical operations in an effective and economical manner, in the form of sulphide; a further object is to utilize this precipitation for improving the recovery of copper from its ores by the froth-flotation process of concentration as described, for example in U. S. Pats. 835,120, 962,678 and 1,064,723. The method consists in adding a precipitant containing ferrous and calcium sulphide to the copper-bearing solution and separating the copper

sulphide precipitated. The precipitant is produced by heating pyrites, or chalcopyrite, bornite, etc., with an equivalent of lime to a low red heat and cooling out of contact with air. (U. S. Pat. 1,178,191.) The effective use of this precipitant requires the presence of a definite quantity of sulphuric acid in the solution and a certain time factor for efficient use. Both the copper sulphide and any copper in the pulp will be floated. (1,333,688; March 16, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Cellulose Ester Solutions.—The viscosity of solutions of nitrocellulose, acetylcellulose, celluloid and other cellulose esters is permanently reduced by heating the solutions, meanwhile preventing the escape of solvent, to a temperature between 60 deg. C. and the temperature at which the ester in question is decomposed. The temperature and duration of the heat are correlated; the longer the heating and the higher the temperature the more is the viscosity reduced. (Br. Pat. 136,141—1919; O. CARLSSON and E. THALL, Stockholm, Feb. 4, 1920.)

Toluene Sulphochlorides. — Toluene-o-sulphochloride is separated from mixtures with its paraisomer containing 60 to 70 per cent of the ortho compound by seeding the liquid mixture at about —6 deg. C. with a crystal of the ortho compound and removing the crystalline ortho compound which separates out. The initial mixture may be obtained by treating toluene with chlorsulphonic acid and crystallizing out a portion of the para compound at —20 deg. C. (Br. Pat. 135,987—1919; F. E. MATTHEWS and E. H. STRANGE, London, Feb. 4, 1920.)

Lactose.—In obtaining lactose from whey, the albumen is precipitated by metaphosphoric acid. The whey is concentrated in vacuo to about one-fifth of its bulk and then heated to about 70 deg. C. A portion of the albumen is thus coagulated and is removed by skimming or decantation. The metaphosphoric acid is then added and the resulting precipitate removed by filtration or settling. The lactose is then obtained from the clear liquid by crystallization in the usual way. (Br. Pat. 135,614—1919; G. MARTIN, Manchester, Jan. 28, 1920). The albumen may also be precipitated by tannic acid, mercurous nitrate, phosphotungstic acid or magnesium sulphate. (135,969—1919. Feb. 4, 1920.)

Phenol Aldehyde Condensation Products.—In the production of insoluble condensation products from phenol or its homologues and formaldehyde or its polymers in the presence of an alkaline accelerator, from 6 to 20 per cent of a vegetable fatty oil (castor, linseed, rape, cottonseed, etc.), or camphor oil is added, either to the initial mixture or after the first stage of the reaction; the product is finally hardened. The product so obtained is flexible when hot. (Br. Pat. 136,298—1919; F. J. ROBINSON, Cowley, Middlesex, and DAMARD LACQUER CO., Westminster, Feb. 4, 1920.)

Purifying Mineral Oils.—In the purification of mineral oils by sulphuric acid and alkalis powdered anhydrous alkali carbonate is used, preferably with calcium chloride or other drying agent, to give a perfectly dry oil. In an example, acid-treated oil, washed with hot water if it is desired to recover the sulphonic and naphthenic acids, is decanted into a vat, heated to 58-70 deg. C. and agitated, while dry anhydrous sodium or potassium carbonate or ammonium carbonate or bicarbonate is strewn over the surface along with calcium chloride. The alkali sulphate, calcium chloride and excess of carbonate are allowed to settle and the oil then filtered. (Br. Pat. 136,169—1919; G. GRISARD, Basel, Switzerland, Feb. 4, 1920.)

Production of Ammonium Nitrate. — Ammonium nitrate is produced in the solid form by bringing together oxides of nitrogen, oxygen, water and ammonia under such conditions that the proportion of oxygen present is in excess of that required to convert the whole of the oxides of nitrogen into nitrogen dioxide, the proportion of ammonia is insufficient to react with the whole of the oxides or nitrogen, and the proportion of water is not in excess of, and is preferably equal to, that which is sufficient to convert the whole of the ammonia added into ammonium nitrate by interaction with the oxides of nitrogen and oxygen. In the case of gases containing about 10 per cent by volume of oxides of nitrogen, produced, for example, by the oxidation of ammonia, an amount of oxygen equivalent to three or four times that theoretically required to convert the whole of the oxides of nitrogen into nitrogen dioxide may be added. The oxygen may be added in the form of oxygen gas, air, or air enriched with oxygen, and the water should be in a finely divided state, for example as vapor or spray. (Br. Pat. 136,190—1919; J. R. PARTINGTON, of the Munitions Inventions Research Laboratory, University College, London, Feb. 4, 1920.)

Concentrating Ores. — The product obtained by treating a soluble soap or its ingredients such as sodium oleate with sulphur, or by treating a fatty acid with a soluble alkaline sulphide, or by adding a soluble soap to an aqueous solution of sulphuretted hydrogen, is used as the mineral-frothing agent in froth-flotation processes. The agent may be obtained by heating the soluble soap or fatty acid with the sulphur or sulphur-containing material, and may be used in processes of differential separation or in the concentration of sulphide or oxidized ores. In some cases acid may be added. (Br. Pat. 136,255—1919; S. TUCKER, E. EDSER and MINERALS SEPARATION, LTD., London, Feb. 4, 1920.)

Treating Ores. — Ores containing more than one sulphide are treated with a solution of a chloride (ferric chloride and manganese chloride being mentioned) which exercise a selective action leaving one or more sulphides, such as zinc sulphide undissolved, and dissolving other sulphides to form chlorides, such as lead, copper, silver and gold chlorides, with precipitation of sulphur. This precipitated sulphur may be separated from the undissolved matter by flotation, or may be left with the zinc sulphide, as it facilitates the roasting of this body and yields a gas richer in sulphur dioxide and suitable for the production of sulphuric acid. The metals contained in the solution may be separated in known manner; for instance, lead may be precipitated by iron, or electrolysis may be employed, or the chlorides may be crystallized. The ferrous chloride resulting from the process may be reconverted into ferric chloride by treatment with chlorine or with air in the presence of hydrochloric acid, or by evaporation to dryness and calcination, in which case ferric chloride sublimes, leaving a residue of ferric oxide. (Br. Pat. 136,163—1919; SOC. ANON. MINERAIS ET MÉTAUX, Paris, Feb. 4, 1920.)

Current Events

in the Chemical and Metallurgical Industries

Republican vs. Democrat on the Nitrate Program

FURTHER expenditure of funds by the War Department on the Muscle Shoals Nitrate Plant should be discontinued, in the opinion of the majority of members of the select committee of the House of Representatives, which has been investigating the matter. However, the minority is unable to agree on this point; in fact the committee is hardly able to agree among themselves on any point. For instance, the majority damns the Air Nitrates Corporation, while the minority as stoutly upholds the Air Nitrate Co.—presumably the same organization! Briefly, the majority condemns the nitrate program as a waste of effort directed by B. M. Baruch at the instigation of Washburn, Worthington, et al., who were to profit from it. They also contend that Chilean nitrate should have been relied upon to make up any deficiency from coke ovens; that the plants were improperly located, extravagantly built, following processes which would either not work or should be promoted by private enterprise. Opponents to the Government program were disciplined during the war, and now the Ordnance officers who directed the construction are held up for severe censure. Muscle Shools, if operated, should produce fertilizer nitrogen, yet the men in charge are held culpable for completing the work, acquiring operating power and a lime quarry. In general, it was a sad débâcle and should be abandoned immediately! Reverse all these ideas, and the reader has the minority view.

The committee agrees that Plants 3 and 4 should be salvaged, that the Alabama Power Co. took unfair advantage of the Government's need of power, and that the Wilson Dam will require $12,000,000 for completion.

As to the disposition of the Muscle Shoals plant, the minority holds that this is covered by a pending bill in Congress and declines to discuss the majority recommendation that it be leased under restrictions for private operation.

Program's Contribution to Victory

1. The majority finds that there has been expended for construction upon the Government's nitrate program to the present time the sum of $116,194,974.37, and that this expenditure produced no nitrates prior to the armistice, and contributed nothing toward the winning of the war.

The minority grants that no nitrates were produced at these plants prior to the armistice, but utterly disagrees with the statement that the expenditures contributed nothing to the winning of the war. If the expenditures for the war program are to be criticized, or their necessity or non-necessity judged because hostilities came to an end unexpectedly in November, 1918, then probably three-fourths of the nation's efforts were useless.

Activities of Baruch

2. According to the majority, the nitrates program originated with the War Industries Board of the Council of National Defense, and is directly traceable to Bernard M. Baruch, chairman of that board.

On the other hand, the Democratic view holds that the nitrate program grew out of the necessities determined by the Gun Division to be essential according to the number of divisions which the General Staff planned from time to time to put into the field. Mr. Baruch played a most important and highly praiseworthy part.

Was Nitrate Program a Misdirected Effort?

3, 4, and 5. The Republicans hold that had the labor and money required to construct the nitrate plants been utilized in producing food or other war essentials, real assistance would have been rendered in winning the war. In June, 1916, Congress appropriated $20,000,000 for the manufacture of nitrates, then the policy of neglect, delay and do-nothing was followed in that regard by the President and the War Department until the late fall of 1917. Had the War Department, early in 1916, purchased and stored in this country large quantities of Chilean nitrates as was advised by General Crozier to the Secretary of War, the only excuses for the building of Government nitrate plants in the late fall of 1917 would be lacking.

The minority charges inconsistency in these three allegations, which are said to be the fundamental principles of the majority report. In substance, paragraph 5 criticizes the President of the United States for not, while we were at peace, hastily embarking upon a war-supply program, which paragraph 4 declares was, when embarked upon after we had gone into the war, "one of misdirected effort," and for which paragraph 6 declares there "was no national necessity at any time." Chilean nitrates could not be purchased on account of lack of funds, and its storage would have embarrassed the explosives program of England and France. The majority omits to state that at the very same time, in 1915 in fact, General Crozier was investigating the subject of nitrogen fixation and recommended the development by the Government of such processes along with the purchase of Chilean nitrates.

Possible Reliance on Chilean Nitrate

7, 8, and 9. These findings contain allegations by the majority that submarine menace and probable high price were not valid reasons for abandoning reliance on Chilean nitrate which, barring coke-oven nitrogen, comprised our entire supply and was able to build up a reserve of 600,000 tons despite our war requirements.

The minority contends that the submarine was a real danger to our supply, and cites the following additional reasons for an internal supply: (*a*) Shortage of ships. (*b*) Need of ammonia as distinguished from sodium nitrate. (*c*) Large but unknown naval requirements. (*d*) Requirements of Allies. (*e*) The propellent requirements as distinguished from explosives. These consisted largely of smokeless powder, for the production of which immense quantities of nitrogen must be had. (*f*) Cumulative demand for nitrogenous fertilizer. As a matter of fact the 600,000 tons was less than two months' supply at the then rate of manufacture.

10. The whole committee reaches approximate agreement that as a result the United States has the following nitrate plants finished or partially finished:

(*a*) Experimental Nitrate Plant No. 1, at Sheffield, Ala., constructed for the manufacture of nitrates by the General Chemical Co. process, at a cost of $12,152,636.91, which plant is supposed to be completed. As pointed out in the minority report, the nitrate feature of Plant No. 1 at Sheffield constituted but one of its units, and it is the only unsuccessful part. This unit was to produce ammonia. It cost $5,502,170.13, including its proportion of overhead expense.

(*b*) Plant No. 3, partially constructed plant at Toledo, Ohio, which cost $7,781,609.06.

(*c*) Plant No. 4, near Cincinnati, Ohio, partially constructed, at a cost of $7,578,229.84.

(*d*) Plant No. 2, at Muscle Shoals, Ala., completely constructed for the manufacture of nitrates by the cyanamide process, at a cost of $69,985,221.42.

(*e*) In addition to the foregoing, the Government has made an expenditure of $5,167,277.42 upon the property of the Alabama Power Co.

(*f*) A quarry site in northern Alabama which cost $60,000.

(*g*) An unfinished dam on the Tennessee River at Muscle

Shoals, Ala., for which there has been allocated $13,170,000, and which, to complete, will require approximately an additional $12,000,000, but according to Democratic view, the dam has only the remotest connection with the nitrates program.

Location of Plants

11. Blaming the President for ill-advised choice in location of the plants, and particularly for ordering the Wilson Dam at a time when he must have known it could not be completed with the funds available for that purpose, and that it could not be completed in time to be of service during the war, the majority view, is countered by the minority's statement that the President and the Secretary of War, either together or singly, may safely assume this responsibility without apology and without it adding to their burdens. They also call attention to the fact that the Wilson Dam was not a war project, in the sense that it had any bearing upon or connection with the war with Germany.

Opponents to Program Disciplined

12. In the words of the minority, the majority's assertion that anyone who opposed or sought to modify the plans of the President and Secretary of War for the development of Muscle Shoals was either disregarded or disciplined is wholly gratuitous. Colonel Hugh Cooper's recommendations as to the Muscle Shoals dam were largely carried out, and a transfer to be Base Engineer at Bordeaux could hardly be regarded as a demotion. No hint was heard that Dr. Charles L. Parsons was disciplined for his opposition to the location of Plant No. 2. His advice upon matters was freely given before and after that time, sometimes acted upon and sometimes not.

It was partly upon Dr. Parsons' recommendation that the Experimental Plant No. 1 (General Chemical Co.'s process) was established, the plant which failed to function. He is a believer in the future great possibilities of the pressure process in competition with other processes and is, as he frankly told the committee, personally interested now in a business way in its development. He was not so interested at the time of his recommendation. We do not deem it any reflection upon Dr. Parsons that the Experimental Plant No. 1 has not yet in its ammonia unit been successfully operated. He had data sufficient to justify the recommendation and the authorities were justified in following it.

Blundering Trial of Haber Process

13. The majority refers to the expenses incurred at Plant No. 1 (modified Haber process) as a colossal blunder and waste of public funds. While the minority admits that too expensive construction was provided, especially in living quarters, they feel that a venture with a process which gave Germany one-third her nitrates during the war was well advised. The General Chemical Co. had carried on laboratory experiments which had been sufficiently satisfactory as to cause it to determine to go into the business commercially, and it was preparing to expend an immense sum of money in the construction of a plant, and had expended about $500,000 assembling materials when the Government became interested. The enterprise was undertaken, admittedly as an experiment, upon the recommendation of eminent scientists, including Dr. Charles L. Parsons, of the Bureau of Mines, who had made exhaustive studies of the various methods in use in the European countries for nitrogen fixation.

Influence of Washburn and Worthington

14, 15, and 16. The minority declares to be wholly misleading the majority's finding that the building of Plant No. 2 at Muscle Shoals was the deciding factor inducing the building of the Wilson Dam—a culmination of years of effort and striving of Washburn, Worthington and others to induce the National Government to dam the Tennessee River for the production of hydro-electric power at Muscle Shoals, a hydro-electric development redounding to the profit of various interests of these two men.

Colonel Joyes Upheld by Minority

17 and 18. The two contracts made by the War Department with the Air Nitrates Corporation, the first being dated Nov. 16, 1917, and the second June 8, 1918, are unilateral and unfair and unjust to the Government. The Ordnance officers, charged with responsibility, failed in most instances to guard the interests of the United States in the contracts for the construction of the nitrate plants. In particular, Colonel J. W. Joyes deserves severe censure for signing the second contract, for purchasing chemical equipment for twice its market value, and his zeal in carrying out the agreed program after the armistice had been signed.

On the other hand, the minority states that it is not correct that the Ordnance officers charged with responsibility failed in most instances to guard the interests of the United States in the contracts for the construction of the nitrate plant and they repudiate emphatically the assertion that Colonel J. W. Joyes merits censure. This faithful officer of the Regular Army, denied the opportunity of serving on the battle line because he was needed here, has rendered to his country, in a position of gravest responsibility behind the lines, a service which entitles him to the praise and honor of his countrymen. Working under the most extreme difficulties, having upon him a very large degree of responsibility for furnishing the munitions upon which success depended, he has acted upon principles of the highest integrity and with commendable prudence. He was not satisfied with the terms of all the contracts which he was compelled by circumstances to enter into. It was a matter of bargaining for things which the Government absolutely had to have and which those with whom he was dealing knew it had to have. That he succeeded, as the record shows he did, in again and again securing modifications of proposals, every such modification being in the interest of the Government, at a time when the cry from everywhere was "speed" and "still more speed," and those with whom he was dealing knew it and knew that they held practically both ends of the string, does greatest credit to his industry, his powers of persuasion, and his patriotism.

Misuse of Appropriations

20. In the opinion of the majority, the funds used to construct Nitrate Plants 2, 3 and 4 were taken from the said "Armament of fortifications (C)" fund, not contemplated by Congress to be used for such purposes.

The minority appear surprised at this statement and understand the assertion to be merely the opinion as to the ignorance of Congress. The terminology "Armament of fortifications (C)," which has been carried in the fortification appropriation bills for long years, they thought had been thoroughly understood by members of Congress, at least. It is the item from which funds have been all along derived by Ordnance for its needed munitions and all the processes essential to obtain them, except a certain amount carried in the fortifications bill under the terminology, "Practice and field artillery ammunition."

Collusion at Muscle Shoals

21. It is obvious to the majority that the War Department forced the completion of this work after necessity had vanished. When hostilities had ceased, an uncompleted steam power plant costing $10,000,000 was rushed to completion; the Waco quarry has been acquired and $60,000 has been expended for land for the same; a modern electric plant, industrial village, transmission lines, and railroads have been completed for the Alabama Power Co. at a cost of over $5,000,000, while work on the Wilson Dam, which had been suspended by the Priorities Board, when it was known an armistice would be signed, on Nov. 9, 1918, was ordered recommenced and rushed.

In the minority view it appeared natural that the War Department was intensely interested in having this magnificent plant 100 per cent complete, because it is without a doubt the nation's greatest material military asset. The manufacturing part of this plant, having a capacity of 110,000 tons per annum of ammonium nitrate, was completed to the point where it was ready to be put into successful operation. The steam-power plant had reached a stage of completion that made it wise business economy to finish it, rather than to leave it standing as a useless ruin; practically all of the machinery had been ordered and commitments were outstanding. As to the other matters, the Government carried out its pre-existing contracts. As for the dam, let it be clearly understood that the President of the United States directed this dam to be built in accordance with the duty imposed upon him by the national defense act of 1916. That dam is for peace uses as well as war uses. It is expressly so stated in the law itself and was so interpreted in practically every argument made upon it in the House and Senate by friend or foe while the legislation was being considered. The hydro-electric power to be there created is to be used by the very terms of the law itself for the making of fertilizer in times of peace and munitions in times of war.

Location of Plants Nos. 3 and 4

22 and 23. The majority holds that the location of Plant No. 3, at Toledo, Ohio, was entirely unsuitable for such a plant, it being surrounded by water and otherwise largely inaccessible. The site selected for Nitrate Plant No. 4, in the Little Miami Valley, near Cincinnati, Ohio, was equally unsuitable, in a locality where construction was costly, labor hard to accommodate, and with high prospective expense for transportation of raw materials. It seems that

they were located in Ohio because a Congressman needed to distribute a certain amount of pork.

However, the minority again finds itself unable to agree with the majority. After some remarks about 1861, it states, so far as the record is concerned, the controlling element in locating Plant 3 at Toledo and Plant 4 at Cincinnati was the fact that there was available at these two cities, and could be secured from facilities already in existence, large blocks of power not elsewhere procurable and absolutely indispensable, a question of very great importance in the war activities.

In justice to the Ohio Member of Congress who has criticized the construction of Plant No. 2, it should be said that his criticism was not leveled at the place—Muscle Shoals—but at the construction of a plant for nitrogen fixation by the cyanamide method anywhere, he, like Dr. Parsons, being a believer in the Haber plan or in one of its modifications.

Was Construction Wasteful and Poorly Executed?

24, 25 and 26. The cost-plus system adopted by the Ordnance Department is, in the majority's view, unduly expensive and demoralized the country's labor. Waste of labor and material was rampant which under ordinary circumstances would approach criminality. Particularly the Air Nitrates Corporation was extremely faulty and inefficient in organization and experience.

In view of the necessity of haste, the impossibility of preparing final and complete plans, and the general instability of materials and labor markets, the minority contend that the cost-plus system was the only practicable method of construction. Some leading contracting firms, whose integrity is above all suspicion, use it almost exclusively, and have for years. The sworn testimony of responsible officials of the Air Nitrates Corporation is to the effect that the costs of labor and materials upon the whole job were in the ratio of 34 per cent to 66 per cent—that is, 34 per cent of the total cost was for labor and 66 per cent for material. It is understood that the usual proportion is 40 per cent to 60 per cent. It is further testified to that there has been an inventory taken with the most painstaking care of every item in every structure and this checked with the invoices paid, with the result that there is shown a deficiency or loss of material of 1.61 per cent.

Air Nitrates Entered Into a Trust Relationship

27. Both parties agree to this item, the minority, however, disclaiming the inference that the principle has been violated. By the contracts between the Air Nitrates Corporation and the United States the Air Nitrates Corporation became the agent of the United States, and hence the relation between that company and the Government was of a fiduciary character, a trust relation which required the utmost good faith and reasonable diligence in protecting the interests of the Government from the destruction and waste of its property by its employees and subcontractors. Complete settlement has not been made with the Air Nitrates Corporation by the Government on account of these contracts.

Shall the Government Operate Muscle Shoals?

28 to 37. The majority believes that it is for the best interests of the country and for the public welfare that there be built up in the United States a nitrate industry by private initiative and capital, capable of supplying the wants of our people for fertilizers in times of peace and explosives in times of war. If a governmental agency should engage in the commercial manufacture of nitrogen compounds for sale, it would discourage and retard this development. Consequently it would be unwise for it to build and operate a plant in conjunction with Nitrate Plant No. 2, at Muscle Shoals, for the manufacture of ammonium sulphate and other nitrogenous compounds for commercial purposes. Furthermore, the disposition of such byproducts as lime and crushed rock would destroy private business in these lines within a radius of 200 miles. However, if Muscle Shoals plant should be operated at a low cost and produce annually 86,000 tons of ammonium sulphate, such amount would be so inconsiderable, in comparison with the total amount required in the United States for all purposes as to make little or no appreciable reduction in the price of agricultural fertilizers. Still, even this amount would not be salable since the quantity produced by the byproduct coke ovens is largely in excess of any amount of ammonium sulphate ever used heretofore in the United States for agricultural purposes. There are 11,000 of these ovens now in operation, 1,500 of which were constructed by Government funds, and the majority is loath to prevent further conservation of natural resources by the supplanting of beehive by retort ovens by appearing to compete with them for the ammonia market. Notwithstanding the fact that the majority calls a governmental experiment in the Haber process a blunder, it understands that private enterprise is now formulating plans for the commercial manufacture of fixed atmospheric nitrogen by the Haber process. They admit for their present argument that it is generally known that the Haber process is much more economical and efficient in operation than the process now used at the Muscle Shoals plant, and that every reasonable encouragement should be given private enterprise. Private enterprise would hesitate and in all probability cease its intention of entering into a business in which any agency of the Government was to compete with products from a plant or possibly a chain of future plants built by Government funds and maintained by the National Treasury and not subject to limitations of the national defense act. On account of the character of Nitrate Plant No. 2 at Muscle Shoals, if it was salvaged the Government would hardly be recompensed for the expense of salvaging it. Three feasible plans for the future of this plant are presented: First, that the plant be kept in a standby condition; second, that it be leased to and operated by private enterprise, with such reservations in the lease as shall reserve to the Government the right to use it in the event of war with reasonable reservations as to price regulation by the Government, and with the further reservation that the product be offered in the general market so that it can be purchased direct by the consumer, including the farmers of the United States, and the majority finds that such a lease can be made; third, that it be operated by the Government.

All these questions the minority dodges on the basis that it is an adverse report upon a legislative proposal now pending, not before the select committee but before the Committee on Military Affairs of the House, to wit, a proposition to install at Nitrate Plant No. 2 the necessary equipment to extend a portion of its units so that ammonia sulphate, which is a desirable form of ammonia for fertilizer purposes, can be produced, and to organize a Government-owned corporation to operate it and sell this product into commerce.

Abandonment of Plants 3 and 4

38. Here the committee seems to be as a unit that these plants should be salvaged as soon as possible, and proper settlements made of all claimants without protracted delay.

Equipment of Waco Quarry

39. The minority, on the same grounds as cited in 28-37 above, declines to discuss the recommendation that it would be unwise for the War Department to attempt to develop the so-called Waco quarry, and that no further expenditures should be made until some policy as to the future of the Muscle Shoals plant shall have been adopted by Congress.

Contract With Alabama Power Co.

40. An expenditure of over $5,000,000 for development of the property of Alabama Power Co., in the opinion of the majority, was unjustifiable and unnecessary, and the same results might have been accomplished by a loan of less than half this amount. The result of this expenditure has been to build up the property of a private corporation and establish it as a power monopoly in northwestern Alabama.

This contract is not upheld by the minority. So far as the record goes the Alabama Power Co. does not stand in a favorable light therein. The conclusion cannot be escaped in the light of testimony that at some stages of the proceeding the company appeared to have imposed upon the Government's necessities and unduly forced increases in certain of its facilities. The contract with this company and various things done in its execution were not satisfactory to the contracting officer in all their phases. It was simply a case where he did the best he could. The pressure was insistent, growing out of public necessity for getting the plant into operation, to begin producing explosive material for the expected 1919 military campaign. The steam power plant could not be gotten ready in time to coincide with the manufacturing part of the enterprise, nor could the dam at Muscle Shoals. At the time the first proposition of this company was submitted to Colonel Joyes, suggesting a Government loan to it of $2,250,000, there was no authority of law to make loans to private industry. The statement is incorrect, that the same results "could have been attained by a Government loan of half the amount."

Wilson Dam Requires 12 Millions More

41. The whole committee finds that the Muscle Shoals Dam, without the building of at least two other dams, will not improve the navigability of the Tennessee River. That to complete the Muscle Shoals Dam will require an additional appropriation of approximately $12,000,000.

The bulk of the majority's report thus appears to be a criticism of the nitrate program, a plan of action formulated under great stress of urgency and in the face of almost complete technical ignorance. Its greatest defect in their eyes was enough to spoil its every deatil, and that defect was primarily due to the fact that the war ended too soon! Yet they are as unable to recommend a constructive future policy as they are of finding good in whole-hearted effort. Granted that we had no commercial plants for the production of synthetic nitrates before the war, and that that lack then cost time and money, by all means let us now throw away the chances we have of systematically acquiring this knowledge.

Divergent Recommendations of the Committee

Majority Recommendations

1. The committee recommends that no further sums of money be paid the Air Nitrates Corporation or its subcontractors on account of its various contracts for the building of Nitrate Plants Nos. 2, 3, and 4 at this time, but that all sums claimed to be due and owing by the Government be retained; that civil suits be instituted against the Air Nitrates Corporation by the United States to recover such sums as shall reasonably compensate the United States for the failure of the Air Nitrates Corporation to perform its said contracts, or that the said Air Nitrates Corporation be compelled to sue for recovery in the Court of Claims, or other proper forum, where the Government may, by set-off, counterclaim, or recoupment, litigate the matters herein mentioned, or that the United States pursue such remedies concurrently, as may be decided by the Attorney-General of the United States.

2. The committee recommends that the materials stored by the Government in Nitrate Plants Nos. 3 and 4 be at once removed to other storehouses of the Government, that said plants be, as soon as possible, salvaged and sold to the best advantage, and that all landowners who have not been paid for lands purchased, taken, or damaged for said plants be compensated for the same.

3. That Nitrate Plant No. 1 be kept in a standby condition for the present with a sufficient force to guard and maintain the same, subject to such experimental use thereof, from time to time, as is necessary in developing nitrate processes or perfecting the said plant. That 1,200 acres of land not now used in said plant be sold at its fair market price; that the houses built in connection with said plant, where the same are not used to house officials or employees of the United States, be leased at fair rentals, notwithstanding the opposition of the Sheffield Chamber of Commerce or any other body.

4. Your committee recommends that Nitrate Plant No. 2 be leased by the War Department on such terms as will secure its continuance as a plant capable of producing fixed atmospheric nitrogen, and with reservations permitting the use of the same by the Government in time of war or threatened war, reserving to the Government a reasonable regulation of prices, and providing for the sale of the product on the general market direct to the consumer, including farmers in the United States, and that if this cannot be done, that the plant be kept in a standby condition until Congress shall determine upon a policy as to the future of said plant.

5. That no further funds should be expended by the War Department on the Muscle Shoals plant, and no further appropriations for alterations, changes, or additions to said plant should be made by Congress for the use of the War Department or any agency of the Government acting under or through said War Department, until some policy as to the future of said plant shall be determined upon by Congress.

Minority Recommendations

1. Not having any exact knowledge from the testimony adduced of the status of the settlements or negotiations looking to a settlement of the contracts with the Air Nitrate Co., having no definite information of the claims and counterclaims of the parties thereto, we do not feel ourselves to be in any position to offer any intelligent advice as to their settlement or as to the procedure that should be followed by the War Department or the Department of Justice. We are content to leave this executive matter to the executive departments whose duty it is to attend thereto, and direct our attention to the performance of our own duties in the legislative branch. Should occasion arise for the exercise of the constitutional powers and duties of the legislative branch, we shall try to inform ourselves and aid in the way that may seem to us to be the proper exercise of those functions.

2. There is nothing in the record nor have we any information from any extraneous source, upon which we are able to predicate any advice as to the removal of the materials now in storage in the buildings at Plants 3 and 4. Whether the Government has other storage facilities that can be economically utilized, we have no idea, nor have we any information whatever as to the costs that would accrue for freight, handling and other necessary activities incident to removal. We see no necessity for any recommendation as to an action concerning the matter, particularly since we have no information of the various elements involved.

We have heretofore concurred in a measure with finding 38, touching the matter of salvage and sale of plants 3 and 4, and have stated our belief that any legal obligations of the Government relative to the lands and landed rights acquired by it, if any are still outstanding, should be liquidated and paid. We have no reason to assume that this will not be done or that any recommendation is necessary or within the duty of the legislative branch of the Government. Whatever of appropriation may be necessary for the discharge of the Government's obligations will, we assume, be properly brought before the House by the Appropriations Committee.

3. There is no objection upon our part to the opinion implied in recommendation No. 4 as to what should be done with Plant No. 1, nor with the lands and houses, so far as we are informed of the facts. The 1,200 acres of surplus land, much of which was secured in contemplation of the erection of a powder plant, appears to be fairly good land for farming purpose and, so far as we know, the Government has no present need for it. These lands were acquired at a very reasonable price, some of them being donated outright. What the market conditions are now we do not know. Good business judgment should be used in disposing of them, as it doubtless will be.

We see no very serious objection to the renting temporarily and until other disposition can be made of the houses built in connection with the plant not in use by officials and employees. Just how Uncle Sam may get along as a landlord we do not know, but he is a very versatile gentleman, capable of doing many things and doing them well.

We have no sympathy with the implied criticism of the Sheffield Chamber of Commerce for opposing this, if they do in fact oppose it, which we do not know as a fact, though we believe there was some intimation to that effect somewhere in the hearings or stated privately to the committee. Those at Sheffield who have properties for rent probably fear Government competition with non-taxable real estate upon which the people carry the insurance and are probably in the same mental attitude toward it as are the private producers, present and prospective, of fixed nitrogen toward the operation by the Government of Nitrate Plant No. 2, for the production of commercial fertilizer.

We see no occasion for any recommendation.

4 and 5. Recommendations 4 and 5 involve directly the legislative question discussed in the findings 28 to 37, inclusive, and 39, with regard to the future use of Nitrate Plant No. 2, and for the reasons there stated, the minority deem it improper to here discuss them.

Research Council, Chemical Division, Annual Meeting

The annual meeting of the Chemical Division of the National Research Council was held in Washington May 7 and 8. The first order of business was the election of officers and members for the ensuing term. The results of the elections were as follows: Chairman of the Division, F. G. Cottrell, of the Bureau of Mines; vice-chairman, Julius Stieglitz, of the University of Chicago; members of the executive committee, C. L. Alsberg, Bureau of Chemistry; A. B. Lamb, Harvard University; John Johnston, Yale University; W. D. Bancroft, Cornell University. The other members of the Division are: C. G. Derick, National Aniline & Chemical Co.; J. M. Francis, Parke, Davis & Co.; E. C. Franklin, Stanford University; Colin G. Fink, Chile Exploration Co.; A. V. Bleininger, Washington, D. C.; Charles H. Herty, New York; W. F. Hillebrand, Bureau of Standards; G. A. Hulett, Princeton University; Hugh K. Moore, Berlin, N. H.; Arthur A. Noyes, California Institute of Technology; Charles L. Parsons, Washington, D. C., and J. E. Teeple, New York.

Charles L. Parsons was appointed a delegate to represent the National Research Council at the meeting of the International Chemical Union to be held at Rome, Italy, in the last week of June.

Reports of Committees

A very comprehensive report on the activities of the committee on explosives was presented by Charles E. Munroe. Among the important problems investigated were: Corrosion of Rifle Bearings; Products of Combustion of TNT; Desensitizing of Explosives for Storage; Hexanitrodiphenylamine; Use of TNT in Blasting. Furthermore, considerable time has been spent on the index to the literature of explosives which will soon be completed.

The report of the committee on synthetic drugs was presented by Prof. Stieglitz. It was pointed out that a number of important synthetic drugs had been placed on the market during the course of the year. Dr. H. N. Holmes told of the activities of the committee on colloids. The outstanding feature in this report was the remarkably efficient method the committee resorted to in educating students and the public in general to the vast importance of colloid chemistry. Lectures, both scientific and popular, had been delivered in most of the large towns of the country before enthusiastic audiences. Nearly every chemical industry in the country is confronted with colloid problems, for example, the rubber industry, dyes and dyeing industries, ceramic, glass, oil, pharmaceutical products, yeasts, etc.

Progress in Various Fields

Dr. Bleininger reported upon the researches in ceramics. There are many basic problems still waiting for a satisfactory solution. For example, there is the problem of finding a suitable refractory for glass pots which will not be readily corroded by the molten glass. A fellowship was established recently at the University of Illinois; the research will be confined largely to the "Viscosity and Electrical Conductivities of Glasses."

Dr. Derick discussed the progress made in the methods of analytical organic chemistry. The importance of the introduction of physicochemical apparatus into organic laboratories was particularly emphasized. Dr. Bancroft reported upon the progress made on research in contact catalysis. Important investigations are being carried out at seven of our large university research laboratories. Hugh K. Moore submitted a detailed account on the activities of the committee on the international tables of constants. The revision of our patent laws was discussed by Messrs. Cottrell and Francis.

Problems Awaiting Solution

Dr. Bancroft, after summing up the work of the Division during the past year, presented to the members a most remarkable collection of problems of far-reaching importance that are patiently awaiting solution. To those who have had difficulties in finding suitable problems for research, it will be a startling revelation to look over the list prepared by Dr. Bancroft. There are significant lines of chemical research to be found in every industry and profession of the country. The most promising field of research appears to be the borderland. Let the chemist co-operate with the geologist in studying the origin and formation of petroleum, or why some clays are plastic and others are not. Let the chemist work hand in hand with the biologist in investigating nutrition problems. There are many vital problems of mutual interest to both physicist and chemist; there are others on the borderland of chemistry and medicine. "And why should the chemist develop the borderlands? It is because the chemist has had the best all-around training."

Public Utility Power Efficiency

The monthly reports of the U. S. Geological Survey show a very interesting relationship between the power production and the efficiency with which the fuels are used in the various public utility central stations throughout the country. The following tabulation shows the total power output and the efficiency expressed in kilowatts per ton of coal used, for each of the seven months for which reports have been made. Some of the variation is undoubtedly due to seasonal factors, but the principal factor is probably the greater percentage load factor during recent months as compared with the period about a year ago. These figures, of course, cannot be taken as absolute in their significance, but are a good indication of the general practice.

Month.	Millions of kw.-hr.	Efficiency. Kw.-hr. per ton of coal
February, 1919	1,834	586
March, 1919	1,842	580
April, 1919	1,718	594
July, 1919	1,929	636
October, 1919	2,240	645
January, 1920	2,575	643
February, 1920	2,327	632

Another interesting point shown by the figures is the relatively greater average efficiency of central stations in states where most of the power is generated at large plants. For example, in Pennsylvania, Illinois, Ohio and other states where large cities predominate, the efficiency is about 600 kw.-hr. per ton of coal or even higher, being nearly 800 in the case of New York and Michigan. On the other hand, in more sparsely settled states, such as North Dakota and Montana, the average is only 150 to 200 kw.-hr. per ton. This is a striking illustration of the large advantage which the proposed super-power plants, if installed, will have in substituting for existing central stations. When it is seen that the average for whole states is five times that for other states, one can readily believe that the estimated saving of 50 per cent of the coal now used in all central stations would be feasible if all were replaced by a super-power system.

Proposed Fertilizer Regulation

Gilbert N. Haugen of Iowa, chairman of the House of Representatives Committee on Agriculture, has proposed a bill entitled "United States fertilizer act" for fixing the standard, labeling, and marketing fertilizer.

In this act the term "fertilizer" is defined as "Any substance, including any combination or mixture, designed and fit for use in inducing increased crop yields when applied to the soil," but does not include animal manure in its natural or unmanipulated state.

In it the Secretary of Agriculture is empowered to establish standards for grades of fertilizers by which its quality and condition may be determined.

Invoices and container labels are to be marked with:

Name and address of manufacturer.
Net weight in pounds.
Per cent by weight of available N_2, P_2O_5 and K_2O.
Name of each ingredient carrying available N_2, P_2O_5 and K_2O, and the proportion of each such ingredient if more than one be included.
Percentage weight, and kind of each ingredient having fertilizer value other than ingredients containing available N_2, P_2O_5 and K_2O.
Grade of fertilizer compared to U. S. standard.
Other facts to prevent frauds.

After defining the matters of standards, labeling, information regarding bulk shipments, etc., the act proceeds to define the terms "misbranding," "adulteration," etc. Authority is given to the Department representatives to enter and inspect any factory or storehouse and to investigate any books or records of the fertilizer industry. The companies are also required to preserve full and accurate records and to answer any inquiry that duly accredited representatives of the Department may submit. It is also provided that the information secured through the operation of these inspectors, with the exception of "secret processes or formulas," shall be available for the use of either house of Congress at its request, and the Secretary of Agriculture is given authority to cause such information to be published from time to time.

Judging from the difficulty encountered by the Government in fixing standards on grain and enforcing other such laws, serious apprehension exists on the fixing of standards on fertilizer. Moreover, the multiplicity of different brands (208 being listed in a single state report, all having the composition of 10 per cent phosphoric acid, 2 per cent ammonia and 2 per cent potash) and the fact that they are taxable have led to a system of registration and inspection fees imposed on the industry by different states whereby the states derive a considerable revenue. In fact, many of the state colleges and agricultural schools which now are either entirely or partially supported from this income would be seriously crippled were this revenue cut off.

Uniformity of requirements and labeling would protect the consumer against fraud and assure him a product of known standard strength. It would also tend to decrease the needlessly large number of brands, in which there is not enough difference in composition to affect plant growth seriously. Manufacturers of fertilizers who now have difficulty in doing an interstate business, because of complexity of regulations, would also be enabled to carry on their trade with greater ease.

On the other hand, the passage of this bill would mean a heavy financial loss to those institutions which derive a considerable income from taxes on fertilizers as now sold, until many state laws could be properly amended.

National Fire Protection Association Meeting

At the twenty-fourth annual meeting of the National Fire Protection Association held in Chicago May 4 to 6, 1920, the committee on hazardous chemicals and explosives presented a report covering regulations for the storage, handling and use of pyroxylin plastics in factories making articles therefrom. The report covered these substances, whether used in the form of raw materials, stock in the process of manufacture, unfinished or finished products or scraps, and the use and storage of nitro-cellulose film.

The term pyroxylin plastics was held to mean and include any plastic substance, material or compound having soluble cotton or similar nitro-cellulose as a base, and thus includes celluloid, fiberloid, pyralin, viscoloid and similar products, whether in the form of blocks, slabs, sheets, tubes or fabricated shapes, as well as lacquers, enamels, paints, thinners, cement and dope. Copy of the full report can be secured from the secretary-treasurer, F. H. Wentworth, 87 Milk St., Boston, Mass. The committee on gases also presented a tentative report for the regulation of refrigerating machines and refrigerants, and tentative regulations for the installation and operation of acetylene compressive plants.

New Amendment to Dye Bill Would Provide an Automatic Tariff

Senator Moses has offered an amendment to the dye bill which eliminates the embargo system and provides for an automatic tariff which is to be the difference between the price of a foreign article and the price of a similar article made domestically plus 20 per cent. He cites examples as follows: If foreign dye cost $2 per lb. to import and the fair selling price of a similar dye made domestically is $4, the tariff would be $2 plus 20 per cent of the home market value, or 80c., bringing the price of the imported article up to $4.80. If the price of the imported article were 15c. per lb. and the price of the home article $4, the tariff would be $3.85 plus 20 per cent. Senator Moses says that his proposal "is automatic and elastic and adjusts itself to every price and at all times places the price of a foreign dye 20 per cent above the price of a similar domestic dye."

The bill also provides that no person can bring in more than enough dyes at one time to suffice him for the current year. It contains a provision for ascertaining prices within the United States, the same as prices now are ascertained in foreign countries. This, Senator Moses thinks, would give absolute protection to the dye industry without embarrassing the textile industries with licenses, permits and embargoes.

Chemists' Club Elects Officers

At the annual meeting of the Chemists' Club held May 5, the following officers were re-elected:

President, Ellwood Hendrick; vice-president, resident, William F. Hoffmann; vice-president, non-resident, V. G. Bloede; secretary, J. R. M. Klotz; treasurer, Henry M. Toch; F. J. Metzger and T. R. Duggan, trustees.

Edgar F. Smith of Philadelphia, William H. Nichols of New York, John Uri Lloyd of Cincinnati, Edward Weston of Newark, H. le Chatelier of France, Ernest Solvay of Belgium, Giacimo Cimician of Italy and T. E. Thorpe of England were elected honorary members.

Lignite Carbonization Research Plant

After some months of investigation and negotiation, the United States Bureau of Mines has completed arrangements for a co-operative plan to carbonize lignite and develop the necessary information that it is hoped will "make possible a favorable technical and business report which shall stimulate duplication of such plants throughout lignite areas."

To this end a co-operative agreement has been made between the Bureau of Mines and John B. Adams and Fred Bremier, under which an appropriation of $100,000 and an additional $200,000 which is to be furnished by these individuals will be used for the construction of the plant required, and as a working capital for its operation. The plant will be installed at New Salem, N. D., on the site owned by the Consolidated Lignite Collieries Co., a subsidiary of which is to be organized by the two men who are contracting with the Government.

The plant contemplated will consist of a battery of ovens of new form which have been designed by the engineers of the Bureau of Mines, under the direction of O. P. Hood, chief mechanical engineer. This battery will, it is estimated, coke at least 100 tons of raw lignite per day and provide for complete recovery of the liquid and gaseous byproducts as well as for the handling of the char, from which it is planned to produce briquets. The briquetting plant will also be of special design, and it is to be an integral part of the plant, so that the char will be handled direct from the battery to the briquetting machine hoppers.

The substance of the agreement under which this work will be done is as follows:

Substance of the Agreement

It is proposed that the Bureau of Mines plan, erect and operate for a period a plant to carbonize brown lignite, briquet the solid residue, utilize the gas, recover tar and oils, measure and investigate all quantities, report on the process, including costs, selling prices and profits.

The plant would require three types of equipment:

1. Standard parts such as rail connections, coal-handling machinery, bins, driers, screens, briquetting equipment, etc., all of which can be purchased on the market from more than one source.

2. Special equipment more or less new in principle and development, part of which has resulted from the work of S. M. Darling.

3. Measuring, sampling and testing devices not usually necessary in a standardized commercial undertaking, but necessary in directing a new process and investigating performance.

It is proposed that the Bureau supply complete plans for the plant, have oversight over the construction and operation, and furnish items classified under 2 and 3.

It is proposed that the co-operating company approve the plans of construction, furnish items under classification 1, furnish all lignite and other raw materials, supplies and operating labor, market all products and conduct the business, leaving the Bureau funds for general oversight, investigation, control of the technical processes and the preparation of a report.

When the investigation fund is exhausted and the fixed structures sold, the co-operative company shall bid an amount equal to the replacement value, less reasonable depreciation.

American Zinc Institute Meeting

The second annual meeting of the American Zinc Institute was held at the Congress Hotel, Chicago, May 10 and 11. A large percentage of the 200 members attended, the tri-state, or Joplin district, being particularly well represented.

During the technical sessions George C. Stone delivered a paper on the differences in European and American zinc smelting practices. He noted that the American industry consumes ore from its own mines, while 80 per cent of that smelted in Europe is imported from Australia and north Africa. It is shipped in cargo with wool at a price which in normal times compares with freight rates on ores in the United States.

This importation permits a wide variety of selection of ores and the producer therefore designs his smelting plant with a certain shaped retort, to work at certain temperatures, with a specific grade of ore in view, and then purchases the ore to fit the furnace. In the American practice one general type of furnace is employed and used for the refining of any type of ore. This does not make for such economies as are enjoyed by the European concerns.

In Europe the fuel economy is very high due to the use of regenerative furnaces of both the recuperative and reversing type. From eight-tenths to one ton of coal is consumed per ton of ore in the European furnaces, while in America, where very few regenerative furnaces are in operation, from two to four tons of fuel per ton of ore is consumed.

The European concerns also exercise more care in the manufacture of their refractory materials in the retort, this being a direct result of the higher development of the ceramic industry among metallurgical producers.

The finished products of the European furnaces analyze much more consistently in impurities than is the case in the irregular American practice. The overall recovery in Europe is 84 per cent of the zinc contained in the ore, while in the United States it averages below 81 per cent. Should American firms adopt European practice, about 20,000 tons of ore would be saved per annum and several hundred thousand tons of coal. On the other hand, the American companies have more mechanical labor-saving devices than are used in Europe.

The discussion on this paper brought out the fact that most zinc producers are not familiar with the practice of mixing ores to get the maximum recovery of metal and the minimum slagging of retorts. Albert M. Plumb urged the further study of American ore mixtures from the point of view of iron, lime and silica content as it affects retort consumption. There are few ores in the United States that are not basic, and the recovery may be increased by more careful regulation of furnace temperatures.

Annual Meeting of the Chicago Chemists' Club

The first annual meeting of the Chicago Chemists' Club was held May 7, and the following officers were elected: President, William Hoskins; first vice-president, F. N. DeBeers; second vice-president, W. Lee Lewis; secretary, Paul VanCleef; treasurer, C. C. Kawin; trustees to serve for three years, Herbert N. McCoy and W. R. Smith.

Reports showed that the club now has a membership of eighty-nine, three of whom are non-residents.

Stamford Chemical Society Meeting

The eighth monthly meeting of the Stamford Chemical Society was held on Monday evening, April 26, at the Stamford High School Building. The two points of interest at the meeting were the election of officers and the rendering of a paper on "Allotropism Among the Metals," by Dr. F. H. Getman, president of the society. The paper was based largely upon the author's research work.

Allotropism Among the Metals

The phenomenon of allotropism was defined by Dr. Getman as the existence of an element in several physical forms; the chemical properties remaining the same. This phenomenon was first forcibly brought to the attention of the scientific world when a large shipment of tin, which was stored for a considerable time in Russia, was found in the form of a gray powder. Fraud was at once suspected. Chemical analysis, however, proved the material to be a high grade of tin.

As a result of recent investigations it has been shown that cadmium, zinc, lead, copper, tin, bismuth, antimony and sodium are in reality metastable systems consisting of two or more allotropic forms. The apparent stability of these metals is to be ascribed to marked retardation accompanying the reversible change of the different allotropic modifications in the neighborhood of their transition points. It is possible to accelerate these reversible transitions and to determine with considerable accuracy the transition temperatures and thus ascertain the conditions of stability of the metals. Obviously the physical and mechanical constants which have hitherto been determined refer to more or less complicated metastable systems.

The members of the society were very much interested to learn that Dr. Cohen, of the University of Utrecht, Netherlands, and Dr. Getman were both working, at the same time, on the allotropic forms of cadmium and that they both arrived at identical generalizations, although they worked from entirely different angles. While Dr. Cohen determined the density and some of the other physical properties of the different allotropic forms of cadmium for comparison, Dr. Getman determined with great accuracy the electrical potential between the different allotropic forms under various conditions.

U.S.P. Revision Organized

Manufacturers of drugs, pharmaceuticals and other chemicals listed in the U. S. Pharmacopœia should get in touch with the Committee on Revision which has just been organized and authorized to proceed on the preparation of the tenth edition of this volume. The U. S. Pharmacopœial Convention was held in Washington on May 11 and 12 for a discussion of the principles to be followed in this revision. Rules were adopted with respect to the object and scope of the work, doses, nomenclature, synonyms, purity and strength of pharmacopœial articles, international standards, physical constants and other related subjects. Some of the points of interest to chemical manufacturers are included in the following provisions:

In the case of newly admitted articles, it is recommended that such titles be chosen as are in harmony with general usage and convenient for prescribing; for synthetic chemicals, with lengthy or unwieldy names, the Committee of Revision shall be empowered to coin short euphonious titles, contracted, if possible, from the true chemical names, but in the case of chemicals of a definite composition the scientific name shall be given, at least as a synonym.

It is recommended that the standard temperature of 25 deg. C. (77 deg. F.) be retained in the revision (except in the case of alcohol) and that an alcoholometric table be inserted in Part II giving the percentage of alcohol at different temperatures.

It is recommended that the Committee of Revision be instructed to revise carefully the limits of purity and strength of the Pharmacopœial chemicals and preparations, for which limiting tests are or may be given. While no concession should be made toward diminution of medicinal value, an allowance should be made for unavoidable, innocuous impurities or variations due to the particular source or mode of preparation, or to the keeping qualities of the several articles.

The "Purity Rubric," which limits the percentage of innocuous impurities, as introduced in the previous revision, should be continued, and tests and requirements should be appended to each article for which a "Purity Rubric" is given.

It is recommended that a range of the content of absolute alcohol, by volume, be stated in the Pharmacopœia, accompanying the text, for each preparation containing alcohol.

It is recommended that official methods for taking physical constants shall be stated in the Pharmacopœia, and these shall apply to all articles in which physical constants are officially used, unless otherwise specifically excepted.

The Committee of Revision will have as its chairman Fullerton E. Cook, and Charles H. LaWall as its secretary. Prof. LaWall's address is 39 South 10th St., Philadelphia, Pa.

It is expected that the Committee of Revision will make public, for comment and criticism, an abstract of new descriptions and standards, and all important changes in preparations and standards proposed, before final adoption.

Washington Chemical Society Meeting

Dr. A. M. Comey addressed the Chemical Society of Washington on the subject of high explosives on May 13. He discussed the development of these materials from straight dynamite through gelatine dynamites, Judson powders, ammonia dynamites, ammonia-gelatine dynamites, permissible explosives and low-freezing dynamites. Mercury fulminate and its principal substitute lead azide (PbN_6) were also described. Methods of testing for strength, speed of detonation and sensitiveness of these and the various military high explosives, of which TNT is the preferred form, were described in detail.

One of the most striking developments in high-explosive work pointed out by Dr. Comey was the partial elimination of nitroglycerine from dynamites; about 40 per cent was an average figure fifteen or twenty years ago, whereas 20 per cent represents present practice.

The next meeting of the society will be held at the Geophysical Laboratory on May 27, at which time Dr. Arthur L. Day will address the membership. Dr. Day has recently resumed his active direction of the work of this laboratory. The various laboratories of the institution will be open for inspection on the evening of the meeting.

First Step Toward Department of Public Works

Passage by the Senate of a bill providing for a joint Committee on Reorganization of the Government Departments and the probability that similar action will be taken promptly by the House is regarded as a long step forward in the campaign to secure a Department of Public Works and other changes in the organization of administrative agencies in Washington. The bill provides for a study of the situation by three members of the Senate and three members of the House. The final report of the committee must be submitted at the opening of Congress in December, 1922. After speeches in favor of the resolution had been made by Senator Smoot, in immediate charge of legislation for the majority, and Senator Underwood, the Democratic leader, the Senate passed the measure by acclamation.

Annual Alumni Banquet of the Chemical Society of Brooklyn Tech

The annual dinner of the Chemical Society of Brooklyn Tech was held at the Chamber of Commerce Club on Saturday evening, May 15. About one hundred students and alumni were present.

Dr. B. Palmer Caldwell was called upon as the most recent addition to the faculty and spoke of the great difference between teaching in the country and in this metropolitan center. He took occasion to show that Dr. Pritchard's criticism of the research work carried out in American colleges and universities was entirely unjustified and that it was vital that much more liberal appropriations be made for this important work. Dr. William H. Nichols later emphasized the same point and showed that much harm would result from the curtailment of university research work.

Dr. Nichols, who is chairman of the board of trustees of the Polytechnic Institute, told the young men present of the tremendous development which had taken place in the chemical industry since he studied chemistry at the Brooklyn Tech. He gave it as his opinion that the developments in the chemical field in the immediate future would far surpass the achievements of the past. He also related some personal incidents in connection with the development of the American dye industry, particularly in the manufacture of aniline oil before the war, which proved to be of the greatest importance when it became necessary to manufacture smokeless powder for which diphenylamine is so essential.

The last speaker of the evening was Dr. Charles H. Herty, who spoke of the failure of the War Department to recognize the value of chemists at the beginning of the late war. He stated that the lack of appreciation of the chemist by the public in general was due largely to the unwillingness of the chemists themselves to inform the newspaper reporters on chemical matters. In speaking of the dye industry, Dr. Herty said that while it was only a small industry in itself it influenced a great many larger industries such as the textile and leather industries. He believed that the dye industry must be protected against foreign competition and vigorously attacked Senator Thomas for opposing the bill in Congress for that purpose. In concluding, Dr. Herty said that the dye industry is not only the main reserve in chemical warfare, but that the health of the people of America depends upon it.

The dinner was a most enthusiastic and delightful occasion. College songs and cheers added pep to the affair.

Book Reviews

CAST IRON IN THE LIGHT OF RECENT RESEARCH. By *William Herbert Hatfield, D.Met.* (Brown-Firth Research Laboratories, Sheffield). London: Charles Griffin & Co., Ltd., 1918. Second edition.

The first edition of this work, which appeared in 1912, attracted the attention in this country of metallurgists and others, not only on account of the original matter of interest and importance contained therein but also from the fact that it was, perhaps, the first fairly complete compilation in one volume of numerous researches and discoveries of very many workers during the last half century. Beginning practically with the classic writings of Prof. Thomas Turner on the influence of silicon in cast iron, published in 1885—an investigation which has had a profound effect upon modern methods in foundry practice and also even in the making of pig iron for foundry use—down to 1912, this book was a compendium of nearly all the important papers that were scattered throughout the journals of technical societies and periodicals up to that year.

The second edition has wisely adhered closely to the original scheme and has added four new chapters, increasing the number of pages from 244 to 286, not counting the indexes. Some idea of the thoroughness of this compendium may be gained from the fact that the index of names in the new edition contains no less than 140 names, from which, by the way, the author has modestly omitted his own name, though the book contains some of his original investigations, such as on page 89, *et seq.*, on the "Influence of Vanadium in Cast Iron."

The reviewer must remember that the work should be judged from the standpoint of metallurgical practices in Great Britain, which differ in some respects from our American practice. *E.g.*, the chilled cast-iron car wheel is peculiarly an American industry of vast proportions; there are probably today over 20,000,000 chilled cast-iron car wheels running on American railroads in freight service under cars with capacity up to 100,000 lb. and over, and the end is not yet reached!

Chapter V, on "The Influence of Manganese," shows its well-known action in neutralizing sulphur; its effect on the iron-carbon system; its influence on white cast iron and on gray cast iron; but no mention is made of the truly remarkable effect of adding a minute quantity of powdered 80 per cent ferromanganese in a ladle of molten high chilling car-wheel iron, increasing the strength over 30 per cent and decreasing the shrinkage in like proportion. It acts here as a desulphurizing and de-oxidizing flux. Since this process was published in 1888 (see *Journal of the Franklin Institute* for March, 1888), the method has been generally used with very great benefit in the manufacture of chilled cast-iron car wheels and other chilled castings. Chapter II devotes twenty pages to "The Influence of Silicon," and an elaborate discussion of the manner in which this element operates on cast iron, but no mention is made of the use of permanent iron molds in making machinable castings of exceedingly fine grain, free from blow holes, graphite and sand pits, etc. Since 1888 one foundry in Philadelphia has made an enormous number of machinable gray-iron castings in permanent iron molds, some of the original molds being still in use; this foundry has more than one hundred permanent iron molds. When it is realized that surface "chill" on a casting made in an iron mold (which may be not thicker than a sheet of tissue paper) will make the casting too hard to be readily machined, the fact that suitable treatment of the metal with silicon has made machinable castings in iron molds a *fait accompli* for thirty years, the value of that element may be more fully appreciated.

In conclusion, the reviewer would say that this book is one of great value to the metallurgist, the engineer and the educated foundryman.

ALEXANDER E. OUTERBRIDGE, JR.

Personal

CARL G. BARTH, a pioneer in the machinery-building industry, has been elected an honorary member of the Taylor Society. Only two other men have been thus honored by the Society, which is the national organization for the promotion of science in management, these being Frederick W. Taylor and Henri Le Chatelier, the engineer who developed scientific management in France.

J. E. BARTLETT has been elected president and general manager of Parke, Davis & Co., Detroit, Mich., succeeding the late Frank G. Ryan.

H. C. BELLINDER, general manager of the Chile Copper Co., arrived in New York from Chile on May 7.

Dr. WILLIAM BLUM, chemist in the National Bureau of Standards, spoke before the electroplaters of Providence, R. I., on May 11, describing the work which the Bureau is doing in this field, particularly the opportunities for research as a means for improving commercial electroplating practice.

Colonel MARSTON TAYLOR BOGERT, of the Department of Chemistry, Columbia University, has been elected president of the American Section of the Société de Chimie Industrielle of France. Prof. Bogert was president of the Society of Chemical Industry of England in 1913, and has been twice president of the American Chemical Society.

J. A. BRETZ has resigned as chief chemist and metallurgist of the Bettendorf Co. to take charge of the laboratory of the Southern Manganese Corp., Anniston, Ala.

C. E. BRODERS has resigned from the staff of the C. F. Burgess Labs. to take a position with the U. S. Auto Gear Shift Co., Eau Claire, Wis.

DONALD G. CLARK, district manager of the Firth Sterling Steel Co., spoke before the American Steel Treaters Society, May 19, on "The Heat Treatment of Stainless Steel."

Dr. COLIN G. FINK of New York lectured to the graduate students of Yale University on "The Organic Chemistry of Metal Carbides" and "Contact Catalysis."

L. W. JONES, dean of the college of engineering and architecture and dean of the school of chemistry, University of Minnesota, has resigned to become professor of organic chemistry, Princeton University, Princeton, N. J.

ROBERT M. KEENEY, electrometallurgist, Denver, Col., attended the convention of the National Electric Light Association at Pasadena, Cal., and read a paper on electric furnace practice.

C. H. KIDWELL, of the staff of the United States Geological Survey, has resigned to join the chemical staff of the Solvay Co., at Syracuse, N. Y.

DORSEY A. LYON is making a tour of the Western stations of the Bureau of Mines.

C. H. WOLFF was elected president of the American Zinc Institute at the annual meeting recently held in Chicago.

CLARENCE A. WRIGHT, hydrometallurgist for the Bureau of Mines at the Salt Lake station, has resigned, the resignation to take effect June 1. He expects to sail for Italy the latter part of June to engage in metallurgical work.

Obituary

HARLEY T. PROCTER, who for many years carried on the business of Procter & Gamble, manufacturer of Ivory Soap, died recently of diabetes at his home in New York City, in his seventy-third year. He had retired twenty-five years ago from active connection with the affairs of the company, which was founded by his father, William Procter. Mr. Procter was a member of the Metropolitan and Manhattan clubs.

Current Market Reports

The Non-Ferrous Metal Market

New York, May 24, 1920.—Price for copper is unchanged at 19¼c., which is regarded as being a rock-bottom quotation. Tin continued to decline, 52¼c. being the present figure. Other markets are steady.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	9.25
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	52.25
Lead, New York, spot	8.80
Lead, E. St. Louis, spot	8.50
Zinc, spot, New York	8.55
Zinc, spot, E. St. Louis	7.60

OTHER METALS		
Silver	oz.	$0.99¾
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	2.70@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	110@115
Iridium	oz.	300.00
Palladium	oz.	105@115
Mercury	75 lb.	92 00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper bottoms	38.50
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless high brass tubing	30.50

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	21.75@22.75
Aluminum, sheet scrap	21.25@22.50
Copper, heavy machinery comp	13.50@14.00
Copper, heavy and wire	13.50@13.75
Copper, light and bottoms	12.25@12.75
Copper, heavy cut and crucible	14.75@15.00
Brass, heavy	7.50@ 8.00
Brass, light	7.00@ 7.50
No. 1 clean brass turnings	8.25@ 8.50
No. 1 comp. turnings	10.25@10.75
Lead, tea	5.25@ 5.40
Lead, heavy	7.00@ 7.25
Zinc, scrap	4.25@ 4.50

The Iron and Steel Market

Pittsburgh, Pa., May 21, 1920.

While the number of rail strikers may have decreased somewhat in the past week or two, the traffic situation is distinctly worse, on account of congestion, and production of pig iron and steel has decreased rather than increased, being now hardly greater than it was when the strike effect was felt most seriously, toward the latter part of April.

The curtailment in operation is progressive, from the blast furnace through to the finishing departments. There is slightly less coke than there was a fortnight ago, due to increased car shortage at beehive coke ovens and at coal mines supplying byproduct ovens, hence there is less pig iron being produced. There is still less production of steel, with accumulation of pig iron at some works, either through stocks of steel having become uncomfortable or through there being a shortage of gas coal for open-hearth furnaces. Of the steel produced not all is going through the blooming mill, there being accumulation of ingots at some plants, while as to finishing departments some of the steel is being put into billets and sheet bars, as materials that can be most easily stocked. Finally, of the finished steel that is made a considerable percentage is not shipped, as the car supply is insufficient even for the reduced production.

The car supply is so poor now that there is no longer much question, from the steel mill viewpoint, of lines of communication being open to customers.

A rough guess as to the amount of steel now accumulated may be of interest. Only a guess can be made, but even that is suggestive. One starts with the ingot production

in March, when the rate was the heaviest since October, 1918. The American Iron and Steel Institute report, covering the output in that month of thirty companies which, in 1918, made 84.03 per cent of the country's total, indicated a rate in March of about 45,200,000 gross tons per annum. The normal ratio is 76 per cent for finished rolled steel, as reported in the statistics, to ingots. Applying 76 per cent, dividing by 52 and passing from the gross to the net ton, one finds a weekly rate of finished rolled steel production of 750,000 net tons, or 125,000 tons per working day. Thus far the computation is reasonably exact and accurate. Another fairly well-known fact is that the rail strike has an average life of about seven weeks to date, having begun in the Chicago district April 1, reaching the valleys and Pittsburgh about Monday, April 12. Assuming production to have averaged 80 per cent of the March rate and shipments 65 per cent of the production, the shipments were 52 per cent of the March rate, leaving 28 per cent at the mills, 28 per cent of 750,000 tons a week for seven weeks being 1,470,000 net tons. There was an accumulation of steel at mills on April 1, apparently large at the time, due to the car shortage earlier in the year, so that a fair guess would be more than 1,500,000 net tons of steel now at mills in equivalent of finished steel, but a part of it really in ingot, billet and sheet bar form awaiting finishing at a more convenient time when fuel is less scarce. On account of mill limitations that part of the stock will be some time getting worked off, while the finished product will also move slowly, at best, for the ending of the rail strike itself, whenever that occurs, will be followed by car shortage and only gradual relief from present congestion.

Markets Apathetic

Buyers of pig-iron and steel products are showing no interest whatever. They could, perhaps, be taking their cue from the stocks of material that have been accumulating, but undoubtedly they are greatly influenced by the very apparent unsettlement of business and financial conditions generally. Buyers of steel always keep an eye on the stock market and there has never been a free movement in steel buying when Wall Street was showing serious declines.

For several weeks the important but unanswered question has been how the consumption of steel was comparing with the production. There are cases of factories closing from lack of steel and other cases of factories running very well, and no comprehensive survey has been made. As noted in this report a week ago, if consumers have been maintaining operations to any extent by drawing upon stocks, and thus consuming more steel than is received, the stocks must have been accumulated at some time, and the only time was last February and March. However, one day last week, when the rail strike was about six weeks old, Ford made a new record for a day's output with 4,600 cars.

Prices

There is no declining tendency apparent in prices, except in prices for prompt steel, and that might be due to there being less bidding because prompt shipment might not mean anything like prompt delivery. In a quiet market, of course, the mills having the least business on books and therefore having the highest prices would naturally approach the end of their orders sooner than others, and would thus be moved to reduce prices. Mills that are booked for a few months have no incentive to reduce prices, it being axiomatic in the steel trade that, generally speaking, reducing prices does not stimulate buying. The exception is when buyers and sellers have played the "waiting game" for a long time. There are now predictions in some quarters that there will be no very active market in steel generally until prices have all declined to the Steel Corporation or Industrial Board level. No one predicts that that schedule of prices is in danger.

Pig-iron transactions are confined to small lots for early shipment, such business making the only market quotable, and thus the market is unchanged, though forward deliveries are not tested. Quotations are: Bessemer, $42.50; basic, $43; foundry, $44@$45, f.o.b. valley furnaces, freight to Pittsburgh being $1.40.

Ferro-Alloys

A few consumers of ferromanganese have run decidedly short, due in part to delay in receipt of ferromanganese purchased long ago in England, and the prompt market is still, with $250, delivered, readily obtainable, and perhaps up to $260, but the shipment must really be prompt, as the middle of the year is only six weeks distant and second half deliveries are merely firm at $200, delivered. Spiegeleisen is $72.50@$75, furnace, for spot, being both firm and quiet at that level. Electrolytic ferrosilicon is quiet at $78@$80, delivered, with 75 per cent not tested, but probably about $155. Bessemer ferrosilicon remains at $62.50 for 10 per cent, $65.80 for 11 per cent and $69.10 for 12 per cent, f.o.b. furnaces at Jackson and New Straitsville, Ohio.

The Chemical and Allied Industrial Markets

New York, May 21, 1920.

There has been little if any activity in the local market since the last report. While producers, in most instances, report a satisfactory supply of crude material, they are met with the difficult task of finding means to transport it from the sources or from intermediate points of shipment.

With plenty of alcohol at the distilleries, the obstacles confronting the shipper have brought a rise in the denatured product slightly above the dollar mark per gallon in less than carload lots, f.o.b. New York, and there are prospects of a further increase. Importation of *barium chloride*, in limited quantities, had been able to ease the demand, but frequent withdrawals by the German Government of permission to export have produced a growing scarcity. Current quotations in less than carload lots range from $175 to $200 per ton. *Glycerine*, with a steady demand, has shown an increase from the previous quotation of 24½@28½c. per lb. to 26½@28½c., and unless new sources and lower prices of crude oil are obtained there is little likelihood now of a return to the old prices. The same conditions affect *paraffine waxes*, where an increase in price has been the result. One of the leading manufacturers quotes crude match wax (white), 105-110 m.p., at 10c. per lb., a movement from 9½c., with like increases in other grades. *Zinc chloride*, *granular*, ranges up from 13½c. per lb. in less than carlots, one dealer securing spot goods at 15c. per lb. notwithstanding the scarcity of the product. There appears to be a sufficient supply of *sodium carbonate* in the vicinity, but conditions are such as practically to isolate it. *Sodium cyanide*, 96-98 per cent, continues to be quoted at 24@25c. per lb. despite a temporary shortage due to the accidental loss of one large shipment. Continued lack of raw material has caused a rise in price of *acetic acid*, 56 per cent, to $7.50@$8 per cwt. in carlots. There has been little movement in this or other acids, and with the exception of acetic, no revision of quotations.

Vegetable Oils

A marked decrease in the prices of domestic *linseed oil* has followed the lower quotations of the English product. Raw material in carlots is quoted today at $1.65 per gal. while the raw imported from England ranges in price from $1.45 to $1.50 in barrels. Domestic linseed oil, raw, in tank cars, shows a drop to $1.60 and a similar reduction is noted in carlot quotations of the boiled material. Higher cost of manufacture here will probably prevent the equalization of domestic and imported oils. At the same time, importation in quantities will continue so long as it aids substantially, as it has been doing, in restoring the English sovereign to its pre-war value. *Olive oil*, commercial, is now quoted at $3.10@$3.25, a sudden increase and due solely to the embargo placed by Spain.

Naval Stores

In anticipation of the arrival of the new product, prices of *rosin* have declined, but thus far it has been an almost impossible matter to secure shipments from the South. The B-D type in barrels of 280 lb. is quoted at $16.50@$18.75, *rosin oil* of the first run declining to 95c. per gal., second run, 88c., third run and fourth run, $1.00. *Turpentine* remains firm with little movement by shippers.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.65 – $0.75
Acetone	lb.	$0.19 –$0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.25
Acetic, 56 per cent	cwt.	7.50 – 8.00	8.75 – 9.00
Acetic, glacial, 99½ per cent. carboy	cwt.	15.50 –16.00	16.50 – 17.50
Boric, crystals	lb.	.14½ – .15½	.15½ – .16½
Boric, powder	lb.	.14½ – .15	.15 – .16
Citric	lb.	.85 – .86	1.17 – 1.18
Hydrochloric (nominal)	cwt.	3.00 – 3.25	3.50 – 4.00
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.13½ – .14
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)		—	—
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09¼
Oxalic, crystals	lb.	.55 – .57	.58 – .59
Phosphoric, Ortho, 50 per cent solution	lb.	.22 – .23	.24 – .25
Picric	lb.	.30 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 18.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	21.00 –25.00	—
Sulphuric, 66 deg., drums	ton	35.00 –40.00	50.00 – 55.00
Sulphuric, 66 deg., carboys	ton	36.00 –40.00	50.00 – 55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	32.00 –
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –30.00	34.00 –
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 –35.00	40.00 –
Tannic, U. S. P	lb.	1.50 – 1.60	1.65 – 1.70
Tannic (tech.)	lb.	—	.60 – .90
Tartaric, crystals	lb.	—	.80 – .85
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl (nominal)	gal.	2.50 – 3.50	—
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.05 – 1.10
Alcohol, denatured, 190 proof (nominal)	gal.	—	1.00 – 1.05
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08½	.09 – .09½
Alum, chrome lump	lb.	.15½ – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.01¾ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02¾ – .03	.03¼ – .03¾
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.08¾ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.33 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – .13½	.13½ – .14½
Ammonium nitrate	lb.	.08¾ – .12	—
Ammonium sulphate	lb.	.07 – .07½	.08½ –
Amylacetate	gal.	—	—
Amylacetate tech	gal.	—	4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	—	.13½ – .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	—
Barium chloride	ton	150.00–160.00	1.75 – 2.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.10 – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)		—	—
Blue vitriol (see copper sulphate)		—	—
Borax (see sodium borate)		—	—
Brimstone (see sulphur, roll)		—	—
Bromine	lb.	.85 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	—
Calcium carbide	lb.	.04½ – .04½	.04¾ – .05½
Calcium chloride, fused, lump	ton	23.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02¼
Calcium hypochlorite(bleaching powder)	cwt.	4.00 – 4.25	4.50 – 5.00
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)		—	—
Caustic soda (see sodium hydroxide)		—	—
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)		—	—
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08¼ – .09	.09 – .09¼
Cream of tartar (see potassium bitartrate)		—	—
Epsom salt (see magnesium sulphate)		—	—
Ethyl Acetate Com. 85%	gal.	1.35 –	1.40 –
Ethyl Acetate pure (acetate ether 98% to 100%		—	1.75 –
Formaldehyde, 40 per cent (nominal)	lb	38 – 40	57 – .65
Fusel oil, ref	gal.	—	5.25 – 6.00
Fusel oil, crude (nominal)	gal.	—	—
Glauber's salt (see sodium sulphate)		—	—
Glycerine	lb.	—	.26½ – .28½
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	—	.13⅝ – .15¾
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	—	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P	100 lb.	3.50 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	—	3.25 – 3.60
Nickel salt, double	lb.	—	.14 – .16
Nickel salt, single	lb.	—	.16 – .18
Phosgene (see carbonyl chloride)		—	—
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.36 – .37	.45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.53 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – .95
Potassium carbonate, U. S. P	lb.	—	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28
Potassium chlorate, crystals	lb.	.14 – .16	.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.31 – $ .32
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.15 – .17	.19 – .21
Potassium permanganate	lb.	—	.85 – .95
Potassium prussiate, red	lb.	$0.90 – $1.00	$1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.36½ – 0.37½
Potassium sulphate (powdered)	ton	$225.00 –240.00	—
Rochelle salts (see sodium potas. tartrate)		—	—
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake	ton	28.00 –32.00	—
Silver cyanide (nominal)	oz.	—	1.25 –
Silver nitrate (nominal)	oz.	—	.74 – .76
Soda ash, light	100 lb.	—	3.50 – 3.60
Soda ash, dense	100 lb.	—	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09½ – .12
Sodium bicarbonate	100 lb.	2.25 – 2.60	2.75 – 3.50
Sodium bichromate	lb.	.33 – .35	.36 – .37
Sodium bisulphite (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .10½
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	—	.10 – .11
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	5.00 – 6.00	6.25 – 6.50
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25¾ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.20 – .21	.24 – .25
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	—	.39 – .40
Sodium prussiate, yellow	lb.	.23 – .02	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01½ – .02	.02 – .02¼
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2.25
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.23 – .24	.25 – .26
Sulphur chloride	lb.	.05¾ –	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 –
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran	lb.	.13 –	.13½ – .17
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ –	.13 – .15
Zinc oxide, U. S. P	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	—	$1.25
Alpha naphthol, refined	lb.	—	1.45
Alpha naphthylamine	lb.	.65 —	.70
Aniline oil, drums extra	lb.	.35 —	.40
Aniline salts	lb.	.45 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.35 —	1.40
Benzidine, sulphate	lb.	1.20 —	1.25
Benzoic acid, U.S.P	lb.	.90 —	1.10
Benzoate of soda, U.S.P	lb.	.80 —	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	.50 —	.65
Beta naphthol, sublimed (nominal)	lb.	—	1.00
Beta naphthol, tech (nominal)	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 —	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 —	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 —	.75
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	—	1.80
Dimethylaniline (nominal)	lb.	1.50 —	1.55
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.40 —	.45
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	—	.85
H-acid (nominal)	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.15 —	1.80
Monochlorbenzol	lb.	.12 —	.15
Monoethylaniline	lb.	1.70 —	1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	.15 —	—
Naphthaline, flake	lb.	.15 —	.17
Naphthaline, balls	lb.	.16 —	.18
Naphthionic acid, crude	lb.	.75 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitro-toluol	lb.	.20 —	.30
Ortho-amidophenol	lb.	3.25 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.35 —	.45
Para-amidophenol, base	lb.	2.50 —	3.50
Para-amidophenol, HCl	lb.	2.50 —	3.25
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	—	1.65
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.60 —	3.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.25
Pyridin	gal.	2.00 —	2.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0 50	—	$0 52
Salicylic acid, U. S. P.	lb.	55	—	60
Salol	lb.	.90	—	1 00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.23
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1 70	—	2 00
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.32
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0 36	—	$0 39
Beeswax, refined, light	lb.	39	—	.40
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1, (nominal)	lb.	.93	—	.95
Carnauba, No. 2, regular (nominal)	lb.	.85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.44	—	.45
Japan	lb.	.21	—	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09½	—	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	....	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	11½	—	12
Paraffine waxes, refined, 128-130 m.p.	lb.	.13	—	.14
Paraffine waxes, refined, 133-135 m.p.	lb.	.15½	—	.16½
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb.	.26	—	.27
Stearic acid, triple pressed	lb.	.28	—	.29

NOTE—Quotations on paraffine waxes are nominal

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.75
Pine oil, pure, dest. dist.	gal.	....
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.38
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots

Rosin B-D, bbl.	280 lb.	115 95	—	$18 75
Rosin E-I	280 lb.	18 75	—	19 00
Rosin K-N	280 lb.	19 00	—	21 00
Rosin W. G.-W. W.	280 lb.	20 50	—	21 50
Wood rosin, bbl.	280 lb.	17 50	—	18 50
Spirits of turpentine	gal.	....	—	2 45
Wood turpentine, steam dist.	gal.	2 35	—	2 40
Wood turpentine, dest. dist.	gal.	....	—	2 00
Pine tar pitch, bbl.	200 lb.	8 40	—	8 50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14 50	—	15 00
Retort tar, bbl.	500 lb.	15 00	—	15 50
Rosin oil, first run	gal.	.85	—	.95
Rosin oil, second run	gal.	.88	—	.97
Rosin oil, third run	gal.	1 00	—	1.05
Rosin oil, fourth run	gal.	1 05	—	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal	$0 40
70-72 deg., steel bbls. (85 lb.)	gal	38
68-70 deg., steel bbls. (85 lb.)	gal	37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal	29

Crude Rubber

Para—Upriver fine	lb.	$0 39½		$0 40
Upriver coarse	lb.	.29	—	29½
Upriver caucho ball	lb.	.30½	—	....
Plantation—First latex crepe	lb	....	—	38
Ribbed smoked sheets	lb.	.37½	—	.38
Brown crepe, thin, clean	lb.	....	—	35
Amber crepe No. 1	lb.	....	—	40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb	.20	—	.22
China wood oil, in bbls.	lb.	.22½	—	23½
Cocoanut oil, Ceylon grade, in bbls	lb.	.18½	—	.18¾
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.19½	—	.20½
Corn oil, crude, in bbls	lb.	.17¼	—	18
Cottonseed oil, crude (f.o.b. mill)	lb	15½	—	16
Cottonseed oil, summer yellow	lb.	.19	—	19
Cottonseed oil, winter yellow	lb.	.21	—	.22
Linseed oil, raw, car lots (domestic)	gal	1 65	—	....
Linseed oil, raw, tank cars (domestic)	gal.	1 60	—	....
Linseed oil, boiled, car lots (domestic	gal.	1.67	—	....
Olive oil, commercial	gal.	3 10	—	3 25
Palm, Lagos	lb.	13½	—	14
Palm, bright red	lb.	.13	—	13½
Palm, Niger	lb.	.12	—	13
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.16½	—	17½
Peanut oil, refined, in bbls	lb.	.22	—	24
Rapeseed oil, refined in bbls	gal	1 70	—	1 72
Rapeseed oil, blown, in bbls	gal.	1 80	—	1 82
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.13	—	13½

FISH

Winter pressed Menhaden	gal.	$1 17	—	$1 18
Yellow bleached Menhaden	gal.	1 20	—	1.22
White bleached Menhaden	gal.	1 23	—	1 24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f. o. b. New York Unless otherwise stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$20 00	—	$22 00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	12 00	—	15 00
Barytes, crude, 88% (@ 24% ba., Kings Creek	net ton	8 00	—	10 00
Blanc fixe, dry	lb.	3½	—	4
Blanc fixe, pulp	ton	60 00	—	80 00
Casein	lb.	15	—	18
Chalk, English, extra light	lb.	05	—	07
Chalk, English, light	lb.	04½	—	06
Chalk, English, dense	lb.	04	—	05
China clay (Kaolin) crude, f.o.b. Plen, Va	net ton	8 00	—	12 00
China clay (Kaolin), imported, lump	ton	25 00	—	35 00
China clay (Kaolin), imported, powdered	ton	50 00	—	60 00
Feldspar (nominal) f.o.b. N. Y. State	ton	15 50	—	18 00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7 50	—	8 00
Feldspar, ground, f.o.b. Baltimore	net ton	18 00	—	25 00
Fire clay, f.o.b. Baltimore	net ton	5 00	—	7 00
Fuller's earth, domestic, powdered	ton	25 00	—	30 00
Fuller's earth, imported, powdered	ton	35 00	—	40 00
Graphite (dust polish grade 30%) Ashland, Ala	lb.		—	0 01
Graphite (dust facing grade 50%) Ashland, Ala	lb.		—	0 01½
Graphite, crucible, 85% carbon Ashland, Ala	lb.		—	07
Graphite, crucible, 90% carbon Ashland, Ala	lb.		—	08½
Pumice stone, imported	lb.	03	—	06
Pumice stone, domestic	lb.	02½	—	....
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton		—	10 00
Quartz (acid tower) 1½ to 2 in., f.o.b. Baltimore	net ton		—	14 00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton		—	17 00
Shellac, orange, fine nominal	lb	1 50	—	....
Shellac, orange, superfine	lb	1 60	—	1 65
Shellac, A. C. garnet	lb	1 30	—	1 35
Soapstone	ton	15 00	—	25 00
Talc, domestic	ton	20 00	—	60 00
Talc, imported	ton	60 00	—	70 00

Refractories

Following prices are f.o.b. Works:

Chrome brick	net ton	$75-80 at Chester, Penn
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn
Magnesite, dead burned	net ton	50-55 at Chester, Penn
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80-85 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f. o. b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200 00	—	$250 00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20	—	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb	.21	—	.22
Ferro-manganese, 70-80% Mn.	gross ton	200 00	—	250 00
Spiegeleisen, 16-20% Mn	gross ton	73 00	—	75 00
Ferro-molybdenum, per lb. of Mo	lb.	2 25	—	2 75
Ferro-silicon, 50%	gross ton	80 00	—	90 00
Ferro-silicon, 75%	gross ton	175 00	—	200 00
Ferro-silicon, 10-15%	gross ton	60 00	—	65 00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	90	—	1 10
Ferro-uranium, 35-50% of U	lb.	7 00	—	....
Ferro-vanadium, 30-40% per lb. of contained V.	lb	6 50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3, f.o.b. Atlantic seaboard	unit	$0 70	—	$0.85
Chrome ore, 48% and over †	unit	....	—	....
Coke, foundry, f.o.b. ovens	net ton	12 00	—	14 00
Coke, furnace, f.o.b. ovens	net ton	11 00	—	12 00
Petroleum coke, refinery, Atlantic seaboard	net ton	....	—	14 00
Fluor spar, gravel, f.o.b. mines	net ton	25 00	—	30 00
Fluor spar, acid grade, lump, f.o.b. Tonnes, Mex	net ton	30 00	—	45 00
Fluor spar, acid grade, ground, f.o.b. Tonnes	net ton	55 00	—	65 00
Manganese ore, 45% Mn and over	unit	80	—	95
Manganese ore, chemical (MnO_2)	gross ton	80 00	—	90 00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	75	—	85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7 00	—	10 00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6 50	—	7 50
Uranium oxide, 96%	lb.	2 75	—	3 00
Vanadium pentoxide, 99%	lb.	12 00	—	14 00
Vanadium Ore	lb.	2 50	—	3 00
Pyrites, foreign, lump	unit	17	—	....
Pyrites, foreign, fine	unit	17	—	....
Pyrites, domestic, fine	unit	16	—	17½
Ilmenite, 52% TiO_2	lb.	02	—	....
Rutile, 95% TiO_2	lb.	11	—	....
Carnotite, [illegible] per lb. of U_3O_8	lb	2 75	—	3 00
Zircon, washed	lb.	10	—	....
Monazite, per unit of ThO_2	unit	42 00	—	....

*Nominal

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15 in.	100 lb.	$2 45	—	$4 00
Angles, 3 to 6 in., ¼-in. thick	100 lb.	2 45	—	4 00
Tees, 3 in. and larger	100 lb.	2 45	—	4 00
Plates	100 lb.	2 45	—	4 00
Rivets, structural, 5/8 in. and larger	100 lb.	4 50		
Rivets, cone head for boilers, ½ in. and larger	100 lb.	4 50		
Sheets, No. 28 black	100 lb.	4 45	—	5 50
Sheets, No. 10 base, galvanized	100 lb.	5 45	—	6 50
Sheets, No. 28 galvanized	100 lb.	5 10	—	5 50

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage. For galvanized corrugated sheets, add 110c. all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

SAN DIEGO—The Citrus Soap Co., 9th and K. Sts., is building a 4-story, 200x300-ft. modern manufacturing plant at Union and Market Sts. Estimated cost, $200,000.

Illinois

ROCKFORD — The Emerson-Brantingham Co., South Independence Ave., plans to construct a 1-story, 80x200-ft. annealing plant, cost, $30,000 and a 1-story, 41x100-ft. core room, cost, $9,000.

Iowa

AMES—A. B. Maxwall, city clk., City Hall, will receive bids until June 7 for the construction of a sewage treatment plant consisting of a pumping plant, Imhoff tank, sludge bed, a 100x148-ft. trickling filter, etc. Noted March 10.

COIN—The School Bd. is having plans prepared for the construction of a 3-story, 65x120-ft. school building. A chemical laboratory will be installed in same. Estimated cost, $135,000. C. S. Buchtel, pres., W. Gordon, 319 Hubbell Bldg., Des Moines, archt.

GLIDDEN—The Bd. Educ. has awarded the contract for the construction of a 3-story, 90x162-ft. school building, to W. F. Kucharo & Co., 622 Hubbell Bldg., Des Moines. A chemical laboratory will be installed in same. Estimated cost, $170,654. Noted May 12.

WATERLOO—Deere & Co., 1325 Third Ave., Moline, Ill., has awarded the contract for the construction of a group of foundry buildings including a 120x200-ft. foundry addition, etc., to the Scales Constr. Co. Foundry equipment will be installed in same. Estimated cost, $400,000.

Maryland

LANSDOWNE—The Natl. Steel Rolling Co., 203 Keyser Bldg., Baltimore, will receive bids until June 10 for the construction of a 1-story, 70x140-ft. steel-rolling mill. The company is in the market for rolling mill machinery, etc. Estimated cost, $100,000.

Massachusetts

BROCKTON—The O. A. Miller Tree Co., c/o G. L. Falk, archt., 63 Main St., has awarded the contract for the construction of a 3-story, 55x160-ft. dry kiln plant on Cherry St., to the George Howard & Sons Co., 153 North Main St. Estimated cost, $50,000. Noted April 14.

FLORENCE—The International Silver Co., 48 State St., Meriden, Conn., plans to build a 1-story, 40x86-ft. forge shop. Estimated cost, $25,000.

WAKEFIELD—The Bd. Educ. will soon award the contract for the construction of a 3-story, 210x250-ft. high school on Main St. A chemical laboratory will be installed in same. Estimated cost, $450,000. F. I. Cooper Corp., 33 Cornhill St., Boston, archt.

WEST SPRINGFIELD (Springfield P. O.)—The New England Box Co., Greenfield, has awarded the contract for the construction of a 1-story manufacturing building on Cold Springs Ave., to the E. F. Carlson Co., 244 Main St., Springfield. Estimated cost, $150,000.

WORCESTER—The Rogers Drop Forging Co., Frank St., has awarded the contract for the construction of a forge plant including a 1-story, 60x85-ft. sand blasting building, 1-story, 120x150-ft. forge shop, etc., to the E. D. Ward Co., 82 Foster St. Estimated cost, $125,000.

Michigan

DETROIT—The Acme White Lead & Color Wks., 1768 St. Aubin St., is in the market for machinery including 300 mills to be used in the grinding of paint for the automobile industry.

DETROIT—The Detroit Graphite Co., 12th St., engaged Smith, Hinchman & Grylls, archts., 710 Washington Arcade Bldg., to prepare plans for the construction of a 2-story factory building for the manufacture of paint, on 12th St. Estimated cost, $50,000.

DETROIT—M. E. Wellhalm, 225 Northwestern Ave., is in the market for brick-making equipment for a modern sized outfit.

KALAMAZOO—The Sutherland Paper Co., Lincoln St., has awarded the contract for the construction of a 3-story, 96x375-ft. paper mill, to O. F. Miller.

MUSKEGON HEIGHTS (Muskegon P. O.)—The City Water Comn. engaged Hoad & Decker, engrs., Engineering Bldg., Ann Arbor, to prepare plans for the construction of a well and filtration galleries having a daily capacity of about 500,000 gal. Estimated cost, $50,000.

Minnesota

ELLSWORTH—The city rejected all bids for the construction of sanitary sewers, disposal works including a disposal tank, sludgebed, etc. Estimated cost, $40,000. Druar & Smith, Globe Bldg., St. Paul, engrs. Noted April 21.

Missouri

JEFFERSON CITY—The City Council will soon award the contract for the furnishing of labor and material including an Imhoff tank, etc., for the construction of 3,650 lineal ft. of sanitary sewers, etc.

New Jersey

HALEDON — The Mayor and the Borough Council will receive bids until June 7 for the construction of a reservoir, dam, filter house and clear water basins, etc.

NEWARK—The Bd. Educ., City Hall, will have plans prepared for the construction of a school building on Oliver St. A chemical laboratory will be installed in same. Estimated cost, $400,000. John H. and Wilson C. Ely, Firemans Trust Bldg., archts.

NEWARK—The Bd. Educ., City Hall, will receive bids until June 8 for the construction of a 3-story, 219x222-ft. school building on 1st and 2nd Aves. A chemical laboratory will be installed in same. Estimated cost, $1,125,000. John H. and Wilson C. Ely, Firemans Trust Bldg., archts.

New York

ALBANY—F. S. Greene, comn., and Irving A. Huie, secy., 55 Lancaster St., will receive bids until June 7 for the furnishing and delivering of lignin or sulphite liquor material for use by the State Highway Comn. in the maintenance and repair of improved highways.

BROOKLYN—J. E. Nitchie, archt., 63 Park Row, New York City, will soon award the contract for the construction of a 4-story, 50x100-ft. factory addition at 73 Otsego St., for the Keystone Varnish Co., 91 Otsego St. Estimated cost, $85,000. Noted April 14.

BROOKLYN—The Valentine Co., 346 Manhattan Ave., has awarded the contract for altering a steel factory for the manufacture of paints on Richardson, Bayard and Lorimer Sts., to Barney Ahlers, 110 West 40th St., New York City. Estimated cost, $50,000.

BUFFALO—The Kimberley Clark Paper Co., Pine St. and Packard Rd., Niagara Falls, has awarded the contract for the construction of a 2-story, 145x458-ft. factory building, to the Lackawanna Bridge Co., Bell and Abby Sts. Estimated cost, $700,000.

BUFFALO—The Natl. Carbon Co., College Ave., Niagara Falls, has awarded the contract for the construction of a 1-story, 25x300-ft. factory, to the John W. Cowper Co., Inc., Fidelity Bldg. Estimated cost, $100,000.

BUFFALO — The Paper Convertible Corp., Niagara Falls, has awarded the contract for the construction of a 2-story, 105x375-ft. factory, to the Lackawanna Bridge Co., Bell and Abby Sts. Estimated cost, $300,000.

FORESTPORT—The Forestport Pulp Mills, Inc., plans to construct additions and make improvements here. Estimated cost, $50,000.

HINCKLEY—The Otsego Falls Paper & Pulp Co. of Fulton has purchased the plant and equipment of the Hinckley Fibre Co. here, and plans to construct a new addition and make improvements at same. Estimated cost, from $250,000 to $300,000. H. L. Paddock, Fulton, pres.

LONG ISLAND CITY—The Drug Products Co., 48 West 4th St., has awarded the contract for the construction of a factory and laboratory on Jackson Ave. and Pierson St., to the Gretsch Eng. Co., 103 Park Ave., New York City. Estimated cost, $175,000.

MASSENA—The Aluminum Co. of America plans to construct additions to its present plant here. Estimated cost, $250,000.

NEW YORK—M. B. Schmidt, archt., 14 East 46th St., will soon award the contract for the construction of a 4-story, 50x50-ft. paint factory on West 58th St., for William Zinsser, West 59th St. Estimated cost, $50,000.

TONAWANDA—The Economy Pulp Mfg. Co. of Buffalo has purchased the vinegar works here and plans to refit and remodel it for a pulp plant. Estimated cost, $50,000.

WELLSVILLE—The village has voted $15,000 bonds to construct an additional filter unit, etc.

Ohio

ALLIANCE—The Bd. Educ. will receive bids until June 7 for the construction of a 3-story, 114x172-ft. school building. A chemical laboratory will be installed in same. Estimated cost, $500,000.

ASHTABULA—Robert Locke, pres., will soon award the contract for the construction of a 1-story, 110x600-ft. sheet steel mill on the State Rd., for the Ashtabula Steel Co. Estimated cost, $350,000.

CLEVELAND—The De Mooy Palmer Co., 65th St. and Sweeney Ave., has awarded the contract for the construction of a 1-story, 50x150-ft. foundry to Ford & Sons Co., foot of East 40th St. Estimated cost, $25,000.

CLEVELAND—The Natl. Malleable Castings Co., Woodhill Rd. and Quincy Ave., has awarded the contract for the construction of a 1-story, 100x500-ft. kiln on Woodhill Rd., to the Amer. Tunnel Co., New Castle, Pa. Estimated cost, $250,000.

COLUMBUS—The Climax Rubber Co., Citizens Bank Bldg., will build a 2-story, 140x190-ft. rubber plant on West Goodale St. Plans include a power plant and office building. Work will be done by day labor. Noted April 21.

EATON—The Bd. of Pub. Affairs will receive bids until June 23 for the construction of a filtration plant, etc. Estimated cost, $27,000. J. H. Beatty, clk.

EUCLID—The village plans to build a sewage disposal plant including settling tanks, screen buildings, etc. Estimated cost, $150,000. G. B. Gascoigne, 618 City Hall, Cleveland, engr.

IRONTON—The Fearon Lumber & Veneer Co. is in the market for dry kiln equipment including seventy-five 6-in. or 6½-in. roller-bearing dry kiln trucks (used preferred).

Rhode Island

WOONSOCKET—The Amer. Wringer Co., 91 Social St., will soon award the contract for the construction of three buildings, including a 1-story, 80x100-ft. dry kiln and a 1-story, 60x186-ft. mechanical roll building, etc. Estimated cost, $100,000. Cooley & Marvin Co., 711 Tremont Bldg., Boston, Mass., engrs.

Texas

PALACIAS—The Palacias Sewer Co. will soon receive bids for the construction of a sewage disposal plant. Estimated cost, $35,000.

VERNON—The Victor Pipe Line & Refining Co., Dixon Bldg., plans to build a 1-story, 2,000-bbl. oil refinery, here. Estimated cost, $150,000. J. W. Hudson, dir.

Virginia

BEDFORD—The city has awarded the contract for the construction of a filter plant, storage reservoir, steel tower and tank, etc., to Diehl & Vance, Virginia-Carolina Bldg., Norfolk.

Washington

MICA—The Amer. Firebrick Co. will double the capacity of its plant by building a hotel and kilns. Work will be done by day labor.

WENATCHEE—The city is having plans prepared for the construction of a complete water filtration plant with a daily capacity of 2,500,000 to 3,000,000 gal. Estimated cost, $50,000. M. Zahren, engr.

Wisconsin

GALESVILLE—The Galesville Canning Co., Onalaska, has awarded the contract for the construction of four 1- and 2-story cannery buildings, to J. E. Wallace, La Crosse. Estimated cost, $100,000.

KENOSHA—The Bd. Educ. plans to build a high school. A chemical laboratory will be installed in same. Estimated cost, $500,000.

MILWAUKEE—The Bernert Mfg. Co., 489 12th St., is having preliminary plans prepared for the construction of a 60x120-ft. foundry. Foundry equipment will be installed in same. Joseph Glaser, 713 Caswell Block, archt. Noted May 4.

British Columbia

VANCOUVER—The Vancouver Gas Co., 425 Carroll St., has awarded the contract for the construction of a retort house plant of special units and machinery, to the Wists Gas Improvement Co., Manchester, England. Estimated cost, $340,000.

VICTORIA—The Victoria Gas Co., 1016 Langley St., has awarded the contract for the construction of a retort house plant of special units and machinery, to the Wists Gas Improvement Co., Manchester, England. Estimated cost, $216,000.

Ontario

BRAMPTON—W. Treadgold, engr., is receiving prices on the supply and delivery of two 8x16-ft. horizontal, mechanical pressure filters, etc., for the city. Estimated cost, $35,000.

ELK LAKE—The Matachewan Gold Mines, Ltd., plans to install a 100-ton crushing mill. Estimated cost, $50,000. W. H. Seaman, mgr.

GANANOQUE—The Eastern Ontario Milk Products Co. plans to construct a factory here. Estimated cost, $150,000. Address L. P. Sherwood, Central Chambers, Ottawa.

LONDON—The Bd. Educ. plans to build a high school on Waterloo St. A chemical laboratory will be installed in same. Estimated cost, $500,000. A. A. Langford, chn. L. E. Carrothers, archt.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold a regular meeting June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN IRON AND STEEL INSTITUTE will hold its spring meeting May 28 at the Hotel Commodore, New York City.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the affiliated societies.

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS will meet in St. Louis May 27 to 29.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Collection Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE CANADIAN INDUSTRIAL CONGRESS will be held at Victoria, B. C., June 2 to 10.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NEW JERSEY CHEMICAL SOCIETY will hold a regular meeting and ladies' day Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

Industrial Notes

THE NEW JERSEY ZINC CO., New York City, has added to its staff Bushnell Bigelow as assistant general sales manager and Walter I. Hess as manager of Eastern sales.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., announces that L. Brandenburger, of Salt Lake City, who was formerly located in the Walker Bank Bldg., has taken larger quarters at 59 West Broadway.

THE ELYRIA ENAMELED PRODUCTS CO., Elyria, Ohio, has moved its New York office from the Architects Bldg., to 103 Park Ave.

THE DIAMOND POWER SPECIALTY CO., Detroit, Mich., received during January, February and March, 1920, orders to equip a total of 635,200 hp. of boilers and economizers with mechanical soot blowers.

THE GORDON DRYER CORP. announces the removal of its New York offices, formerly located at 39 Cortlandt St., to 1 Liberty St. Announcement is also made of the removal of its Bush Terminal experimental and research laboratory to Providence, R. I., where the main works and offices are located.

EDWARDS F. WILSON, formerly chief chemist and fuel engineer of the Westmoreland Coal Co., at Irwin, Pa., has opened a consulting office and testing laboratory at 222 South Third St., Philadelphia, where he will specialize in fuels, iron and steel, industrial water, etc., reopening in this connection the business of the Iron-Masters' Laboratory, of which he was formerly in charge.

THE ATMOSPHERIC CONDITIONING CORP., Philadelphia, Pa., announces the appointment of Benjamin Nelson as Western manager, with offices at 1301 Monadnock Block, Chicago, Ill.

THE WELLMAN SEAVER-MORGAN CO., Cleveland, Ohio, has elected John A. Penton, president of the Penton Publishing Co., a director to fill the vacancy on the board caused by the death of Samuel T. Wellman.

GUY FRIDLEY, formerly in charge of the fertilizer department of the Davidson Commission Co., Chicago, Ill., is now president and general manager of the Fridley Commission Co., Inc., Chicago, which company both sells and buys fertilizer materials.

R. A. BROWN, president of the Alabama State Fair Association and president of the Chamber of Commerce, Birmingham, Ala., has been elected president of the Steel Cities Chemical Co., Birmingham, Ala., to build the Lay Culpeper plant.

WELLS, BRACKMAN & COLE is a new firm of architects and engineers that has been formed at Detroit, with James R. Wells president, Donald Cole vice-president and Harry C. Beckwith secretary-treasurer. The offices of the new firm will be located at 531 McKerchy Bldg., Detroit.

THE CAMPBELL GLASS & PAINT CO. and the Glidden Varnish Co. have established a branch office in Oklahoma City at 15 N. Lee St. Parker Spencer will be in charge of the distribution of products in the territory.

THE EATON MFG. CO., of Omaha, Neb., has established a branch sales office at 132 West Second St., Oklahoma City, in charge of J. S. Kotva.

THE O'REILLY-LEEWRIGHT CO. has established a manufacturing plant at Oklahoma City for the production of paint and roofing compounds.

THE NATIONAL BUREAU OF WHOLESALE LUMBER DISTRIBUTORS will move its headquarters from Washington, D. C., to Chicago, locating in the Arcade Bldg., 615 South Michigan Ave. L. R. Putnam, formerly with the Southern Pine Assn., has been retained by the new association as executive secretary.

THE SERVICE MACHINE CORP. has moved its plant to 449-51 E. Ohio St., Chicago, Ill.

THE MERCANTILE CHEMICAL CO. has established a new plant at 2955 W. 47th St., Chicago, Ill.

THE RELIANCE WEIGHING MACHINE CO., maker of automatic recording weighing machinery, has purchased the business of the National Automatic Scale Co. New quarters for the organization have been provided in the Mallers Bldg., Chicago, and the company's factory in the central manufacturing district of Chicago will be greatly enlarged.

THE MONROE STEEL CASTINGS CO., Monroe, Mich., has sold its capital stock and physical assets to Detroit interests. The capacity of the plant will be immediately increased for the production of a general line of steel castings. Carl Clark is president and general manager of the new company.

THE METAL & THERMIT CORP., New York, announces the appointment of Charles F. Lederer in the rail welding department.

THE GENERAL BRIQUETTE CO., New York City, announces that Henry Schoch, sales engineer, has been elected vice-president of the Nukol Fuel Co., of Ontario, Canada. The Nukol Fuel Co. is manufacturing "Nukol," an anthracite briquet, for the Ontario market.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa., has appointed A. E. Hitchnie, formerly manager mining section, industrial department, to the position of assistant to the manager, industrial department, in charge of mining and chemical industries.

THE SCHAFFER ENGINEERING & EQUIPMENT CO., Pittsburgh, Pa., in order to provide for the expansion of its business and to obtain plant facilities, has sold a large block of its capital stock to the Fawcus Machine Co. The Schaffer Company's processes, engineering achievements and line of machines include pedometers, hydrators, coal injectors and screens. The Fawcus Machine Co., manufacturer of gears and special types of machinery, with large plants at Pittsburgh and Ford City, will build all machinery required. The new officers and directors of the Schaffer Engineering & Equipment Co. are: A. F. Cocke, president and general manager; J. C. Schaffer, vice-president; Eliot A. Kebler, vice-president; A. A. Alles, Jr., treasurer, and Walter Crew, secretary.

THE PAGE STEEL & WIRE CO. announces the removal of its offices to the offices of the American Chain Co., with which it has consolidated, in the Grand Central Terminal, New York.

THE GENERAL COMBUSTION CO., Chicago, Ill., announces the appointment of George R. Brandon, formerly engaged in engineering and sales of foundry equipment and cranes, as district representative and sales engineer. The General Combustion Co. manufactures "Conjax" furnaces for all industrial purposes. Mr. Brandon's headquarters will be 342 Monadnock Bldg., Chicago.

S. S. HEPWORTH CO., New York City, has appointed C. A. Oland general manager and E. F. Babbitt assistant manager, effective June 1, 1920.

THE WALTER E. LUMMUS CO., Boston, Mass., has appointed Raymond R. Collins, formerly head of the construction department, as sales manager.

HANFF-METZGER, INC., general advertising agent, New York, has appointed Francis Juraschek head of its technical department.

THE IMPROVED EQUIPMENT CO. announces the removal of its offices to 24 State St., New York City, on May 1, 1920.

THE WORTHINGTON PUMP & MACHINERY CORP., New York, announces that in addition to its lines of hydraulic machinery it can furnish improved water-power machinery of all capacities for low, medium and high head service, including oil pressure system, water wheel governors and other auxiliaries. It is equipped to produce hydraulic turbines, and an experienced staff has been secured to take care of this department.

THE JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J., announces that George E. Long, senior vice-president, is retiring from that office, but will continue as a member of the board of directors.

THE ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, reports a repeat order for a 1½-ton Greaves-Etchells furnace from Charles Bertolus, St. Etienne, France; a new order for a G-E ½-ton electric furnace for A. Hamilton & Son, Cardiff, for the manufacture of castings; and the closing of a contract with the Emery Steel Co., Baltimore, Md., for an electric furnace of new design for annealing steel castings. Announcement is also made of an electrode cooling ring and economizer, which effectively prevents the ignition of the hot gases escaping from the furnace roof. The net result of this is considerable saving in the wear of the furnace roof, and also great economy in the amount of electrodes consumed.

Manufacturers' Catalogs

THE STANDARD ELECTRIC & ELEVATOR CO., Baltimore, Md., has issued a very attractive 80-page catalog entitled "Modernizing America's Industries." It suggests methods for industrial modernization and gives facts that should be of value to officials, managers, production engineers and maintenance engineers. Many illustrations are given, among which are some of the officials of the company, interior of several departments, together with their products, and descriptive matter.

THE READING VALVE FITTINGS CO., Reading, Pa., has issued a catalog of steel and iron flanged and screwed fittings and flanges.

THE W. S. ROCKWELL CO., New York, announces six new publications. No. 209 is entitled "Automatic Hardening and Tempering Furnaces"; No. 210, "Worth-While Facts for Users of Blast Gates"; No. 211, "Saw-Hardening Furnace"; No. 212, "Spring-Fitting Furnaces"; No. 213, "Drop Forging Equipment and Layout," and No. 216, "Factors to Be Considered in Heating and Cooling Steel." The last publication mentioned has been written for the benefit of the man in charge of shop operations, and attempts to express the principles governing heat-treatment work.

THE STEERE ENGINEERING CO., Detroit, Mich., announces three pamphlets, on electrically welded steel pipe and fittings, cooling coils, and welded steel piping.

THE HIRES TURNER GLASS CO., Philadelphia, Pa., calls attention to a very attractive catalog on "Glass for Every Industry." This catalog, which deals with "Lighthouse" quality glass and accessories, is published in four languages: English, Spanish, French and Portuguese, and has been prepared for the convenience and information of purchasers. Complete information and illustrations are given for glass for building and other accessory purposes, including plate glass, window glass, wire glass, rolled glass, "Saftee" glass, etc.

THE NEW YORK TESTING LABORATORIES, New York City, is distributing a four-page folder on Metallurgical Service.

THE STAR BRASS WORKS, Chicago, now has ready for distribution a 24-page bulletin, 4-A, covering spray cooling equipment for the cooling of water from steam and ammonia condensers. This literature gives illustrations of many recent installations, in addition to information respecting spray cooling systems for power and industrial plants.

THE DURIRON CASTINGS CO., Dayton, Ohio, announces Bulletin 111, on comparative tests on vitrified tile pipe, lead pipe and Duriron pipe, conducted by the testing laboratories of the school of engineering of Columbia University, November, 1919.

WILLIAM GAERTNER & CO., Chicago, Ill., calls attention to two catalogs. Catalog M illustrates and describes instruments of precision, such as measuring microscopes, comparators, cathetometers, etc. Catalog L, on optical instruments, illustrates and describes spectrometers, spectroscopes, optical benches, photometers, etc.

THE WHEELER CONDESER & ENGINEERING CO., Carteret, N. J., has published the 1920 edition of Steam Tables for Condenser Work. The book gives the properties of saturated steam from 29.8-in. vacuum to atmospheric pressure in increments of tenths of an inch. The vacuum in inches of mercury is referred to a 30-in. barometer. This method is of course superior to the old method of giving absolute pressures in pounds per square inch, since it is customary to read vacuum in inches of mercury. A complete table is also given of the properties of saturated steam above atmospheric pressure. The pressures below atmosphere have been especially calculated for this book by Prof. Marks.

THE BRIDGEPORT BRASS CO., Bridgeport, Conn., has prepared a book on "Brass." The book, which is most excellently printed and illustrated, describes in detail the art of brass making, dating back hundreds of years, leading up to the most modern practices as in use in the Bridgeport Brass Co.'s plant, including the electric casting shop. The important steps in the making of tubes, sheet, rods and wire are also shown. Following a full description of the modern methods of manufacture, which includes some details of methods not commonly found in print, the properties of brass are briefly noted as they are affected by composition, cold-working and heat treatment. This section should assist engineers in drawing specifications. In the compilation of this work the company has deviated from fixed conventions and traditions of the brass industry by making an open book of the practices and processes of brass making. It is extremely well written, and there are few even who have been associated with the brass industry for years who would not find it a valuable addition to their library.

THE METAL & THERMIT CORP., New York, has issued a third and revised edition of its pamphlet entitled "Laboratory Experiments With the Thermit Process of Welding." This pamphlet is useful as a guide for acquainting students with the substance, characteristics and results of the Thermit reaction. The pamphlet illustrates and describes various experiments which are intended to show the speed of the reaction, the heat produced thereby and the effects obtained by the superheated liquid slag and the superheated liquid steel.

WILLIAM R. PERRIN & CO., Chicago, Ill., calls attention to a new pamphlet on filter presses. This four-page pamphlet illustrates and describes filter presses of various designs, gives a table of sizes, working pressure, weights, etc., filter presses with square plate and frames, and a separate sheet is inclosed on recessed filter plates and flat filter plates and extension frames.

NATIONAL ENGINEERING CO., Chicago, Ill., has published a catalog on the National Screen Separator, which contains eight pages of illustrations and descriptive matter.

BAUSCH & LOMB OPTICAL CO., Rochester, N. Y., calls attention to an attractive 64-page catalog on Photographic Lenses. Many interesting illustrations are given, together with descriptive matter.

EDWARD R. LADEW CO., INC., Glen Cove, N. Y.: "Ladew Leathers" is the title of a 56-page book which illustrates and describes different kinds of belts, with price lists, automobile leathers, whole leather, leather packings, pump leathers, leather shafting rings, rub roll aprons, mill strapping, etc.

THE BLAW-KNOX CO., Pittsburgh, Pa., started in April, 1920, the monthly publication of *Blaw-Knox Life*. The May issue is out now and both issues are very interesting.

THE PFAUDLER CO., Rochester, N. Y., has issued a 32-page booklet, Bulletin C-5, on glass enameled steel equipment for the chemical industries which is designed to give a comprehensive idea of the application of glass enameled steel equipment and apparatus to the manufacture and handling of corrosive and sensitive liquids. Each illustration shows either a standard type or a characteristic feature.

ALLDAYS & ONIONS, LTD., Birmingham, England, is issuing a 4-page pamphlet on Oil-Firing for Boilers, which deals with its patent oil burners, giving diagrams and full particulars of a number of characteristic conversions to liquid fuel.

THE GRISCOM-RUSSELL CO., New York, is issuing Bulletin No. 902, on Multi-whirl Cooler, which is for the cooling of oil used in the lubrication of turbine bearings, reduction gears or quenching oil in the heat treating of steel. In either case the oil is constantly circulated through the cooler, thus maintaining the oil at a constant temperature and permitting the continued use of the original quantity of oil and its maintenance at the proper viscosity for efficient results. The apparatus takes its name from the whirling path of the oil, which path is accomplished by the use of the helical baffle which directs the oil in its flow without appreciably retarding its progress. This baffle also serves to bring the oil into intimate contact with the cooling surface and it insures a high rate of heat transfer. The shell is of cast iron and the tubes of seamless drawn brass or copper, expanded into a fixed tube plate at one end and into a floating head at the other which latter permits expansion and contraction without strain on the tube joints. The cooling of quenching oil insures maintenance of the quenching bath at a fixed temperature and also permits the use of cheaper grade oil.

THE DU PONT CHEMICAL CO., Wilmington, Del., is distributing a booklet entitled "The Way to Increased Production," which gives some facts in regard to the company's gigantic sale of war surplus material. Although the book is by no means complete as an inventory of the matrial on hand, it nevertheless does give an idea of the mountains of supplies handled by this organization. The du Pont Chemical Co. took over the supplies and equipment of the war plants of the du Pont Co., and some idea of the magnitude of the work involved can be had when it is considered that the inventories of the various plants developed something more than 70,000 cards, consisting of from one to a dozen separate items. In all, it was found that there were more than 500,000 different items of material and equipment available for sale, and these include an enormous range of articles in daily use, covering a little of everything, from pins to platinum. General machinery of all kinds is on hand, and there is also special machinery built for manufacturing purposes peculiar to the powder business but which can, in many instances, be used in other industries with slight changes. The du Pont Chemical Co. is now engaged in a national advertising campaign to sell these materials and the stocks are moving fast. The pamphlet ought to be a valuable handbook for buyers in every line in the present state of the market.

EIMER & AMEND, New York City, has issued two new bulletins. Bulletin No. 268 is entitled "The Hortvet Cryoscope," which is of importance in the testing of milk. Bulletin 269 is entitled "American Rotary Vacuum Pumps and the MacLeod Vacuum Gauge."

NICKLE ENGINEERING WORKS, Saginaw, Mich., announces a new bulletin entitled "Agitator Driving Yokes," a standard power transmission device—made in several styles and sizes—for driving agitator or stirrer shafts in chemical tanks and kettles. Illustrations show how these driving yokes are mounted on both open and closed containers. A table of dimensions, convenient for draftsmen, is also given.

H. R. WAHL & CO., Chicago, Ill., has published a catalog describing a new type of machine, adapted to such work as dewatering, classifying and washing ores or other granular material, known as the Wahl dewatering machine.

THE JOINTLESS FIRE BRICK CO., Chicago, Ill., is distributing a booklet entitled "General Information for Installing Plibrico Jointless Fire Brick."

THE ESTERLINE CO., Indianapolis, Ind., in the *Esterline Graphic* treats the subject of Graphic Instruments in the Field of Transportation. The company says that many people think a curve drawing meter is a delicate, sensitive instrument which must be handled by an expert with the greatest care, but that the Esterline graphic instruments have given satisfactory service under the severe conditions as described in this pamphlet.

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

L. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Industrial Editors
J. S. NEGRU
Managing Editor

Volume 22 — New York, June 2, 1920 — *Number* 22

A Dollar for War, A Penny for Progress

APPROPRIATIONS for the fiscal year ending June 30, as given in the regular supply bills and three deficiency bills in Congress prior to that date, show the national budget to amount to about 5⅔ billion dollars, really a huge sum when most of us can remember the political hullabaloo raised by the first "Billion Dollar Congress." But the size of it, staggering as it is, is not so important as its distribution, as has been brought out very forcibly by Dr. ROSA of the Bureau of Standards.

He arranges the budget into groups. In the first is found expenditures on account of previous wars and our military establishment. Another group covers primary governmental functions—the executive, judicial and legislative. Next comes public works—rivers and harbors, buildings, reclamation and parks. A fourth includes research, educational and developmental activities, such as in the Agricultural Department, Geological Survey, Bureau of Standards and Bureau of Mines, Library of Congress, Public Health and Vital Statistics. Last comes self-supporting activities such as Post Office, Patent Office and Land Office. Tabulating:

Wars	$5,280,000,000	or	93 per cent
League of Nations	0		
Governing	181,000,000	or	3 per cent
Public Works	168,000,000	or	3 per cent
Development	57,000,000	or	1 per cent
Self-Supporting Offices.	balance		
Total	$5,686,000,000	or	100 per cent

For destruction 5,280 millions and for development 57 millions! "A dollar for war, a penny for progress"—a slogan for 1920 perhaps worthy of a place alongside PINCKNEY'S "Millions for defence, not a cent for tribute!" Rather than increase the burden of taxation, the Congress is unable to afford an expenditure of more than 9 cents per capita on the Bureaus of Plant and Animal Industry, 2½ cents on the Bureau of Mines and Geological Survey, 3½ cents on the Bureaus of Standards, Fisheries and Foreign and Domestic Commerce, and the same amount on Public Health Service. Particularly adequate appears an expenditure for education of 7 cents per capita by a national government, one million of whose drafted soldiers could not read and write!

It requires little argument to convince technical engineers that research pays. It requires as little to get an admission from any American that education pays. The moot point is whether the United States Government should finance the research, or how far it should go in supporting education. The determining answer seems to be that it can and ought to proceed energetically along those lines which are basic or fundamental—applicable to many activities of various nature and differing magnitude. The individual farmer cannot of himself experimentally determine the exact advantage of a potash fertilization—his state agricultural school is more likely to be working along those lines if he happens to live in the South. If he lives in the North he will naturally turn to the national Department of Agriculture for an unbiased opinion on his problem.

Similarly in metallurgy and chemistry. Who is interested in collecting data on little-known natural resources with only a remote chance of quick financial reward unless it is the Bureau of Mines? Could one get a better opinion on the proper pyrometer for a certain problem from Dr. BURGESS or from an instrument maker specializing in thermocouples? Where does the chemist go when he wants a certificate of accuracy for a fine thermometer?

Illustrations might be endlessly multiplied to little point, since each individual reader is familiar with one or more of them. Dr. ROSA presents an almost unanswerable argument to the lay mind, however, which ought to be widely used when occasion warrants. Starting from the premise that the Government should be constructive and helpful to the people and to business generally and without regard to condition or location in order to establish good relations, elevate business methods, increase efficiency and the general joy of living, it certainly seems that 1 per cent of its total expenses is a very small proportion in view of the economic value of the work. But even a considerable part of this miserable pittance is consumed by activities on behalf of the Government itself—in routine tests and investigations. Even here the Government would spend far less for its purchases if it spent more in standardizing and specifying those purchases and systematically testing the deliveries. Apart from the service the Government can render in educational work, all its scientific and developmental work develops wealth multiplied like fruit from seed. There is now required many times the revenue formerly needed; expenditures for development, however, lighten taxation by largely increasing the taxable wealth. It is as productive and profitable in peace as in war. It constitutes a standby reservoir of unsuspected potential possibilities.

Finally, if the reasons are not already sufficient, there remains the military reason. Who denies that Germany was so hard to beat because she was so well prepared technically? On our part, the development of our intellectual, moral and material resources was a thing consuming time, and costing many, many priceless lives, yet, as the event proved, more indispensable to final success than the initial equipment of armies and fleets. The conclusion is irresistible that a Government that pays great attention to education, research and industrial development is making the best preparation for possible wars in the future. It tends to prevent war, and so pays for itself twice over.

What will our children's judgment be of men who had nothing for a League of Nations, and but 1 per cent for construction?

Another Case Of Secrecy

THERE has just come to attention another instance of unreasonable and wholly unnecessary attempt at secrecy on the part of a certain prominent firm in the metallurgical industry in this country. This corporation has gone to the extreme in having all its plant equipment and machinery built in its own machine shops for the avowed purpose of preventing any outside interests from securing even a clue as to the methods and appliances used in its plants.

We much deplore any policy like this and do not hesitate to criticize the attitude of mind which gives rise to such methods. Under no circumstances can an industry expect to profit permanently by such policy. A free exchange of information and a very general knowledge of and interest in plant processes are the best possible means for encouragement of additional development of the art and industrial advancement of the manufacturing plants engaged within the field in question—indeed, within any line of activity.

No company can afford to take such a stand as this corporation in question. It is out of the question for any one company to know so much about a particular process, metallurgical, chemical, or what not, as to be unable to learn more if research and development are encouraged on all sides. Concentration of industry is desirable up to the point sufficient for best efficiency; but there is no reason for feeling that a reasonable measure of publicity is the occasion for undue competition. If any element of an industry cannot succeed despite a certain measure of competition, because of its greater skill of management or more rapid adaptation of science to the plant process, CHEMICAL & METALLURGICAL ENGINEERING is heartless enough to believe that it does not deserve to succeed. This narrow-minded metallurgical concern is making a success of its manufacturing operations; but we should much prefer to see this success by a frank, open policy rather than by the means which it apparently desires to use.

Chemistry Conquering Another Industry

THE fertilizer business has been very negligent of all branches of chemistry in times past, but we can be much encouraged to see that it is rapidly being convinced of the need for chemical control. One large manufacturer is quoted as saying recently, "Why, we have to analyze almost every shipment of phosphate rock which we receive these days." And the interest in the analysis is by no means confined to the phosphate, for with the present scarcity and high cost of the nitrogen and potash supplies it is increasingly necessary to make accurate determination of all the materials used and the products shipped.

In writing of the present fertilizer situation, Dr. WHITNEY well says that there is an active change going on at the present time converting a sort of "scavenger business" into a true chemical industry. This progress should be accelerated, too, for the urgency of the national food situation will place new burdens upon the fertilizer manufacturer which he will be ill prepared to bear without the best of support by all branches of the related sciences. Thorough knowledge of the materials and processes used will give added power to meet these new demands; and surely there is no more promising means for gaining this added knowledge than through full chemical control.

In this advance within the factory for the production of fertilizer a still larger need for investigation of methods of fertilizer use and application is co-existent. The possibilities of many fertilizer materials coming on the market in the form of practically pure chemicals must be taken into account by the agriculturist. If he can be supplied with the needed amounts of potash, phosphorus and nitrogen in usable form as pure salts, what is the farmer expected to do with them? Thus far the practical application of fertilizer to the soil has been based upon the supply of useful elements mixed with a bulky mass of much less, or in some cases no, fertilizing value. To change from this method the farmer must learn to use the salts in an entirely different way. It immediately is suggested that as all these salts are readily soluble they should be applied in solution. This is all well enough for some of the crops, and this plan might easily be adopted where correct sprinkling facilities are available, as is generally the case in the tobacco-growing districts. But the wheat or corn grower has no such equipment, and a new practice will therefore have to be introduced. It does seem, however, that the possibilities of such complete change as this are not at all out of the question, if we can supply these materials at prices that are attractive to the user.

Stop, Look, Listen, And Keep a-Looking

ONCE more the season of the year has rolled around when the seniors of college are graduated into freshmen of life. In the main they have been taught to listen attentively and absorb everything they have been told in a very credulous manner. The closer they have confined themselves to the details embodied in their courses and the more intensively they have imbedded these few facts in their memory, the greater has been their reward in grades and honors. However, in the school of life, other factors in addition to listening and concentrated attention control the attainment of success. The most important of these is zealous looking and believing better after seeing. Of course this must not be construed that before reaching sophomore requirements in the great world college our credulous freshman must turn into an incredulous, absolute Doubter. But he must have a sense of weights to attach to what he believes, which for want of a better word to embody the idea may for the present be called scruples. When he gets experienced in scruple determinations, he should be classed as a junior and in the interpretation of the weights he has no doubt qualified for the senior class of the school of life.

Now, the world college does not care much about the annual cycles and has no semesters, lecture periods or terms. A man may spend his life in the freshman class or he may ascend into the higher classes almost immediately upon matriculation. There are no flunks, but just promotions, and these only to whom they are due.

All of us unconsciously grade the men we meet day by day. As a personal example, making editorial calls upon men engaged in the industries with which this journal is concerned, after getting sufficiently acquainted, the most desired information is to get his scruples of belief on various topics, especially on those the journal

is printing relative to his field. If he says something to the effect that if all the articles are as full of bunk as such and such a one, which he happens to believe he is entitled to criticize adversely, he is at a loss to know whether to put his entire confidence in any of those articles with which he is only slightly familiar, he is immediately graded out of the freshman class. If he shows a degree of tolerance for the views of the author with whom he disagrees, he has passed through the sophomore class and if he can show better logic in his own channels of thought and not be a mere shallow advocate, he has certainly reached seniority.

This same idea may be expressed chemically and for those not mathematically inclined we will now substitute the salt content for the scruple. How much salt do you, Mr. READER, add as a condiment to the stuff with which you feed your brain? If you don't add any, it is probable that you have a poor mental digester and your brain is nothing more than a warehouse for the facts that someone else is generous enough to think out and store with you. If you are too liberal with your salt and add it in great quantity, it is likely that you have a pork barrel on your shoulders instead of a regular head. You'll need a soaking out or you'll wilt everything new and fresh that you touch.

The man who takes the time to listen and look certainly has the best chances for success. In reading technical literature, his attitude should be that of a listener in an audience of sixty or seventy thousand, several of whom have dared to speak out in meeting. If he has never contributed, he will probably not know how to interpret properly the spirit of the author. If he has contributed, he will stop, look and listen, and if the ideas conveyed in the article interest him, he will keep a-looking and develop them.

Chemistry Gone Wrong

WE LATELY saw a piece of silk that had an interesting history. As raw material there were sixteen ounces to the pound, but after washing this was reduced to twelve ounces. In order to avoid confusion by the higher mathematics of the silk industry, let us keep in mind this pound of raw silk that weighed, first sixteen ounces, and then twelve ounces. The twelve-ounce pound was passed through a bath of stannic chloride and afterward through another bath of sodium phosphate. These baths were repeated alternately a considerable number of times, after which the silk received a bath of aluminum sulphate to swell the fiber. Then back it went to the tin and the phosphate baths again, to charge the swollen fibers with more loading. Then it had treatment in another bath of silicate of sodium. After this it was dyed a fine rich black with logwood, which added more weight. The final treatment was with oil, to give it luster. The result was ninety-six ounces of beautiful black "silk," of which twelve ounces were and eighty-four ounces were not.

Just how long stockings that are made of this fabric will last is a subject for speculation, but the merchant that guarantees that the fibers are all silk and that the stockings contain no cotton is right as to the facts, although the truth may be strained in the exposition. He shows sound business judgment in refusing to accept the return of goods after they have been worn.

The Simple Life For Some Employers

IN THESE times of varied talk and opinions on the labor situation, such as befog the mind of the observer to the despair of any real decision, comes the clear-cut statement of WHITING WILLIAMS, who has spent seven months of investigation among the common laborers in many steel plants and coal mines throughout the country. His research has been made recently and consequently his opinions carry more weight than those of men formerly associated with the laboring class who have grown away from the viewpoint of the worker and become corpulent in purse and body from the general development of industry.

Mr. WILLIAMS says the average common laborer wants first a steady job; second, living conditions permitting full rest when off duty, and third, education in what the employer is trying to accomplish. Briefly and plainly, he requires "joy in his job." It would seem comparatively easy to bring about this condition for the laboring man if the employer has a touch of human nature in his make-up. Let the boss forego too much criticism, although it may be merited in many instances. Let him study his business to keep the supply of work uniform throughout the year, and lend every aid in improving housing and living conditions for his men.

The thing that strikes home forcibly, however, is that the laboring man must feel the importance of his part in the economic structure. The enthusiastic scientific management expert with a goal wherein each man handles only one small operation has carried things to a point where effort has become purely mechanical. The human factor and true craftsmanship have suffered. A large fraction of a man's life is lived at work, and if pleasure cannot be found therein, he becomes useless alike to himself and employer, with a mind filled with bitter resistance.

The situation calls for human sympathy without patronage on the part of the employer, and if he cannot operate on this basis with profit, it is far better that his factory be turned over to someone else or the doors closed.

Fate of The Dye Bill

THE dye bill (H. R. 8,078) is breathing heavily but is not dead yet. Senator THOMAS of Colorado talked against it for nearly a week. Other champions of liberty who lend their voices to importers or to those textile manufacturers who would rather get their dyes cheaply than have their country independent have announced their intention to "speak at length" against it. This indicates an organized filibuster, but it also indicates that if it comes to a vote, it will pass. Much depends on whether Congress adjourns or takes a recess.

It is reported that the European Allied governments have decided to stop supervision of the German dye industry and have consented that Germany may supply as much of the world's dye needs as she can for the next five years. It is also said that the dye industries of England and other Allied countries have failed to keep pace with the development in the United States and they fear that the United States might get as definite a lead as Germany had before. The sales of American-made dyes to Latin America alone in 1919 totaled $3,100,000. And this, according to a bulletin of the Chemical Foundation, is merely the beginning.

Readers' Views and Comments

Microstructure of Iron and Mild Steel at High Temperatures

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with interest the editorial on "Extrusion or Diffusion" in the April 28, 1920, issue of CHEMICAL & METALLURGICAL ENGINEERING. I am inclined to believe that the casual reader will credit Mr. Scott and myself with much more than the results of our work will justify. We did not intend, as the reader of this article may be inclined to believe, to discredit Dr. Howe's general theory. The evidence he has is too strong to be lightly brushed aside. We did wish to show, however, that in the case with which we were dealing, i.e., steel heated for a considerable period at high temperature and in vacuo, the conditions which then prevail offset any such result that Dr. Howe's theory requires. The reference made to Dr. Howe is to a particular application which he made of his theory in explaining the apparent decarburization of specimens used for thermal analysis under the same conditions as our specimens were heated and not to the theory in general. The conditions which prevail in an enclosed internal cavity are quite different from those at the outer surface of a specimen heated in vacuo; many of Dr. Howe's best illustrations are of specimens showing the condition at the surface of internal cavities.

Washington, D. C. HENRY S. RAWDON.

What Does the General Electric Get Out of It?

To the Editor of Chemical & Metallurgical Engineering

SIR:—One night last week as I sat in the smoking room of a sleeping car there came in, first an elderly man, well preserved and apparently prosperous, who turned out to be the principal stockholder in a zinc company. Then appeared a younger one, an engineer, returning home after installing some machinery in the West. We were the only occupants of that room that evening, and in time the old gentleman began to talk. He started in with such a tirade against the Government that his critical faculties became unusually sensitized, and, as he liked to hear himself speak, he soon developed his art to cover a larger field. His animus against President Wilson seemed to have its origin in the fact that he had been a college professor as well as college president, and this led to an expression of keen distress that we have become no less than a professor-ridden people.

"They're all tarred with the same stick," he exclaimed, "and the trouble is catching. Now it's cropping out in industry. Wherever you go they want some damned professor to butt in. I got no use for 'em. One manufacturer after another is beginning to blow about his old labbatory and a lot of overhead charges that increase the cost of everything. First it was the General Electric Co. and now the Westinghouse and a lot of other little concerns are about as bad; but I got it in for the General Electric because I hold that they started it. They make good machinery—and so do the others—but whenever I buy anything from them I got to pay for their old labbatory when I settle the bill. Either they know their business, or they don't, and if they don't why can't they get some practical man to teach 'em? Who's this Dr. Whitney of the General Electric that they make such a fuss over? Some big college just gave him a gold medal—because he hires a lot of their professors to work for him, I suppose."

"Ever meet him?" asked the engineer.

"No; an' I don't want to," replied the man of zinc. "I bet he couldn't sell a ton of spelter if he took all day at it! And I'd ruther have a good gang of smeltermen with a reliable foreman over them to run my plant than all the Whitneys in the world. As for that fella Langmore [he persisted in calling him Langmore, so he probably was not of Scotch descent], he sure does make me tired. He goes down to Washington and talks by the hour to a lot of professors, and even they can't understand him! What's all this piffle got to do with making machinery anyway? Ain't he supposed to work for the company?"

"Well," remarked the engineer, "they seem to think it pays. You know, they made tungsten ductile, and that improved the electric light service. There was something worth while, wasn't there?"

"Say, every time anybody invents something they give the labbatory credit for it. I'll bet dollars to doughnuts some practical man did the inventing."

"I believe Langmuir had a hand in it," suggested the engineer.

"Aw, don't talk to me about Langmore; he's the worst of the lot. All he done, I'll bet, was to come around and bless it after it was invented. It's like the minister that baptizes a baby and then thinks it's his. He's no more practical than a college professor. He goes down to Washington, as I said, and makes a great hullabaloo over particles that are so small they ain't got no size to 'em. Then him and all the other roosters crow over it. It's nothin' but a lot of damned showin' off; that's all it is!"

"But," remonstrated the engineer, "it seems to be a step toward the better understanding of the phenomenon of light, and if we could only master that it might lead the way eventually to the discovery of a light motor. That would be something practical, wouldn't it?"

"Practical your grandmother! It's tommyrot. Thomas A. Edison invented the electric light. I'll admit that. These other fellas is jealous, and they're tryin' to pull themselves up by their bootstraps. That idea of a light motor is just about the worst I ever heard. Right in line with perpetual motion! Look here; it takes power to make light, but you can't get power from light. That's as bad as runnin' down hill to climb up!"

"Well, it's only the fossil energy of the sun we use when we burn coal, as Prof. Cimician said. It would be more economical to get it direct. That stands to reason, doesn't it?"

"I don't doubt it stands to the reason of this Prof. Shimmy, or whatever his name is, but you know as well as I do that it ain't practical. You might as well use windmills."

"I've often thought we might use windmills more than we do. Some day we may have sense enough to come back to them. But let's come down to something more familiar. Take the smelting of zinc, for instance. Doesn't that need research?"

"Now I think I know what I'm talking about when it comes to zinc, and I tell you it don't need research or any other monkeyshines to smelt it. *We know how to do it,* and have since your granddaddy was your age. You just put that in your pipe and smoke it!"

"Yes, but the furnaces are very small, the design is antiquated, the physical chemistry of the reactions is hardly studied, and the waste of heat in smelting zinc is out of all reason compared with smelting copper or iron. Wouldn't it be worth while to cut down the cost by gleaning some more knowledge of the subject and making practical applications of it?"

"It's easy to see," the old gentleman retorted, "that you don't know anything about the zinc business. We install the best and most economical furnaces that can be designed at a point where fuel is cheapest. That's what experience teaches. That is the practical fact, and it is not theory. No, sir; all that's needed in the zinc business is to keep up the price of spelter. Then we'll make you all the zinc you want. I'm going to bed. Good-night."

And to bed he went. But somehow I felt drawn to that engineer. I asked him to stay until I returned with my satchel, to which he agreed. In it I had a little legacy from a dear aunt who had often been a source of inspiration to me, but who has passed from us. I refer to Mrs. Ethel L. Cohaul. I shared my legacy with him. MARTIN SEYT.

Spark Coil for Explosion Pipettes

To the Editor of Chemical & Metallurgical Engineering

SIR:—In these days of the high cost of chemical equipment any substitution that can be made in the interest of economy which does not result in impairing efficiency is apt to receive a hearty welcome. Doubtless the following idea has occurred to many other chemists, but as I have not yet seen it in print I hope that some others will find the substitute to work as well as I did.

Some time ago the writer had occasion to direct some work involving a number of analyses of combustible gases. A gas analysis apparatus of the Steel Corporation type was available, but it was impossible to get a spark coil for it without some delay, and some sort of substitute must be sought.

A Ford spark coil proved the solution, and, needless to say, it could be purchased at once. These coils will give a spark of at least $\frac{1}{4}$ in. under the pressure in the cylinder of the car at the moment of explosion and at atmospheric pressure the spark will be about $\frac{3}{4}$ in. long —plenty long enough for this sort of work. We found two dry cells adequate for the primary current.

The only adjustment required is some sort of a clip to make contact with the disk on the side of the coil, and various ways in which this may be done will suggest themselves to the reader. As simple a way as any is to fasten a piece of spring steel or of brass across the disk with screws in the wood casing. This clip will hold the leads in contact with the terminal. This type of apparatus, according to our experience, is just as satisfactory as any Ruhmkorff induction coil and considerably cheaper. GEORGE S. TAYLOR.

Holyoke, Mass.

British Chemical Industry

(FROM OUR LONDON CORRESPONDENT)

London, May 7, 1920.

THE question of wages of workers in chemical industries referred to in my last article[1] has been settled for the time being, the Chemical Industrial Council having conceded an advance of about $2 per week plus 12½ per cent. The negotiations were prolonged and difficult owing to the attitude of a small section of extremists among the workers. Fortunately for the industry, the manufacturers' representatives possessed a lengthy and intimate knowledge of labor and in some cases were specially released from highly technical and executive appointments for the good of the industry as a whole. Although there is some hope that there will be a peaceful interval, the situation is really dominated by the activities of other trades unions, which are displaying considerable rivalry in securing the best possible terms for their members, with the result that a concession to any one union immediately brings in its train, irrespective of existing agreements, further demands from others whose jealousy and cupidity have thus been aroused. It is felt that unless industry as a whole combines to put a stop to this procedure, wages and prices will rise to such an extent as to render something in the nature of a miniature revolution inevitable, and it is small comfort that conditions in the United States and elsewhere are shaping in a similar manner.

"CHEMICAL TRADE YEAR BOOK"

This buyer's guide, which is a descendant of the "Trade Directory" last published by the *Chemical Trade Journal* in 1911, has just been issued at the price of 10s. by Bandon & Morris, of 17 Red Lion Passage, London, W. C., 1. In conjunction with the official directory of the Association of British Chemical Manufacturers, it will no doubt be of service to American merchants and manufacturers, although it cannot be described as either representative or complete. The Directory of the Association of British Chemical Manufacturers is obviously issued solely in the interests of its members, while the "Chemical Trade Year Book" not unnaturally consists essentially of those firms that have paid for advertising space. To be really complete and of value, such publications should be more on the lines of the American "Green Buyers' Guide" or the "Chemical Engineering Catalog," the former of which is particularly comprehensive and complete and is, moreover, issued free of charge. In addition, many of the firms quoted are often not the actual manufacturers or agents, but are acting as "ghosts" to others. It is hoped that this note will be of some service to American firms that may have occasion to consult such directories.

MR. BARTON BOOMS THE CLAUDE PROCESS

Evidently as a counter-blast to the official announcement of the acquisition of the government synthetic ammonia factory and interests by the Brunner Mond syndicate, the merits and prospects of the Claude process have just been advertised in the daily press.[2] It will be remembered that the Claude process consists essentially in the use of very high pressures of up to 1,000 atmospheres as against the 200 atmospheres previously employed, greatly increased yields and a substantial

[1] [illegible] MET. ENG., vol. 22, p. 837 [illegible]

[2] [illegible] MET. ENG., vol. 22, p. 481 [illegible]

reduction in the quantity of catalyst required being claimed. According to Mr. Barton's announcement, it is proposed to form a company known as Atmospheric Nitrogen & Ammonia Products, Ltd., with a capital of $10,000,000 and to erect a synthetic ammonia plant in Cumberland adjoining a large coke-oven plant owned by the same company. Interesting features are the announcement that the necessary supply of hydrogen will be obtained at a very cheap rate by special treatment of producer gas and that it is intended to place on the market, as a new type of fertilizer, ammonium chloride derived from synthetic ammonia, instead of ammonium sulphate, as in the case of other manufacturers in this branch of the nitrate field.

Status of Chemical Market

There has been practically no change in the chemical markets during the past month, but it cannot be stated that supplies are as yet approximating to the demand, particularly in regard to heavy chemicals and such items as formaldehyde, acetic acid and acetone. Mercury has also been a strong feature, but prices now show a downward tendency. As regards dyestuffs, there is still a shortage and great difficulty in making this up from Germany owing to the reduction in output due to shortage of coal in that country.

Future of Explosives Factories

The enormous cordite and explosives factory at Gretna will probably be continued and the original government factory at Waltham Abbey dismantled. In addition, it is proposed to use the ether-alcohol plant at Gretna for the purification of commercial methyl alcohol, and it is hoped that there will be an adequate demand for this from the dye, medicinal, photographic and other chemical industries, and also for ether, possibly in connection with the development of power alcohol. In regard to the latter, extensive new laboratories and a special staff of assistants are being provided for the government chemist and experiments are to be carried out on manufacture from vegetable substances and in regard to denaturing. The problem of finding peaceful uses for munitions factories is gradually being solved, and small arms, ammunition and fuse works are turning their attention to mechanical and other toys, clocks, sewing machines and the like, while Kynoch's large works at Arklow, in Ireland, are to be used for the manufacture of artificial manure in conjunction with the development of the Avoca copper mines. The new company is to have a capital of about $12,000,000.

Conference of Chemical Engineering Group

The third Conference of the Chemical Engineering Group dealt with labor-saving devices in chemical works, and while the papers presented were on the whole somewhat mediocre, they serve to focus attention upon the growing tendency of British manufacturers to eliminate manual labor wherever possible. An interesting point brought out during the discussion was the extensive use made in Germany of pneumatic conveying of materials and chemical substances, hot air being sometimes used with the object of simultaneously drying the material on its way from the hydro-extractors, etc., to the packing room. The subject of the next Conference in July at Newcastle is to be filtration, a subject which has not received the same careful attention in this country as in America, owing to the more restricted field for continuous and automatic appliances. It is, however, interesting to note that Vickers has recently undertaken the manufacture of the Gee type of centrifugal filtering and grading machine developed by Centrifugal Separators, Ltd., and that these machines are being extensively introduced in the china clay industry, in paint and composition works and even for the separation of sludge from sewage and the waste liquors and outfalls of chemical works. The machines not only filter but grade the precipitate, and their chief disadvantages appear to be the impossibility of washing the precipitate and discontinuous operation, difficulties which are likely to be overcome.

Colloidal Fuel

Another new company to exploit this process is a private one, the United Oil & Coal Corporation, Ltd., and it is rumored that L. C. Harvey, the European manager of the Fuller Engineering Co. of America, is a director. G. C. Calvert of the Metropolitan Laboratories, London, is stated to have patented similar mixtures under the name of "Colloil," while in regard to the application of these mixtures to railway work, experiments are being conducted by J. G. Robinson, chief engineer of the Great Central Railway Co. The latter have proved very successful, giving results fully equal to the use of bituminous coal, and it is stated that Mr. Robinson has developed a new type of burner, the dust and oil being mixed at the burner instead of previously, thus eliminating the use of a fixateur or peptizing agent.

Personal Notes

Sir Henry Birchenough has been appointed chairman of the British Dyestuffs Corporation in place of Lord Moulton, whose advanced age and heavy judicial work prevent him from continuing his work in this connection.

Prof. Henry Louis has been appointed foreign secretary of the Society of Chemical Industry in place of Dr. R. Messel, F.R.S., whose death last week is universally regretted.

Sir Richard Glazebrook is the first president of the new Institute of Physics, which has just been founded by the co-operation of the Faraday Society, the Optical Society and the Physical Society of London.

An Anglo-American amalgamation may be recorded, the British interest of the Monsanto Chemical Works, St. Louis, having amalgamated with R. Graesser, Ltd., of Ruabon, North Wales, under the style of the Graesser-Monsanto Chemical Works, Ltd.

Italy to Use Explosives in Agriculture

With a view to disposing of the surplus supply of explosives and at the same time benefiting agriculture, a series of experiments has been conducted by the Italian Ministry of War in connection with the breaking of ground. The results have been so satisfactory that it has now been determined to proceed to the practical use of explosives in agriculture on a large scale. In addition to preparing the land for cultivation, it is claimed that the use of certain explosives not only destroys parasites but also to a certain extent reduces the necessity for fertilization. It is proposed to establish in all districts of Italy demonstration fields where trials of the system which has been adopted will be carried out; such fields have already been created in Umbria, Puglie, Tuscany, and the liberated provinces. At the same time, the Ministry of War will turn over the large quantities of available explosives at favorable prices.

Scientific Control of the Filter Station—I

A Discussion on Clarification of Filtrate — Use of Lighter Filter Cloths Made of Open Woven Fabrics Advocated — Form of Solids in Cake Important — Method of Application and Use of Filter-Aids

By ARTHUR WRIGHT, M. E.

INDUSTRIAL filtration, as it has been so aptly put, "is a lowly art." Yet for so many years have rule-of-thumb methods obtained, it is consistent that with the introduction of the modern filter we are beginning to recognize that there are fundamental principles underlying the best operation of these filters. Filtration is no longer summed up in the old adage, "get a good hard cake," but comprises, in addition to clarification, the complete washing of the soluble from the deposited solids, the drying of the cake, thorough discharge of the cake so that the filter medium is maintained in a free filtering condition for recurring runs, and a consideration of pumps, filter cloth and other auxiliaries. It is only when these principles are understood and applied that the filter station reaches its true economy and efficiency.

Much effort has been made to acquaint superintendents and managers of plants with the advantages and fine points of the different types of filters, but inadequate attention has been given to instructing the operators. The results, so often recorded, of machines starting with capacities far in excess of requirements and a month later lacking capacity are due, time and again, to inefficient operation traceable to ignorance on the part of the operator. Superintendents should know the "tricks of the trade" in order to exercise intelligent control, but the operator should be the plant's expert on the particular material being handled and it should not be left to him to learn by graduating from the school of experience. That is too costly. To instruct him is cheaper and not difficult even with foreign unskilled labor.

To go into the detail necessary to bring out the underlying principles would make a single article too long, and it has been thought best to divide this subject into five papers with the separate headings; 1, Clarification; 2, Rate of Flow; 3, Washing and Drying; 4, Discharging; and 5, General Discussion and Auxiliaries. This is the first, on clarification, the others will appear in subsequent issues of this paper.

Clarification

Clarity of filtrate is in the vast majority of cases the primal object of the filter, but, as will be shown later, it is too often over-emphasized. When absolute clarity is not required, a different attack than will be here outlined is often possible.

The number of cases where capillary attraction and adsorptive action are real factors in clarification are relatively so few and far between that this general law can be defined: Clarity of filtration is due to superlative straining of the particles of suspension from the liquid in which they are suspended. This statement will doubtless call for criticism from some quarters, but it is held to be basic by reason of success obtained in handling a large number of problems completely ignoring capillary and adsorptive actions and concentrating solely on straining.

Open Woven Fabrics

The choice of straining or filter medium determines the nature of the straining or filtering. It is the popular belief that woven fabrics effect clarification by surface filtration; i.e., that the solids are caught on the surface of the fabric and build up to form a cake. Such a belief is rational when comparing a woven fabric to a granular bed filter medium. It is obvious that any particle penetrating the surface of a sand bed has opportunity to be caught in the interior of the bed before issuing from the false bottom as cloudy filtrate. Both theories are, however, subject to a liberal interpretation, for we have only to witness the number of times the filter cloth is clogged and not opened even though the surface be hand-cleaned with vigorous scrubbing and the cloth given reverse washes. Or, again, to watch the working of boiler feed-water filters wherein the initial flow is not clear and after running clear can run for a period only before the filter must be cleaned.

The answers are obvious. In the former, solids penetrate into the cloth and are firmly held in the meshes of the cloth—surely not true surface filtration. In the second case, clarification begins only when the retained solids form of themselves a filter medium on the top of the sand bed. The reason that the rate of flow is approximately constant in sand filters is that as the deposit on the bed builds up it has the effect of building up a resistance to the flow, increasing the filtering pressure. At some point this pressure builds up sufficiently to force the deposit through the surface of the sand bed and to work into the interior. Manifestly, if the filter is run long enough, the solids will issue through with the filtrate. In point of fact, therefore, the initial filtration through fabrics approximates filtration through-a-depth and with sand beds true clarification commences with surface filtration.

Surface Films

With the above in mind we have ground for the contention that too many industrial filters are equipped with too dense a filter cloth. Mechanical wear will often dictate the choice of a heavy cloth, but this should not be the signal to use a dense cloth. It cannot be expected that with the use of open cloths the initial clarity will be satisfactory, but it will be found that there is no hardship in refiltering the first runnings. Usually the filtrate brightens up readily and the amount to be returned can be added to the feed of the filter or else run through a separate filter which is used as a "polisher." Local conditions will govern the best means of handling this cloudy filtrate.

It is not practical to equip the filters with a more open cloth or a thinner fabric and not provide for the handling of cloudy filtrate. Absolute clarity can sometimes be obtained with such cloths by working with a low initial pressure, as for instance, gravity feed. There are cases where this is good practice, but as a general rule it is precarious, for it is required only that an insufficient deposit be made on the cloth when the pressure line is opened and the solids are pushed through into the filtrate. The basic idea is that the clarification shall be effected by virtue of the deposit of the solids on the filter cloth rather than that the cloth shall be the real medium. If this be carried out, it will be found that those particles which clog the dense cloth pass through into the filtrate so that the open cloth is maintained in a free filtering condition for recurring runs. This, of course, is obvious and need not be elaborated upon save to consider further the kind of cloth to use.

Use of Double Plies

It must be borne in mind that cotton is a cellulose product and with very few exceptions swells when immersed in liquids. Consequently, weaves that seem quite porous before wetting are quite dense afterward and similarly, loosely woven fabrics that will often seem flimsy when cut upon the table will prove quite substantial in practice. Many investigators have been impressed with the excellence of thin muslins, but have been deterred in their use by reason of their frailty. Such mediums are indeed very efficient, for they effect the nearest approach to instant surface filtration and by reason of the thin yarn from which they are woven do not clog up if their surface be cleaned—not enough thickness to hold solids.

The writer has seen installations where thin cloths were used, but in order to increase their strength two layers were used. This usually proves to be a poor expedient, for the conception that the inner cloth backs up any rent or tear of the outer cloth is not well founded. To obtain this result the two layers should be made integral one with the other by close lateral stitching or by spot pinning, etc. Then the possibility of a wrinkle in the outer cloth occurring at the point where the cloth is broken is decreased, but such a procedure has the same effect as if a heavy single cloth were used and there is no advantage worth the effort.

To prove the futility of double thicknesses of muslin one has but to inspect a filter so equipped that has been in operation a few days and note the accumulation of cake that occurs at the bottom of the leaves or plates. This increases with every run and is accounted for by the fact that the outer cloths are ripped or have "pin" holes, so that the under cloth must do the filtering at such points. More cake builds up than can clear through the hole when the filter is discharged, and this excess works down to the low point of the leaves.

Fabric Re-enforcement Gives Satisfaction

The idea of re-enforcing the muslin so as to strengthen it is good, but the under cloth must be of an excessively open weave such as "hose duck," burlap, cocoa matting or the like. Then any solids penetrating the muslin issue from the leaves as cloudy filtrate. It is amazing to what extent the muslin can be torn and still give good service under such conditions. The length of life of the muslin is then made positively practical even when using those machines that require the cloths to be sewn to the leaf. Diverse opinions have been rendered on this subject, but the writer is much impressed with the working of a battery of Sweetland filters having an aggregate filter area of over 7,000 sq.ft., where, after a thorough investigation was made of this point by several months' experimentation, muslin backed by burlap was used; the life of the muslin doubled, the output increased, and material economies were effected.

What is true about providing for cloudy filtrate when using cotton filter cloths is even more pertinent when using metallic cloths. These fabrics are designed as permanent mediums and their initial cost is justified only by their long life. Consequently, how much more fatal it is to allow these cloths to clog up. Users are the best judges of the delays and trials when caustic, acid and heat treatments are resorted to in order to regain their porosity. So much of this is needless if only provision be made to take care of cloudy filtrate and an open weave of uniform mesh be used. In a later article scale formation and its prevention on metal cloths will be dealt with and should not be confused with this subject of clarity.

Importance of the Form of Solids in the Cake

Much of the above is needless precaution for those handling materials with solids of a crystalline nature. There are niceties in their efficient handling, but there is none in respect to clarification save where some impurities are likewise present, the nature of which is not crystalline. In such cases the above is of positive importance.

A case occurred in a plant where calcium sulphate was thrown down from an acid liquor, but a considerable percentage of flocculent precipitates were present as well. The superintendent and chemist were advised of the advantage of using open cloths and tried them. They reported utter failure; the clarity never did become brilliant. One glance at their cakes as discharged from the filter told the whole story. As every filter manufacturer warns against the formation of tapering cakes due to inadequate agitation in the filter, they were informed on this point, but, in that they were not troubled with poor washing, had no difficulty discharging, and the leaves were not warped excessively, they were not equipped for thorough agitation in the machine. In consequence, with their open cloths the upper part of the leaves was subjected to the work of clarifying the lighter solids that were fine enough to penetrate the filter cloth and did not coat the surface with a substantial deposit. This instance serves to show the relation of agitation to clarity and also illustrates what small, insignificant factors can often be the deciding point between success and failure in this art of filtration.

Use of Filter-Aids

Decantation prior to filtration is often practiced and more opportunities are afforded these days for its use by reason of the excellent record of the continuous types of thickeners. The main advantage of decantation is in increasing the capacity of the filter with the possibility of using continuous machines in place of intermittent types. There are numerous cases where this procedure is eminently advantageous, but in the main it is confined to those materials that readily settle with a satisfactorily clear supernatant liquor. Where the

supernatant needs further clarification, the usual experience is that such a procedure is really "two bites at a cherry," and the clarification of the decanted liquor with its finely divided particles is a matter of nice control if anything approaching efficient operation is to be had. This clarification is made far simpler, however, if the solids are waste products such that a filter-aid may be added without chemically affecting the filtrate.

The use of filter-aids as agents assisting clarification is rightfully being recognized as efficacious, and they are being employed more and more. A filter-aid, whether the specific products on the market or a waste industrial material such as calcium sulphate, calcium carbonate, sawdust flour, pulverized bone-black, etc., must have three main properties. Its specific gravity must be such that when mixed in water or the liquid being filtered it will stay in suspension sufficiently to be easily handled in the filter; its filtering characteristics must be high and its chemical composition inert or harmless to the liquid. In this paper the discussion is confined to the use of filter-aids as clarification agents, and their use as aids in increasing the capacity, discharge, etc., reserved for later treatment.

Pre-Coating the Cloths

The fundamental use of a filter-aid as a clarification agent is in producing an auxiliary filter medium upon the filter cloth by means of "pre-coating." Pre-coating is the term used to define the initial filtration of a filter-aid before opening the main liquor line. This filtration is generally only for a minute or two, and it is sufficient when the effluent issuing from the filter is brilliant. Too often the impression seems to be that this coating must be of some sensible thickness, one-eighth or one-sixteenth of an inch, where, in fact, a film is quite sufficient. On raw sugar liquors it is practical to pre-coat the cloths, using 1 lb. of "filter-cel" per 100 sq.ft. of filter surface, and on examination of a filter leaf after coating it will seem to be without any deposit, but the clarity of the filtrate will be found to be brilliant when filtering the sugar liquor and a white surface will be noted on the inner face of the cake when discharged. This is possibly the minimum amount to use and safer results are obtained by doubling this amount, but even this will give a coating difficult to measure and no liquors have been encountered, to date, that will not give brilliant filtrate through it. Obviously, more than this is an extravagant use of the material and unnecessarily increases the initial resistance of the medium.

Methods of Applying Filter-Aids

The vehicle to use for this pre-coating is a matter for local decision, but there are three methods in practical use giving eminent satisfaction. First, to make up a slurry of the filter-aid and water (or when handling varnishes, etc., some solvent), and to filter it in the usual manner, shutting off when the filtrate is brilliant. In most machines the amount of unfiltered slurry demands its withdrawal from the filter before admitting the sludge. Best practice, therefore, is to locate the slurry mixing tank below the filter so that the excess unfiltered in the machine may be drained back, using the minimum of air pressure to hold the coating on the cloths.

To obviate this draining back some plants use the second method, where clarified effluent is used instead of water or the solvent and sufficient filter-aid is added to insure a pre-coat when the following operation is carried out. The pre-coating liquor is admitted to the filter until full, when the regular liquor is fed to the machine. Experience shows that the first deposit on the cloths is the filter-aid and that there is no trouble in getting clarity nor in dealing with excess unfiltered liquors. The layout for this method is usually to locate the pre-coating tank above the filter so that no pump is necessary to feed the pre-coating slurry to the filter, gravity feed with large pipe lines being sufficient.

The last method is that so extensively used in the sugar refineries of the United States and Canada. Here the solids of suspension in the liquors to be clarified are present in relatively low percentages and it is found quite practical simply to add sufficient filter-aid to the unfiltered material so that the volume of the filter-aid far exceeds that of the original solids. This liquor may then be fed as in the second method. The coating will be found to be such a close approximation to straight filter-aid that the practical results are the same.

Where positive clarity of filtrate is essential, as in the manufacture of artificial silk, this scheme of an auxiliary medium is well nigh indispensable. Local conditions may exact some research in order to find that filter-aid best suited to the requirements, for while "filter-cel" is almost a universal material, it is not best when handling heavy caustics or some food products, to which the "filter-cel" imparts a detrimental taste. In any case, however, to persevere and find the right material will be found well worth the effort.

(Part II, dealing with the Rate of Flow, will be published in a subsequent issue.)

Growth of Manufacturing Industries in New South Wales

Figures released in January by the statistician of the government of New South Wales show that the industrial growth of that state has been rather limited, as the number of manufacturing establishments increased only from 5,269 to 5,450, involving an increase during this period of only 9,870 in the number of employees, or 1.7 per cent per annum, making a total of 126,481 of such employees on March 31, 1919. The male adult workers, whose salaries averaged $636.48 in 1914-15, averaged $764.89 in 1918-19, which have been further increased by the all-around advance of about $4.12 per week, following the Board of Trade's decision that the basic wage should be $18.84 per week. During the same period the total output of factories in the state increased in value from $331,511,193 in 1914-15 to $509,224,467 in 1918-19, but a large portion of the increase indicated is due to increased values rather than to output.

Chicle Gum in British Guiana

Announcement has been made in a report submitted by Consul McCunn of the discovery of chicle-producing trees in British Guiana. Prospecting expeditions sent into the interior have recently returned to Georgetown with full 600 lb. of chicle, and preparations are now being made by the discoverer, who holds a concessional right over 6,200 square miles of territory, to send out four prospecting parties in order to continue investigations and ascertain the capacity of the tract. Territory thus far examined is reported to be capable of yielding 200,000 lb. of gum annually.

Calcium Molybdate as an Addition Agent in Steel Making

By Alan Kissock

IN THE production of alloy steel, molybdenum, like most similar metals, is commonly added to a steel bath in the form of a ferro-alloy, usually less than a half an hour before the furnace is tapped.

In the open-hearth furnace practice varies, from melting the ferro in a small electric furnace and making a hot metal addition, to crushing to about one-quarter mesh and adding it cold, or, as is perhaps most common at present, the alloy is thrown into the furnace, container and all, just as it comes from the manufacturer. In the electric furnace, with its more concentrated heat, the manner of introduction is of lesser importance.

Formerly a ferro containing from 75 to 80 per cent molybdenum was generally specified. Because of the difficulty of securing an ore suitable for manufacturing such a high-grade alloy, and because of the high melting point of the metal, with attendant difficulties of production, the cost of this alloy was necessarily high. In the continued attempt to decrease production cost, and since there can be no real objection on the part of the steel manufacturers, more recent practice has been to produce a ferro containing approximately 50 per cent molybdenum. This grade of ferro, besides being less costly to produce, is perhaps the principal factor in the success of its direct addition to steel. Its lower melting point is responsible for less segregation and eliminates the necessity of pre-melting or fine crushing.

Merit and Cost of Molybdenum

In the attempt to create or stimulate the use of anything new, the first requirement is to establish its merit and secondly to decrease its cost. The first requisite—the value of molybdenum as an alloy for certain steels—is continually becoming better known. Principally from lack of demand, the war-time price of ferromolybdenum has fallen considerably, but if the metal is to find extensive use it is necessary that a reasonable and more constant cost be established.

In deposits of commercial extent, molybdenum seldom occurs in percentages sufficient to permit, even by the most efficient known means of ore concentration, a recovery of greater than 10 lb. of metal per ton of crude ore mined. Often considerably less may be extracted. A great many costs, therefore, must be charged against these few pounds of metal recovered, from the mining, through the often-difficult concentration, to the final transportation.

To these must be added the cost of electric smelting with its heavy losses, even in the best of practice, the difficulties of coming within the customarily rigid specifications of the consumer, and the uncertainty of selling the product when finished. It is easily seen, therefore, that if a fair and reasonable return is to be made to the producer, ferromolybdenum cannot become cheap enough to compete largely with some of the more common steel-alloying elements. Assume that every possible cost of mining and treatment has been brought to its lowest point. Then if any further decrease in cost is to be obtained, it becomes possible only through some improvement in the metallurgical treatment or through the elimination of some step in the preparation of a suitable product for the steel manufacturer.

With these facts in mind, it occurred that it might be possible successfully to introduce molybdenum into steel by the use of a salt of the metal rather than by the use of ferromolybdenum. Could this be efficiently accomplished, then the electric-furnace reduction of ores and products would be eliminated and in its place a much lower-cost chemical treatment could be substituted.*

Chemical Compounds as Addition Agents

The idea of introducing an alloying metal into steel by means of some salt or compound thereof is not particularly new. It has been tried, both in the furnace and in the ladle, with certain of the metals, and with more or less success. Several difficulties, however, are encountered in considering the more common salts or compounds of molybdenum.

The ordinary 60 per cent molybdenite concentrate, or even the higher grade, is unfit for direct addition for several reasons. All such concentrates contain a certain proportion of silica and in basic furnace practice it is desirable to avoid, as far as possible, any introduction of silica into the bath. Upon addition of molybdenite to steel at least a portion of the ore would be converted into the trioxide and as such would readily volatilize and be lost. The most serious objection, however, is the 25 to 30 per cent sulphur content of high-grade concentrates. In a test made at the plant of the Southern California Iron & Steel Co. in Los Angeles, an attempt was made, by the addition of high-grade molybdenite, to introduce 0.4 per cent molybdenum into steel. It was found that although a considerable proportion of the molybdenum entered the steel, sulphur, with its great affinity for iron, was also introduced to the extent of 0.25 per cent. By long treatment in the furnace, with manganese and lime additions, this sulphur content might have been lowered, but with the furnace-man's constant effort to keep the sulphur low in his product, a molybdenite would hardly be looked upon with favor.

Roasted molybdenite concentrate or trioxide of molybdenum would serve as a direct addition agent, were it not for the ease with which this compound is volatilized. At 1,200 deg. F. the vapor pressure of molybdic oxide is quite high, so that recoveries from an addition at steel-furnace temperatures would be unprofitably low. Such roasted concentrates would also carry the silica gangue of the unroasted material, and though it is possible to manufacture a more pure trioxide, the cost of such is prohibitive.

Since molybdenum unites in varying proportions with oxygen, it is possible that one or more oxides might be found which would not be volatile at furnace temperatures. The difficulty, however, of efficiently producing such oxides makes such compounds of doubtful value for consideration as addition agents.

Sodium molybdate might serve as another possible agent but for the higher cost of producing it of a sufficiently high molybdenum content.

In the case of some molybdenum ores, a step between concentration and the manufacture of ferro involves either a furnace or a chemical treatment for the removal of possible impurities and the production of an alkaline salt of molybdenum, preferably calcium molybdate. Although in the production of ferro from molybdenite it is not always necessary to precede electric furnac-

*Compare, for instance, J. P. Bonardi, "Notes on the Metallurgy of Wulfenite," Chem. & Met. Eng., vol. 21, p. 364, Sept. 15, 1919.

ing by a roast or wet treatment, such a process can be readily applied and a calcium molybdate of high grade very easily produced.

Theoretically, calcium molybdate should serve as an excellent addition agent to steel. It can be easily and comparatively inexpensively made of a high grade, containing practically nothing but the oxides of molybdenum and calcium. The salt is easily reduced and the lime apparently prevents loss by volatilization of the molybdenum trioxide. Upon reduction of the molybdenum, by the carbon or silicon in the steel, the lime would simply serve as a small added source of material for the ordinary basic slag.

Early in 1918, in New York City, several small steel heats were made. An experimental electric furnace was employed and molybdenum was successfully introduced by the use of calcium molybdate with a recovery of 95 per cent.

Encouraged by these tests and with the kind co-operation of P. E. McKinney, metallurgist at the U. S. Naval Gun factory, a commercial test was made at the Navy Yard in Washington, in September, 1918. The calcium molybdate was made from the wulfenite ores of the Mammoth Development Co. of Los Angeles, and furnished gratis by that company for the test. Using a Heroult furnace, six tons of scrap was melted and at the proper time sufficient calcium molybdate added to introduce about 1 per cent molybdenum into the steel. The molybdenum content of the product, as shown by final analysis, confirmed commercially the previous experimental results. At a later date, C. E. Margerum, metallurgist of the U. S. Naval Ordnance plant at Charleston, W. Va., repeated the success secured at the Navy Yard in Washington. A third electric-furnace test was made at the plant of the Carbon Steel Co. in Pittsburgh, Pa. A 6-ton Heroult furnace was employed, and a repetition of the success of the two previous heats gave ample assurance that calcium molybdate was a satisfactory addition agent for use in the electric furnace.

Molybdate in the Open Hearth

Having succeeded in these attempts, it was conceded that because of the strong reducing action of the electric furnace, the results obtained were to be expected. That the same success could be secured in the strongly oxidizing atmosphere and action of the open-hearth furnace was, however, open to argument, and considerable skepticism had to be overcome.

Experimentation has shown molybdenum to have less affinity for oxygen than either iron or carbon. Industrially, this is again proved by the fact that once in the steel bath neither "oreing down" nor "boiling" appears to lower the molybdenum content.

Provided the molybdate could come in direct contact with the molten metal, it was thought that the salt might be reduced either by the metallic iron itself or by one of its reducing constituents. By the courteous aid of the officials of the Carbon Steel Co., 50 tons of pig iron and scrap was charged into one of the basic open hearths at their plant in Pittsburgh during November, 1918. At the proper time sufficient calcium molybdate was added to introduce the desired percentage of metal. Analysis of the ingots produced showed a high recovery of the molybdenum added, and the success so attained amply rewarded the effort expended.

Early in May, 1919, with the kind interest and co-operation of the staff of the United Alloy Steel Corporation, a second open-hearth test was arranged. Two 100-ton heats and a third but smaller basic furnace heat were made and the desired amount of calcium molybdate added in each case. The practically complete recoveries of molybdenum secured proved beyond question that molybdenum in this form may be successfully, and very efficiently, introduced into steel made in the open-hearth. In all tests, rolling mill recoveries correspond with those usually obtained with the customary ferro addition.

In order that the molybdate may come in direct contact with the molten iron, it is necessary that the addition be made in the early stages of the heat. In one of the tests the molybdenum was in the open-hearth furnace over a 14-hr. period and under very severe oxidizing conditions. The fact that the molybdenum content remained practically constant is proof of another very important consideration in connection with the metal. It is conclusive evidence that molybdenum, like nickel, and unlike vanadium, "stays" with steel. In the use of molybdenum, therefore, the "crops" and scrap ordinarily encountered in all alloy steel manufacture can be remelted with but little loss, thereby reducing the amount of alloying metal required. Because of the economy that may be effected, the importance of this fact must be appreciated when considering molybdenum as an alloying metal to replace certain of the metals now being used, and for purposes in which it may serve equally well.

Method of Operation

The introduction of molybdenum into steel by means of calcium molybdate involves no complications whatever, it being only necessary to bear the following in mind:

With the strongly reducing action and concentrated heat of the electric furnace, the time of addition is of less importance. Best results have been secured by introducing the molybdate immediately after skimming of the first, or phosphorus slag, the final or white slag indicating, of course, that reduction has been complete.

In open-hearth practice, the molybdate must be added in the early stages of the heat, not with the charge because of possible loss in the furnace bottom, but preferably a little before the melt becomes "level." In other words, in any type of furnace it is only necessary to remember that the molybdate must come in *direct contact with the molten iron*, and therefore in the basic open-hearth it must be added just before the lime begins to come up. A layer of slag would completely prevent contact with the metal. Shipped in sheet iron drums of convenient size, the molybdate is added, containers and all.*

Advantages

From the standpoint of the miner the production of calcium molybdate is particularly advantageous. In almost every occurrence, molybdenite is associated with considerable percentages of both iron and copper sulphides. In order to produce a marketable concentrate, all of the copper and a considerable portion of the iron

*All rights to the process as outlined, both in the United States and foreign countries, are covered in U. S. Pat. 1,299,115 and are owned by the Steel Alloys Co., Investment Building, Los Angeles, Cal. It has been arranged that license to use the process will be furnished gratis by the Steel Alloys Co. to any steel company that may purchase calcium molybdate from such molybdenum producers or sellers as may be specified upon the license. Since it is expected, however, that the arrangement mentioned will be made with all potential consumers, profits to be distributed to the steel manufacturer, either in payment of royalty or limiting of purchasing power, will be elected.

must be removed. This may be accomplished by selective flotation, but this cleaning process not only adds to the operating costs but invariably means a lower extraction. In other words, any refining operation, whether it be in concentration or in the electric furnace production of ferro, is necessarily a costly one. Neither copper nor iron interferes in the production of calcium molybdate, so that the need of either of these refining operations is entirely eliminated. It therefore becomes unnecessary for the miner to make a high-grade concentrate or to separate therefrom any of the copper or iron sulphides that might be contained. The millman will readily appreciate the saving that may thus be effected.

The production of calcium molybdate offers a further advantage in that the equipment for its manufacture does not involve great cost nor is especial skill required in the operation. The method is comparable to the cyanide process in that large tonnages may be readily treated and in many cases such may be carried out right at the mine. The electric-furnace production of ferro not only requires very large expenditures for tonnage treatment, but also necessitates particular experience and skill. Only in rare cases is the mining company in position to carry out such an operation, and it thus becomes dependent on some metallurgical concern to put its product into marketable form.

Calcium molybdate is readily made, and with high recovery, from all molybdenum ores by simple chemical treatment. The salt as usually furnished carries approximately 40 per cent metallic molybdenum and contains no impurities detrimental to good steel manufacture. It has been proved beyond question that molybdenum, in this form, is a very efficient addition agent for the introduction of the metal into steel.

The particular advantage of the process is that a carbon-free molybdenum addition agent may be afforded to the steel manufacturer at a price which will assuredly permit the competition of the metal with those at present in more general use. It is not within the scope of this article to attempt to point out the use or benefits of molybdenum in steel. The value of alloy steel in general is constantly becoming better appreciated. In the writer's opinion, molybdenum is the only metal commercially available in this country which is capable of developing in steels properties equivalent to those produced by metals which must now be imported. A possible strategic value exists in the ample and constant domestic supply of molybdenum that is now assured. From the results of the work that is being done by concerns, as well as individuals of prominence, it is certain that molybdenum will shortly fill an important place in the alloy steel industry.

Los Angeles, Cal.

Radium Scarcity

Owing to the scarcity of radium—which is now priced at $78,000 a gram—and the failure to discover new sources of supply, it is feared the shortage will become exceedingly acute. In the meantime, it is reported that radium for use in medical research is being prepared by a special method. A weak solution is made which gives off radium emanations; these, which are detected only by delicate instruments, are collected in tiny sealed glass vials and the vials are sent to medical men. It is stated that the efficacy of such bottled emanations lasts one week.

World Production of Coal in 1919

The world's production of coal in 1919 seems to have dropped back to the level of 1910. Preliminary estimates, necessarily rough, place the total output of all kinds of coal in 1919 at 1,170,000,000 metric tons, or 1,290,000,000 net tons. This is 162,000,000 metric tons less than the production in 1918, the last year of the World War, and about 171,000,000 tons less than that of 1913, the year before the war began.

This estimate is based by the Geological Survey upon reports to the Supreme Economic Council from countries which contribute about 85 per cent of the world's output. Obviously, returns from the other countries may materially alter this figure; if anything, they will probably reduce it still further.

The following table shows the estimated production of the world for each year from 1910 to 1919. Because of disturbances and interruptions in the compilations of Government statistics, particularly in central and eastern Europe, the figures since 1913 are not to be regarded as final. The metric ton of 2,205 lb. is used because it is the prevailing unit in non-English speaking countries. Americans will remember it most easily as being roughly equivalent to the gross ton and the English ton.

WORLD'S PRODUCTION OF COAL 1910-1919
(Metric Tons of 2,205 lb.)

Year	Production, in Part Estimated	Per Cent Produced by U. S.	Year	Production, in Part Estimated	Per Cent Produced by U. S.
1910	1,160,000,000	39.2	1915	1,190,000,000	40.5
1911	1,189,000,000	37.9	1916	1,270,000,000	42.1
1912	1,249,000,000	38.8	1917	1,336,000,000	44.2
1913	1,341,000,000	38.5	1918	1,332,000,000	46.2
1914	1,208,000,000	38.5	1919	1,170,000,000	42.1

Comparative production in five of the belligerent countries before and after the war is shown in the following table:

PRODUCTION OF COAL IN CERTAIN COUNTRIES, 1913 AND 1919
(In Millions of Metric Tons)

	1913	1919
United Kingdom	292	237
France (present boundaries)*a*	44	22
Belgium	23	18
Germany (present boundaries)*b*:		
Bituminous	173	109
Lignite	87	94
United States	517	494

(*a*) Includes Alsace-Lorraine. (*b*) Excludes Alsace-Lorraine and the Saar.

It is pointed out by the Supreme Economic Council that from 1913 to 1919 the output of bituminous coal in the four European countries shown in the table has fallen from 532,000,000 to 386,000,000, the decrease being about 20 per cent in the United Kingdom and Belgium, and nearly 40 per cent in Germany. In the Saar Valley, whose output appears to have fallen from 12,000,000 tons in 1913 to about 8,000,000 in 1919, the percentage of decrease was over 30. The reduction in the French output is mainly due to the destruction of the mines in the Nord and Pas de Calais.

The output of lignite in Germany in 1919, though less than in 1918, was still greater than before the war, being 94,000,000 tons, as compared with 87,000,000 in 1913.

In the break-up of Austria-Hungary the bulk of that country's coal and lignite, the production of which amounted before the war to about 55,000,000 tons, was inherited by the Republic of Czechoslovakia. The 1919 production of Czechoslovakia was about one-third less than the same territory produced in 1913.

The Fertilizer Situation

A Statement of the Present Tendencies of the Fertilizer Industry—Fewer Brands—Thermal Phosphoric Acid Processes—Theory of Fertilizer Use—Solution Method of Applying Concentrated Fertilizer Salts

By MILTON WHITNEY

TO ANYONE who has given careful thought to the fertilizer situation for the past few years, especially since 1913, there is evidence of a profound change taking place not only in the methods of sale but in the fundamental methods of manufacture. It has been long recognized that the old trade or brand names have outlived their usefulness with the organization of capital and the merging of small interests into great enterprises. With the advent of the European war and the consequent shortage of material and uncertainties as to supplies, it was realized that many of these brands could not be maintained, and they were merged into uniform grades without material effect upon the volume of the trade in commercial fertilizers. The advantages they were supposed to give competitors handling comparatively small amounts of material were found to be a liability of the larger concern because of the increased cost of manufacture, printing and distribution. From one point of view they may have served a useful purpose, but that day is now past, and they must be discarded. From another point of view they were detrimental in that they retarded to some extent the passage of the fertilizer trade into the real chemical industry that it is destined to become.

Conservation of Phosphate

Even before the war emphasized the limitations of rail transportation and the necessity for greater conservation than in the past, it was recognized that the enormous losses entailed in the mining and marketing of the large annual output of Florida and Tennessee phosphates made it of the utmost importance that some adequate scheme be devised to conserve our phosphate deposits. Practically all of the rock mined at present is converted into superphosphate by treatment with sulphuric acid. The acid phosphate manufacturers demand a rock notably free from iron, alumina and calcium carbonate. As a consequence it has been estimated that for every ton of rock that is converted into the superphosphate by treatment with sulphuric acid two tons are discarded as unsuitable for such treatment. The Bureau of Soils is at present conducting investigations which it is hoped will lead to the development of a method by which phosphoric acid may be profitably obtained from this discarded material. It is worthless so far as sulphuric acid treatment is concerned. Its only salvation lies in another method. If the Bureau of Soils plan succeeds, it will mean the conservation of by far the greater part of our phosphate deposits.

The fusion of a mixture of phosphate rock, sand and coke in an electric furnace permits the volatilization and subsequent collection by the Cottrell precipitator of phosphoric acid of satisfactory purity and concentration. If water power could be obtained around $6 per hp.-yr., this method would be adapted to commercial production, but at the present price, $20 to $25, the cost of production of phosphoric acid by the electric furnace is about three-quarters of a cent higher than by sulphuric acid treatment. Moreover, it is not likely that water power will ever be available in large quantity at a price sufficiently low to warrant its use in the production of phosphoric acid, which must be sold on the ton basis, when there is such a large and rapidly increasing demand for power by producers of the more expensive chemicals sold on the pound basis. Recent work in which oil fuel is used as the heating agent, instead of the electric furnace, gives promise of a commercial method for preparing phosphoric acid.

Advantages and Disadvantages of Phosphoric Acid

There are certain advantages and certain disadvantages in the use of phosphoric acid. One of the disadvantages is the difficulty attending the transportation of a corrosive liquid. However, this can be readily overcome by converting the acid into one of its soluble solid salts, as will be shown later. Some of the advantages are that it can be produced at the mine from mine-run material, since the presence of impurities which offer objections in the case of sulphuric acid treatment are actually necessary for successful furnace treatment. If the rock is high grade, sand must be added to displace the phosphoric acid. The presence of relatively large percentages of alumina, instead of being a drawback, greatly facilitates the smelting of the phosphate charge. The mine-run material, therefore, is generally more suitable for fusion work than high-grade rock.

It seems best to convert the phosphoric acid thus produced into a solid salt by neutralizing it with ammonia or potash. The substitution of these bases for lime saves a considerable part of the freight and provides a soluble product which does not revert to an insoluble compound, as is the case with acid calcium phosphate. While the saving of the rock which is now thrown on the dump was the primary cause of the investigation which is being conducted by the Bureau of Soils, it now develops that the fusion process will have other advantages in that several of the products from the nitrogen-fixation plants can be freely mixed with ammonium or potassium phosphate, which cannot be mixed with the acid calcium phosphate without reversion of the latter and decomposition of the fixed-nitrogen product.

The fertilizer industry of the past has been largely a scavenger industry, using materials that were formerly waste products, some of which were even detrimental to health. One of the first of these products to go into commercial fertilizers was cotton seed and cottonseed meal, then the fish scrap, an offal from the fish houses, then animal tankage and refuse from the slaughter houses.

Unlike European practice, where fertilizer constituents are generally applied singly from time to time, the American practice has been to use mixed fertilizers and make only one application. A theoretically ideal mixed fertilizer must contain three representatives of nature's nitrogen cycle, phosphoric acid and potash. Nitrate nitrogen is immediately available for plant use and nourishes it in the very earliest stages of growth, while the nitrogen of ammonium salts becomes available only after it has been oxidized to the nitrate condition by processes that take place slowly in the soil; hence a supply of nitrogen is furnished the plant at a later period of its growth. The third representative of the nitrogen cycle above referred to is the so-called organic ammoniate or protein body. These bodies must undergo still more complex changes, requiring a correspondingly longer period of time. The soil must first convert the protein into an ammonium compound, then oxidize the ammonium salt to nitrite and finally to nitrate before the nitrogen can be taken up by the plant. In the time required for this transformation, the plant has probably reached the last stages of its development.

Organic Ammoniates for Feeds

Some years ago it was found that some of the organic ammoniates used for fertilizers could be used as concentrated feeds for animals. As a result of the European war and the efforts made to increase animal production, these organic ammoniates have gone more and more into feeding purposes. Up to the beginning of the war, the price of the organic ammoniates was controlled in a way by the world price of nitrogen in nitrate of soda.

In October, 1919, the department called a conference of producers of tankage, dried blood, fish scrap and cottonseed meal in order to ascertain why the price of nitrogen in these forms had not followed the drop in the price of nitrogen in nitrate of soda and ammonium sulphate. It was very clearly shown at that conference that changes of great magnitude had been going on and that the bulk of these materials is now being used for feeding purposes, and that their price per ton was regulated not by the price of nitrate of soda but by the price of other feeding stuffs. Today the competition between feeders and fertilizer manufacturers for these organic ammoniates is very great and is the subject of frequent comment in the trade journals. The cost of nitrogen is fully twice as great in the organic ammoniates as in mineral compounds. Judged by fertilizer standards, cottonseed meal at $80 a ton has become a luxury, while from the feeding standpoint, comparing its protein content with other feeds, its price is low as a feeding material. It is unlikely, therefore, that the price will decline materially or that the farmers will stand for the fertilizer manufacturers bidding for material against the feeders.

Increasing Scarcity of Organic Ammoniates a Source of Concern

The increasing scarcity, not to speak of the high prices, of organic ammoniates for fertilizers has been a source of real concern to the fertilizer manufacturer, for not only are these ammoniates in great demand as a source of nitrogen to make up their ideal of mixed fertilizer, but they are also depended upon to give the finished goods the proper mechanical texture. In the South generally cottonseed meal has been used as a conditioner; in the North tankage, fish scrap and dried blood. Mixtures consisting of ammonium salts, potassium salts and acid phosphate are likely to cake and harden in the bags and hence are not as easy of application as when mixed with organic matter. What to use as a conditioner is beginning to be a real problem. Dried ground peat is one of the natural materials that suggests itself as a substitute, but it is just as expensive to prepare peat as it is to dry and grind tankage. The value of peat is mainly as a conditioner, while tankage, cottonseed meal and fish scrap have an intrinsic value in their available nitrogen content.

Dependence of Nitrogen Supply on Other Industries

It seems rather illogical to depend so largely for our nitrogen supply upon the amount of cotton grown, the number of animals slaughtered or the quantity of fish caught, when it is well known that these have been limiting factors in the manufacture of fertilizers and have been always wholly inadequate to the needs of the country in order to fertilize properly such staple crops as wheat and corn. The use of fertilizer is advancing westward year by year and the demand for it will certainly increase much more rapidly than waste products can be made available, even if these were not being converted into feeds, but with this conversion the situation is serious in the extreme. Some realized before the war that we should have to come to fixed-nitrogen products. Few realize now that these fixed-nitrogen products are essential to maintain and to increase our crop yields by the extensive use of fertilizers. The developments of the war in the production of munitions have shown the lines along which this fixed-nitrogen problem is likely to be worked out and the commercial practicability.

Fixed-Nitrogen Products as Fertilizers

There are two main products that have heretofore been made on a large scale for munitions which can be utilized for fertilizer purposes. Calcium cyanamide is probably the cheapest form of fixed nitrogen, but this product is not entirely satisfactory. It can be used only in small quantity in our mixed fertilizers because it reverts the acid phosphate, and has in addition certain disadvantages in direct application to the soil. While some of the disadvantages of this material may be overcome, it has not been received with universal favor in Europe, where it has been longest used. The American farmers would have to change their methods of applying fertilizers in order to use a material which cannot be safely mixed with other fertilizer ingredient.

The other product of the nitrogen-fixation plants is ammonia. Ammonia may be oxidized to nitric acid and applied to the soil in the form of a salt of this acid, or the ammonia may be neutralized with sulphuric or phosphoric or nitric acid and used in the form of ammonium sulphate, phosphate or nitrate. Ammonium sulphate is well known in American agriculture at the present time, it being a byproduct of the coke industry. Ammonium nitrate is a new product to American agriculture. It is a much more concentrated form of nitrogen than ammonium sulphate, and it, therefore, carries a smaller cost per unit of nitrogen for transportation. On the other hand, it is highly deliquescent and has the further disadvantage that it can be mixed in only small amounts with other fertilizer ingredients, as in larger amounts it reverts the phosphoric acid and there

is a loss of nitrogen. Ammonium phosphate is equally new to American agriculture and is a highly concentrated fertilizer material.

Use of Fixed-Nitrogen Products

This leads to a consideration of how to use these fixed-nitrogen products. It has been shown that if phosphoric acid is abstracted from the rock there is economy in freight and in conservation of our phosphate deposits. Ammonium phosphate prepared by mixing ammonia from the nitrogen-fixation plant with phosphoric acid produced at the mine may be mixed in any proportion with ammonium nitrate, and if to this combination potassium phosphate be added, a mixture is obtained which is apparently not deliquescent, which does not undergo chemical change and which is the most concentrated form that it is possible to make a fertilizer and in which every constituent pays its own transportation charges. It contains two forms of nitrogen, but the third form—organic nitrogen—is missing.

When these stable salts of dipotassium phosphate, monoammonium phosphate and ammonium nitrate are mixed in the proportion to give a fertilizer of the formula 2-8-2—2 per cent nitrogen, 8 per cent phosphoric acid (P_2O_5) and 2 per cent potash (K_2O)—the mixture is so concentrated that it would require only only 326.4 lb. of the combined salts to make a ton, making it necessary to use 1,674.6 lb. of filler if it is to be diluted to the usual strength of the fertilizer of that composition. It could, however, be used in its concentrated form. A mixed fertilizer having the formula 4-8-4 would require 75.91 per cent filler to give the dilution in an ordinary fertilizer of that composition. A mixed fertilizer of 4-8-10 would require 69.6 per cent filler and one of 10-8-4 would require 58.76 per cent filler to give the usual dilution.

Method of Application of Concentrated Chemical Fertilizer

These mixtures are all completely soluble in water. They could be applied to the soil in the concentrated form of crystals, just as nitrate of soda is applied or as acid phosphate is applied. If it is desirable to maintain the degree of dilution in ordinary fertilizers, they could be locally mixed with peat or any similar substances in the proportion above given. The one filler that costs nothing and is readily accessible to all is water. In other words, the fertilizers could be dissolved in water and spread on the surface or applied in the drill. This would of course involve some change in farm implements, but not a very serious one. It seems to the writer that it would be of great advantage to the intelligent farmer to be able to obtain the separate ingredients, and by dissolving them separately in water and then mixing the resulting concentrated aqueous solutions in proper proportions to obtain a complete fertilizer of any desired composition. There would be the further advantage of uniform distribution and immediate and thorough incorporation in the soil.

Objection may be made that the solutions of the fertilizer salts would be too concentrated for ordinary application. An alternative method would be the mixing of such a solution with a definite amount of soil or sand and distributing this mixture in the same way as fertilizers are ordinarily distributed at present. This would not involve the use of any new machinery or any change in the present methods of agriculture. As an illustration, a complete fertilizer of the composition 4-8-4 would be made up as follows: Weigh out 148 lb. of K_2HPO_4, 161 lb. of $NH_4H_2PO_4$ and 173 lb. NH_4NO_3 and dissolve them in 182 gal. of water.

The advantages and disadvantages of such fertilizers may be summed up as follows: It must be admitted that the absence of the organic ammoniates is a distinct disadvantage in that it takes away a material that supplies the plant with nitrogen during the last stages of its development. On the other hand, the saving of freight and drayage, the more thorough mixing with the soil at the time of application and the ease with which subsequent applications can be made to the growing crop, either of the entire formula or any part of it as desired, are all advantages.

Preparation of Dipotassium Phosphate

Mention has been made of the proposed use of dipotassium phosphate in these mixtures as the most concentrated salt of potash in mixed fertilizers. This raises the practical question of the commercial preparation of such a salt from materials available. It has been established by numerous experiments that if potash shales are mixed with phosphate rock and coke, the shale taking the place of sand that is ordinarily added, the fusion takes place equally well and that part of the potash is volatilized and caught in the Cottrell precipitator as a monopotassium phosphate. The experiments have not proceeded far enough to indicate whether the evacuation of the phosphoric acid is as complete with the shale as with the sand, but there seems to be a possibility of collecting the two materials in one and the same operation. The monopotassium phosphate should be converted into the dipotassium phosphate to increase the percentage of potash in the salt and also on account of the greater stability of the latter salt. The conversion could be readily effected by mixing the monopotassium phosphate with potassium carbonate, which is now produced in considerable quantities from some of the deposits in this country. The most common salt of potassium used in this country for fertilizer purposes is the chloride. Potassium chloride mixed in the proper proportion with phosphoric acid and the mixture heated would yield dipotassium phosphate, and hydrochloric acid would be evolved. Hydrochloric acid is of considerable commercial value, and its sale would probably pay for the energy expended in converting.

Summary

This review of the fertilizer situation is not intended as exhaustive. Space does not permit the tabulation of figures, and perhaps they are not necessary. The statements made and the illustrations used will have served their purpose if attention is drawn to the fact that the fertilizer industry of today and of the future is bound to be a chemical industry based upon chemical investigations and control, instead of the scavenger and rather vague industry of the past, and if we come to realize that the time has arrived when we must meet the situation in a somewhat different point of view from that which has prevailed. The fertilizer industry has passed through the trying period of the war, and it has emerged upon a stronger and much more substantial basis than it had before the war. Changes must occur. It was foreseen that they must occur. The result has been to bring them more prominently before us and to establish the industry on a still more substantial basis.

Instruction in Iron and Steel at M. I. T.

By Carle R. Hayward

THE course which is described here is that required of students taking the metallurgical option in the department of mining and metallurgy at the Massachusetts Institute of Technology. Other students with adequate preparation may take the course if they desire. In addition to the field covered in this course the students receive instruction in iron and steel analysis in the chemical department, testing materials in the mechanical department and a thorough course in metallography and heat treatment which give them a knowledge of the chemical, mechanical and physical properties of iron and steel.

In a recent reorganization of the course some new features were introduced which have increased the interest of the students and at the same time given them a more thorough grounding in the subject.

Changes Made to Meet Criticism

The first of these changes was to meet a criticism, often heard, that the tendency in college work is to give the students "spoon feeding" in lecture courses instead of throwing them on their own resources. The lectures were accordingly cut to twenty hours, with an additional twenty hours allowed for preparation. It is obvious that only basic principles can be pointed out in this time and references given to the literature for details.

The time set free from class-room work is used in the library. The students are directed in their reading by assigning references to the files of technical journals or standard treatises on the different phases of iron and steel operations. In order to assure a thorough search of the literature five subjects are assigned on which concise summaries are to be prepared. The subjects of these papers may vary in different terms. Those used by the last class were as follows: 1. Blast-furnace construction. 2. The chemistry of the blast furnace. 3. The chemistry of the open-hearth processes. 4. Piping and segregation in ingots and castings. 5. The production of malleable castings and case-hardened steel.

It has been found that the students have taken a great interest in this part of the work and the net results have been very satisfactory. The library is used as never before and a familiarity cultivated with standard works and periodicals.

Neighboring Plants Visited

Another feature of the course which has proved both profitable and beneficial is the visiting of such plants as are available about Boston. These visits are part of the required work and each student writes a report of the trip. After the reports are completed the class meets to discuss the various operations and clear up any obscure points. The management of the different plants, realizing that these visits are part of the required work of the course, have heartily co-operated in this plan, which has contributed much to its success.

Although there are no iron blast furnaces in the vicinity of Boston, it is possible to study open-hearth practice and steel rolling at the American Steel & Wire Co.'s plant at Worcester, steel foundry work with open-hearth and electric furnaces, together with forging and heat treatment, at the Watertown Arsenal and other operations such as Tropenas converter practice, cast iron practice in cupolas and air furnaces, drop forging, etc., in various plants.

During the summer some of the men get positions in well-known steel plants, where they get practical experience which is valuable either before or after taking the course.

It is too early to judge the final results of this plan of teaching, but the indications are that the variety of instruction gets and holds the interest of the students and sends them out better equipped to meet actual plant conditions than does a course consisting more largely of lecture or class room work.

Cambridge, Mass.

Growth of the Artificial Silk Industry

Artificial silk, which a few years ago was looked upon as a novelty which provoked smiles in the trade, is growing continually in favor and has become a recognized part of the silk industry. Mr. Monges, a clerk in the American Consulate at Lyons, has compiled some history and statistics on the subject. The world's production of artificial silk was 2,000,000 kilos (about 4,420,000 lb.) in 1902, and the figures increased to 8,000,000 (about 17,680,000 lb.) in 1914. Germany is said to be producing about 5,000 kilos (about 11,000 lb.) daily, and France will be producing about 4,000 kilos (about 8,800 lb.) daily when her machinery has been put in order. The total production for 1919 is not given, but it is well known to have been far below the demand.

It was in 1885 that Audemars, of Lausanne, Switzerland, filed a patent on a vegetable fiber for use in incandescent lamps. In 1884 Comte de Chardonnet discovered the collodion thread which he aspired to place alongside of silk in the textile world. But not until 1895 was it possible for the company which he founded to put on the market a thread which was denitrated and consequently less inflammable. Up to 1903 the new industry, interesting though it was, was not seriously regarded in the industrial world, but rather was considered in the light of an interesting novelty. In that year, however, the Société de la Viscose put on the market the artificial silk which until recently has been the last word in artificial textiles.

On account of the substance which it employs (wood), the new industry has been enabled to adapt itself to all climes and is today in full swing in Belgium, Switzerland, Hungary, Poland, Germany, Russia, Italy, Japan and the United States.

At Lyons a renewed impetus was given recently to the use of chemical textiles by the invention of an entirely new process, the product of which is called silk cellulose. This new form of cloth is claimed to possess a brilliancy comparable to that of silk schappe. It has a remarkable solidity and durability, a touch similar to that of silk, and it is impervious to water. A big factory for the production of the new textile is projected for the Lyons district.

There are five kinds of artificial silk—nitrated silks, collodion silks, the viscose silks, the acetate silks and the gelatine silks.

It is to be noted that the increasing activity of the artificial textile industry, instead of coming into competition with that of the natural silk, coincides with and supplements the growth of the latter. The difficulty experienced by natural silk weavers in providing sufficient material, together with the top prices the natural silk commands, furnishes proof that natural silk is more than ever in demand and has nothing to fear from what many be called a "distant" competitor.—*The Review*, April 1, 1920.

Physical Properties in Rolled Rifle Barrels

By F. L. Moister *

THE specifications for barrels for U. S. Rifle Model 1917 provide for steel of the following chemical and physical properties:

Carbon	0.45 to 0.55
Manganese	1.10 to 1.35
Silicon	0.20 to 0.30
Phosphorus (max.)	0.05
Sulphur (max.)	0.05
Elastic Limit, lb. per sq.in. (min.)	70,000
Tensile Strength, lb per sq. in. (min.)	100,000
Per Cent Elongation in 2 in, (min.)	15
Per Cent Reduction of Area (min.)	30

Barrels made by the Remington Arms Co. were rolled from a 1½-in. round billet and were not subjected to further heat treatment. It was therefore

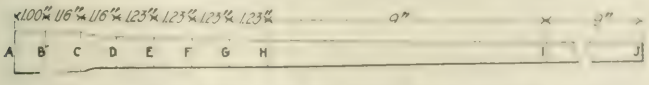


FIG. 1. ROLLED GUN BARREL FOR MODEL 1917 MAGAZINE RIFLE

necessary to obtain the specified physical properties by rolling.

The steel rolled into barrels at ordinary temperatures of hot-working will have elastic limits of about 60,000 lb. The additional 10,000 lb. must be imparted by rolling at low temperatures, but not low enough to reduce the ductility below requirements. The rolling temperatures ranged from 1,200 deg. F. for the lower to 1,260 deg. F. for the highest carbons (650 to 680 deg. C.).

The rolls are designed to finish a barrel in eleven passes. The barrel is an eccentric product, large at the butt and small at the muzzle, but not having an even taper. The rolling reductions are shown in Fig. 1, and also in the accompanying table.

Section	Diameter In.	Area Sq. In.	Per Cent Reduction
Billet*	1.500	1.767	.....
A	1.400	1.539	12.8
B	1.400	1.539	12.8
C	1.300	1.410	20.2
D	1.060	.802	49.5
E	.982	.737	57.0
F	.905	.643	63.6
G	.878	.605	66.9
H	.850	.567	67.9
I	.800	.503	71.4
J	.750	.442	75.0

*Original billet 1⅛ in round, 9.70 to 10.27 in. long.

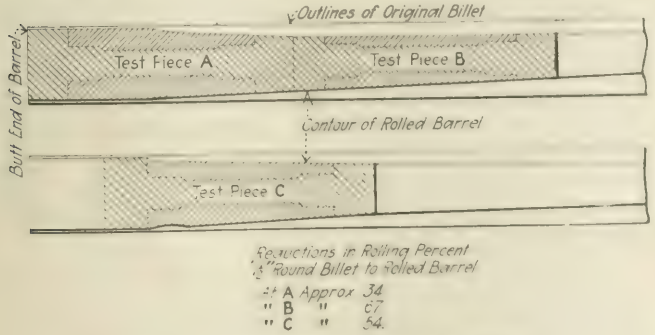


FIG. 2. LOCATION OF TEST PIECES

Consideration indicates that:

First, the finishing temperature varies in different parts of the barrel in proportion to the varying reductions in rolling.

Second, the physical characteristics of the steel vary in proportion to the variations in finishing temperature and reductions in rolling.

Third, the lowest elastic limit and tensile strength will be found in that portion in which rolling reductions are the least and in consequence the finishing temperatures the highest.

Ten billets from the same heat of steel were heated in the same furnace to 1,250 deg. F. (678 deg. C.) and were rolled into barrels on the same mill so as to equalize heating and rolling conditions as far as possible. The finishing temperatures were not determined, but the surface color indicated a range from about 1,000 at the butt to 850 at muzzle (540 to 450 deg. C.).

Three sets of five tensile tests each were taken from points in the barrel to represent the least, greatest and intermediate reductions numbered "A," "B" and "C." Series "A" had its center of gage length as near the extreme butt end as practicable, and series "B" adjoined "A" from same barrels. Series "C" was taken from five other barrels with 1½ in. discarded from butt. Test piece was then cut from as near the butt end as practicable.

Fig. 2 shows the location and methods of cutting these test bars.

Results of the tests, shown graphically in Fig. 3, follow the theory that as reductions increase and

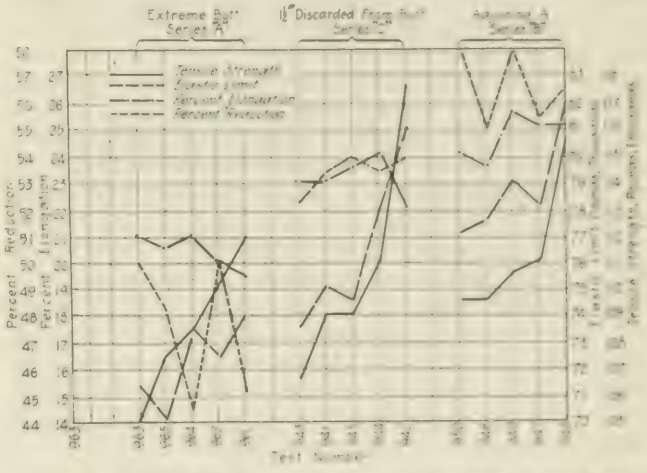


FIG. 3. GRAPHIC REPRODUCTION OF TEST RESULTS

temperatures decrease the tensile strength and elastic limit are increased proportionately. Thus the lowest results were obtained in the "A" series, the highest results were obtained in the "B" series, and intermediate results were obtained in series "C."

Series "A" gets the least reduction in rolling and is finished at the highest temperatures; "B" gets the most reduction in rolling and is finished at lowest temperatures, while "C" gets intermediate reduction in rolling and finishing temperature.

The character of the fractures closely followed the difference in tensile strength. All "A" fractures were flat, slightly lipped, and showed faint radial lines. "B" fractures were semi-flat, and deeply lipped, with radial lines very pronounced. In one piece these lines extended entirely through the section like a split or seam. "C" fractures were semi-flat, lipped more than "A" but not as deep as "B," and the radial lines pronounced, but not as much as "B."

As the radial lines or fissures in all the tests become

* Engineer of Tests at the Eddystone Rifle Plant for U. S. Ordnance Department.

more pronounced as reductions in rolling increase and finishing temperatures decrease, this fact indicates that if the finishing temperatures should be carried low enough the structure would be completely broken down.

Radial lines invariably show in the fractured test piece if rupture occurs toward the muzzle end, i. e., the point of greatest reduction. They never show in the test of an annealed barrel. These radial lines are planes of weakness, produced by pressure in rolling at low temperatures, developed into visibility by pulling in the testing machine, but entirely removed by annealing.

The apparent loss in elongation in series "A" over "B" and "C" is due to fractures occurring outside the middle third of the gage length in all cases, invariably toward the butt pop mark, the weakest portion. In "B" and "C" fractures occurred in the middle third.

Tests were made on an Olsen 100,000-lb. testing machine, working with a speed of cross-head up to elastic limits equal to 0.048 in. per minute. Elastic limits were taken by a Berry strain gage.

The Magnesite Industry in 1919

THE production of magnesite in the United States in 1919 fell off about 30 per cent, but was nevertheless greater than in any year prior to 1917. F. McN. Hamilton, state mineralogist, estimates that California produced 42,000 tons of crude magnesite, or about one-half the production in 1918. According to R. W. Stone, of the U. S. Geological Survey, Department of the Interior, producers in the State of Washington shipped about 55,000 tons of dead-burned magnesite, which is equivalent to about 120,000 tons of crude magnesite, or 20 per cent less than in 1918. The output of crude magnesite in the country in 1919 was therefore about 162,000 tons. The material shipped from the State of Washington went to manufacturers of refractory wares and to steel mills east of Mississippi River, except about 500 tons that was distributed in Montana, Washington, California and Texas. About three-quarters of the California material was calcined and used in the plastic trade and the remainder was natural ferromagnesite used for making refractory materials.

Production Is Satisfactory

The large production indicated should be satisfactory and encouraging to the domestic producers, for even as late as June, 1919, it was expected that receipts of foreign magnesite would practically terminate the domestic industry. The imports, however, were not received as expected, and the demand for magnesite for refractory and plastic wares had to be supplied from domestic sources.

The Northwest Magnesite Co., of Chewelah, Wash., was the largest producer in the United States and made some shipments during each month in the year. Its shipments were smallest in May and June, but increased rather steadily to the end of the year, and are still large. The American Mineral Production Co., of Valley, Wash., sold its output crude to the Northwest Magnesite Co., whose quarries are near by. The Western Materials Co. took over the Double Eagle quarry, formerly operated by the Valley Magnesite Co., at Valley, Wash., and became a new producer in the state.

At the end of 1919 the principal producers in California were the Porterville Magnesite Co. and the Tulare Mining Co., at Porterville; the Western Magnesite Development Co., whose mine is on Red Mountain in Santa Clara County; and the White Rock mine, in Napa County. Smaller operations in California were in progress on the property of the Dinuba Magnesite Co., Tulare County; the Gustine Magnesite Co., Santa Clara County; Sinclair & Ferguson, Fresno County; and possibly one or two others.

Imports

The imports of magnesite in 1919, reported by the Bureau of Foreign and Domestic Commerce, comprised 6,381 short tons of crude magnesite, valued at $103,311, and 9,471 short tons of calcined magnesite, valued at $270,721, or a total value of $374,032. These imports came from the following countries:

	Short Tons	Value
Austria-Hungary	2,650	$64,933
Italy	2,416	62,753
Germany	34	2,023
England	29	4,849
Scotland	94	9,369
Canada	8,066	216,605
Mexico	2,563	13,500
	15,852	374,032

Presumably the material reported from Italy came originally from Austria-Hungary, and that from Mexico came from Santa Margarita Island and was calcined near San Diego. The imports in 1919, which amounted to less than 16,000 tons, were very small in comparison with those of former years. Grecian magnesite was not entered in 1919, and it is understood that none is likely to be imported for some time to come. The California magnesite must therefore continue to be used for the manufacture of Sorel cement, and as the value of this material for floors and for stucco on exterior walls becomes more widely recognized it would seem that some of the California deposits could be operated continuously and with profit. Unless the imports of magnesite suitable for making refractory material increase greatly, the domestic material suitable for refractory purposes —that is, the Washington magnesite and that from the White Rock mine in California—will continue to be used by domestic consumers, so that a fairly good year may be predicted for 1920.—*U. S. Geological Survey, Press Bulletin.*

India's 1919-20 Sugar Crop

The Indian Department of Statistics has issued its final memorandum on the sugar-cane crop of 1919-20, its figures being based on reports received from provinces containing 99 per cent of the total area under sugar cane in British India. Of the Indian states, estimates are furnished by Baroda and the states in Bombay Presidency. Estimates for the Orissa and Chota Nagpur Feudatory states have for the first time been received this year.

The total area shown is estimated at 2,667,000 acres, as against 2,884,000 acres in 1918-19, or a decrease of 7 per cent. The total yield of raw sugar (gur) is estimated at 3,001,000 tons, against 2,370,000 tons last year, or an increase of 27 per cent. The season has, on the whole, been favorable for the crop.

In addition to the areas for which particulars are given above, the crop is grown on a very small scale in certain other tracts in British India, the average area of which for the last five years has been about 25,000 acres, with an estimated production of 28,000 tons.

Manufacture of Potassium Permanganate

Generalizations With Details Obtained From Plant Operation — Chemistry of the Sodium Manganate Process — Dissolving and Chlorinating —Potash Crystallization — Research Possibilities

BY RAYMOND B. STRINGFIELD*

DURING the war, several plants were constructed in southern California to supply the demand for permanganates, and the total tonnage produced was very considerable. No data, however, were available as to either scientific or operating details, and in consequence each plant had to work out its own salvation. Pressure of production necessarily greatly interfered with research, and cessation of hostilities, with the accompanying slump in the permanganate market, found many troubles still unsolved, and one by one the plants ceased operations. The interesting economic feature, however, is that no two plants had the same troubles, and had their combined knowledge been pooled the probabilities are that some if not all of the plants would still be operating profitably.

While potassium permanganate may be obtained in several different ways,[1] the sodium manganate process is the one which has been chiefly used in this country. The literature on the production of permanganate is scanty enough, and as practically no details of actual commercial operations have been published in English, it is hoped that the following notes taken from the author's experience with the industry in southern California will be welcome.

CHEMISTRY OF THE PROCESS

The sodium manganate process for the production of potassium permanganate may be divided into four main steps. Finely ground manganese ore and caustic soda, either with or without sodium nitrate as an oxidizer, are mixed and heated, either in a reverberatory furnace or a shallow iron pan, to form green sodium manganate.

$$MnO_2 + 2NaOH + O = Na_2MnO_4 + H_2O$$

This product is ground, dissolved in water, and the solution treated with chlorine and either sulphuric acid or carbon dioxide to convert the sodium manganate to sodium permanganate.

$$2Na_2MnO_4 + Cl_2 = 2NaMnO_4 + 2NaCl$$

If no chlorine is used, the reaction

$$3Na_2MnO_4 + 2H_2SO_4 = 2NaMnO_4 + 2Na_2SO_4 + MnO_2 + H_2O$$

takes place, with the formation of only two-thirds the possible amount of permanganate and the precipitation of manganese dioxide. With the use of chlorine, the function of sulphuric acid or carbon dioxide is chiefly to neutralize the excess caustic soda, reducing the alkalinity, thereby allowing the more complete reversion of the manganate to permanganate.

The sodium permanganate liquor is freed from any manganese "mud."

The liquor is evaporated until the bulk of other salts present have crystallized out. The theoretical amount of potassium salt is then added, and the solution allowed to cool, potassium permanganate crystallizing out.

$$NaMnO_4 + KCl = KMnO_4 + NaCl$$

In the following description, the operation is not strictly that of any one plant, but details are combined from several plants in southern California.

FURNACES

The most important step in the process for making permanganate is the furnace reaction. Using caustic soda, equilibrium is reached in the reaction at a lower percentage of manganate than when potash is used,[2] but a considerable excess of alkali is necessary in either case, and economic conditions in this country favor the use of soda. Impurities in the ore affect the process in several ways. The presence of a small quantity of iron in the ore is beneficial, the reaction going slightly further toward completion, the iron perhaps acting as an oxygen carrier. Silica and alumina are detrimental, passing into solution later as sodium silicate and aluminate, their subsequent removal being an occasional source of trouble.

Although it is probable that further development would have been the roasting of the charge in comparatively thin layers in mechanically rabbled furnaces at a temperature below fusion, and with only air oxidation, the furnace operated most successfully was a gas-fired reverberatory furnace of the type shown in Fig. 1, operating at 980 deg. C. This furnace was built double, a crew of two men per shift handling the mixing, loading, rabbling and unloading for both furnaces.

Incoming manganese ore was passed through a Blake crusher, and then through a Herman ball mill, using 3-in. iron balls, the 80-mesh product being sent to storage. On account of inadequate grinding facilities, ground caustic soda was purchased in barrels. Sodium nitrate was delivered in 200-lb. (90.7-kg.) sacks.

The manganese oxides, "mud," recovered from the process were air dried on a cement floor, and returned to be used in a fresh mix.

The standard batch consisted of 325 lb. caustic soda, 225 lb. sodium nitrate and 350 lb. manganese ore (147.5, 102.1 and 158.2 kg. respectively). This was mixed in a small concrete mixer and loaded into the furnace with wheelbarrows, through charge holes in the top. It was then spread out with long-handled rakes, made from 4 x 6-in. (10.2 x 15.25-cm.) steel plates on 1-in. pipe,

*Chemical Engineer, Arthur R. Maas Laboratories.

[1]For electrolytic methods see CHEM. & MET. ENG., vol. [illegible], p. 387, and vol. 21, p. 680 (1919).

[2]For the excellent work of [illegible], Mellor and Russell, J. Soc. Chem. Ind., vol. 14, p. [illegible] (1895).

and as it fused was mixed frequently. When well fused, the mass was thoroughly stirred with compressed air by plunging a 1-in. (2.5-cm.) pipe on the end of an air hose into various parts of the charge. This was repeated just before the furnace was discharged, and had the effect of increasing the percentage of sodium manganate about 1.5 per cent, and of leaving the mass spongy and much easier to grind. The charge was withdrawn by raking through the side discharge holes into wheelbarrows, from which it was spread on a brick floor to cool before grinding. Under normal conditions, eight charges could be handled in one furnace in twenty-four hours, making sixteen for the double furnace. On the charge given above, the average recovery from the furnace as crude green sodium manganate was 72 per cent of the weight of the raw charge. The "green" averaged 25 per cent sodium manganate, which is comparable to Australian practice.[3]

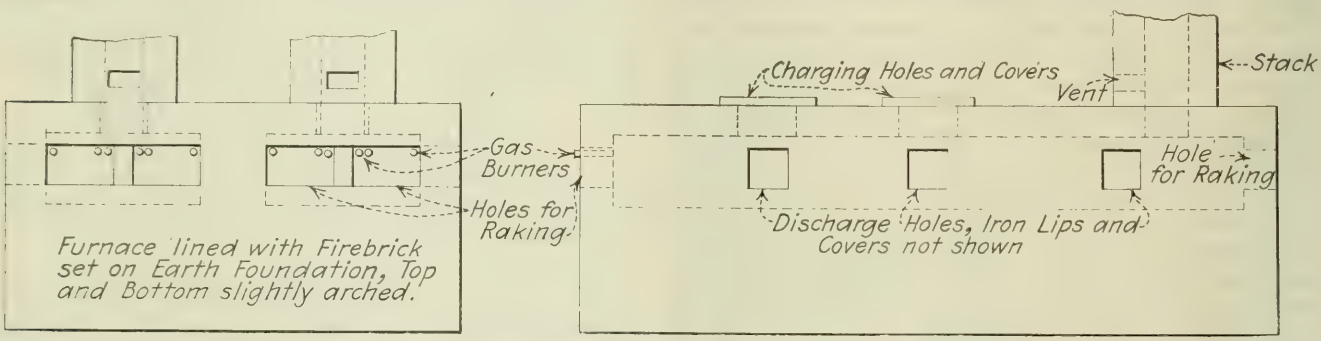

Charging Holes and Covers
Vent
Stack
Gas Burners
Holes for Raking
Hole for Raking
Furnace lined with Firebrick set on Earth Foundation, Top and Bottom slightly arched.
Discharge Holes, Iron Lips and Covers not shown

FIG. 1. FURNACE FOR SODIUM MANGANATE, 12 x 18 FT.

Under any operating conditions obtainable, the "green" was found to contain much sodium manganite, which decomposed on dissolving, throwing down a brown "mud," a mixture of manganese oxides. It was found that this "mud" could be air dried and worked into a fresh batch without lowering the quality of the "green." On account of the large amount of water in the "mud" it was not used alone, the mix being 325 lb. caustic soda, 200 lb. sodium nitrate, 250 lb. manganese ore, and 200 lb. air dried manganese "mud" (147.5, 90.7, 113.3 and 90.7 kg. respectively).

Dissolving and Chlorinating

The green manganate was passed through the same Blake crusher used for manganese ore, then through another Herman ball mill. The ground product was fed into a 700-gal. (2,650-l.) mechanically agitated dissolver, until the solution reached a specific gravity of 1.18, corresponding usually to the equivalent of 4.4 per cent $KMnO_4$. A greater density than this did not permit settling of the precipitated "mud." The liquor used for dissolving was the weak solution from the "mud" washing, carrying about 1.0 per cent $KMnO_4$. Into this dissolver, chlorine gas was run in the proportion of 1 lb. to every 4.45 lb. (0.45 to 2.01 kg.) $KMnO_4$ in solution, giving from 55 to 60 lb. (24.9 to 27.2 kg.) per batch. Two chlorine cylinders were mounted on platform scales and the gas introduced through several small holes in a pipe in the bottom of the dissolver. No trouble was had with the chlorine, except that the evaporation would cause cooling, and it was necessary in cold weather to turn the steam hose on the cylinders to melt off the ice, and increase the pressure of the chlorine.

From the dissolver, the muddy liquor was run either to a sulphating tank, Fig. 2, where strong sulphuric acid was added, or to a carbonation tower, where it was treated with carbon dioxide gas. In either case, the alkalinity of the solution was reduced to less than 1.0 per cent free NaOH, this point being easily controlled, with a little experience, by the color of the liquor, the green of the manganate changing to the full permanganate color at about 1.5 per cent alkalinity. The effect of the chlorine is apparently to form hypochlorite, which remains as such until the alkalinity is reduced, when it oxidizes the manganate to permanagate. The chlorinated liquor should be neutralized as soon as possible, and should not be exposed to the sunlight on account of the decomposition of hypochlorite and evolution of oxygen. The possibilities of electrolytic oxidation of the manganate in a suitab'y designed cell are very interesting.

The sulphated liquor was run to one of a series of four settling tanks, from which, after the mud had settled, it was decanted to a fifth tank, and the clear liquor from the top of this tank run over a weir to a "soda liquor storage." Both steel and concrete were found to be suitable for storage, little corrosion taking place as long as the liquor was alkaline, although the concrete was slowly affected. The mud was washed by counter-current decantation, and finally sent to the drying floor. This washing system could very profitably be replaced by a system of Dorr thickeners.

Evaporation

From storage, the "soda liquor" was pumped through a small measuring tank to open steel pans, where it was evaporated by means of steam coils immersed in the liquor, using steam at 60-lb. pressure (4.2 kg. per sq.cm.). As the solution became concentrated, the other salts present, being less soluble than sodium permanganate, were thrown down and were raked from the bottom of the kettles, centrifuged as dry as possible, washed with hot water, and sent to a salt dump. The handling of the salt is influenced considerably by the alkalinity of the liquor. When of proper alkalinity,

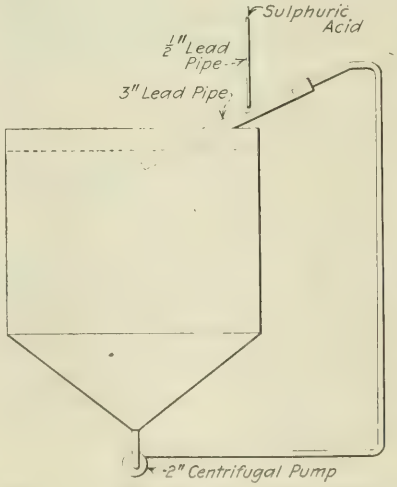


FIG. 2. DETAIL OF SULPHATING TANK

[3] See MET. & CHEM. ENG., vol. 18, p. 546 (1918).

the salt comes down granular, does not scale the coils, and carries most of the silica and alumina in the solution with it. This is especially true when carbonated liquor is used, sulphated liquor carrying a much larger percentage of impurities in solution. If the liquor is excessively alkaline, the salt is very fine, and tends to form hard cakes in the centrifugals, making thorough washing very difficult. On the other hand, too low an alkalinity causes the formation of a hard scale on the coils. As the alkalinity increases, due to concentration, the tendency for the permanganate to revert to manganate increases, and above 5.0 per cent NaOH is liable to cause trouble, the probable equation being:

$$2NaMnO_4 + 2NaOH = 2Na_2MnO_4 + H_2O + O$$

The kettle men were taught to test their own samples by the procedure given later, and when the liquor reached a concentration equivalent to 14.0 per cent potassium permanganate, an amount of potassium sulphate or chloride equivalent to the permanganate present was placed in a wire basket and lowered into the boiling solution. This dissolved rapidly, and the

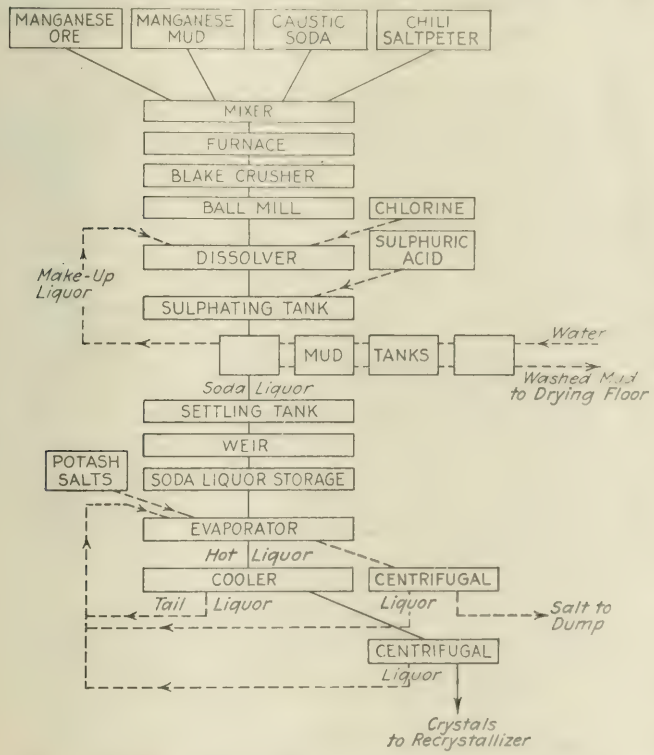


FIG. 3. FLOW SHEET, MANUFACTURE OF PERMANGANATE

solution was then drawn off to shallow iron coolers holding about 400 gal. each. These were supported so as to have free circulation of air, and cooled in four to six hours. After drawing off the cool mother liquor, the crystals were raked into a centrifugal, spun free of liquor, washed with cold water, recrystallized if necessary, dried on screens in a current of warm air, and packed in containers for shipping.

In connection with the crystallization, some interesting solubility effects are observed which deserve much further study. Various mixtures of chlorides, carbonates and sulphates are observed to repress the solubility of permanganate greatly, a mother liquor of 3.0 per cent being common, and 1.0 per cent not uncommon, against a normal solubility of potassium permanganate in pure water of 6.0 to 7.0 per cent. It should also be noted that the true color of potassium permanganate crystals is a brownish black. In former years, the trade has demanded purple crystals. The color was due to a film of decomposed permanganate on the surface. This was caused by the method of drying, and decreased the purity of the crystals 0.2 per cent or more. Most users have now become accustomed to the black crystals, and demand them as the purer product.

Laboratory Control

As mentioned before, a simple method was developed for the analysis of the ordinary permanganate liquors, and the kettle men were taught to make this determination on the soda liquor going to the kettle (to calculate the amount of potash to be added) and on the concentrated "hot liquor." This lessened the labor in the laboratory very materially, and made it possible to run it one shift only without delaying plant operations.

As several of the analytical methods used have not been published, a résumé of these may be of interest.

Permanganate. For purposes of comparison, all results, even on soda liquors, were expressed in terms of potassium permanganate.

On Liquors, Salts and Raw Crystals[1]—Ten c.c. N/10 $FeSO_4$, containing 10 per cent H_2SO_4, was titrated cold with a solution of the unknown permanganate, and results read from a table based on the following: For strong liquors, dilute 10 c.c. to 500 c.c. then

$$\text{per cent } KMnO_4 = \frac{158}{\text{c.c. titration}}$$

For weak liquors, salts and raw crystals, use larger or smaller quantities and correct the result accordingly.

On Green Manganate[1]—Dissolve 5 to 10 g. $NaHCO_3$ in 200 c.c. of water, add 5 g. finely ground manganate, stir until dissolved, dilute to 500 c.c., settle out MnO_2, and titrate with this solution as above. Multiply result from table by 3 to give total yield of permanganate obtainable with complete chlorination, since with this method three molecules of manganate give only two of permanaganate and one of manganese dioxide.

On Potassium Permanganate, U.S.P.—Dissolve 0.750 g. in 200 c.c. hot distilled water in a 400-c.c. beaker, add 5 c.c. 1:1 H_2SO_4, and pipette in very carefully 25 c.c. N oxalic acid. Stir until the MnO, formed is all dissolved, and titrate the excess oxalic acid with N/10 $KMnO_4$. At the same time, run a standard on 0.750 g. of potassium permanganate of known purity. This was prepared by recrystallizing U.S.P. potassium permanganate twice from distilled water, and drying in an air oven at 105 deg. C. On this product, water insoluble was determined on a 10-g. sample, and purity called 100.00 — insol$_{10}$ which was usually over 99.95 per cent. To calculate results, using a slide rule, let t_1 = back titration of standard, and t_2 = back titration of sample. Then purity of the sample =

$$\text{per cent standard} - \left(\frac{t_2 - t_1}{237}\right), \text{ i.e.}$$

$$99.95 - \left(\frac{14.3 - 13.0}{237}\right) = 99.95 - 0.55 = 99.40 \text{ per cent}$$

Duplicate determinations by this method check easily to 0.05 per cent, which is a much greater accuracy than can be obtained by the method of the U.S.P.

[1] Credit for this method belongs to R. W. Poindexter, Jr., of Poindexter & Co., whose suggestions were responsible for its development.

Alkalinity (Causticity due to NaOH).[5] On any strong liquor, dilute 25 c.c. sample to 250 c.c., and of this, take 10 c.c., decolorize with neutral H_2O_2 dropwise, filter with suction on an asbestos Gooch crucible, wash, keeping volume as low as possible, precipitate carbonates and sulphates with 10 c.c. of 10 per cent $BaCl_2$, filter, wash and titrate with N/4 HCl, 1 c.c. = 1.0 per cent NaOH. On weak liquors, H_2O_2 and $BaCl_2$ may be added in same solution and filtered together.

Research Work Needed

Several phases of this process present opportunities for interesting and commercially important research work. Much of this work requires equipment usually found only in a good university laboratory, and in case of an opportunity to engage in such work, the following suggestions are offered.

1. The effect of various proportions, temperatures, impurities and catalyzers on the furnace reaction between caustic soda and manganese ore.
2. Solubilities and phase rule diagrams for mixtures of the chlorides, sulphates, carbonates and permanganates of sodium and potassium.
3. The development of a suitable cell for the electrolytic oxidation of sodium manganate to permanganate.
4. Decomposition of permanganate solutions in the presence of MnO, MnO_2, etc.
5. Best conditions for the elimination of silica and alumina from permanganate solutions.
6. Conditions affecting the reversion of permanganates to manganates in alkaline solutions.

Summary

1. Details for the manufacture of potassium permanganate as carried on in southern California have been given, with analytical methods used in controlling the process.
2. A number of lines of research work are suggested.

Los Angeles, Cal.

[5] Since this method was developed, a similar method has been published by Craig, *J. Soc. Chem. Ind.*, vol. 38, pp. 96-7T (1919).

Wood Pulp Manufacture in Argentina

The utilization of the forestal riches of Misiones Territory, Argentina, for the manufacture of paper pulp is a suggestion that has met with favor among those interested in developing this industry in the country. Adequate means of water transportation is one of the especial advantages emphasized by Trade Commissioner Brady.

This territory, containing about 11,700 square miles, is in the extreme northwest of Argentina, lying between the Rivers Parana and Uruguay, which, in that region, average about fifty miles apart. Since the Parana is navigable for large steamers, water communication can be maintained with Buenos Aires, Montevideo and other ports. Misiones is tropical and heavily wooded, more than 700 varieties of trees having been counted; among these is an abundant tree, called caraguatazol, said to be very well suited for paper pulp.

Although the Territory of Misiones is sparsely settled, it is one of the sections to which immigrants are now turning. A holding, containing 416,800 acres, covered with heavy forests with an abundance of Araucanian pines 65 ft. high, was recently offered for sale at about $2 per acre.

Camphor Production in British Empire

The world's annual requirements and the present practical monopoly of production by Japan of camphor, together with the present high price and increasing demand, have drawn attention to the possibilities of profitable cultivation of camphor in other countries and particularly within the British Empire.

Prof. P. Carmody, F.I.C. (late Director of Agriculture, Trinidad), discusses the situation in the *Times Trade Supplement* of April 10. He points out that refined camphor is now about 2s. ($0.49) per oz. and 23s. 6d. ($5.72) per lb., whereas five years ago it was per pound little over the current price per ounce; and although there are—or have been—great fluctuations, the price may rise further unless increased production is assured.

Commercial camphor, he states, chiefly originates in Formosa, but as "the camphor is obtained there by distillation of the wood the annual destruction of trees must be very considerable, and this may account for the reports of diminishing supplies." It is estimated that 10,000,000 lb. of camphor is required by the world annually. Other present sources are the Fukien Province of China, Shikoku and Kiushiu Islands in Japan, Cochin China, Sumatra, Java and Borneo.

Results Already Obtained in British Colonies

In 1852 the tree was introduced into Ceylon, but little more was done until in 1893 a supply of seeds was obtained from Japan, and 1,000 trees were grown therefrom, from which, in 1901, the yield of solid camphor from fresh prunings was about 1½ per cent. "It is estimated," Prof. Carmody states, "that the yield of prunings (6 to 8 in. long) would amount to 56,000 lb. per acre per annum, and that with camphor at 2s. per lb. the net profit per acre per annum would amount to £74 ($360)." In 1906 there were over 100 acres devoted to camphor growing in Ceylon, but the cultivation was not commercially successful, as less than one ton of crude camphor was harvested.

At the present time experiments, with satisfactory distillation tests, are being carried out in the Federated Malay States, but in Mauritius the oil yielded is not the camphor of commerce.

In 1906, Prof. Carmody states, about fifty trees in Trinidad were transplanted to a better soil, with the result that "the growth has been quite satisfactory and a normal yield of solid camphor has been obtained on distillation," and in Dominica trees "obtained from Trinidad in 1911 have made satisfactory growth and have yielded solid camphor."

Requirements of Successful Cultivation

In the matter of successful cultivation, he advises that "seeds or seedlings from trees that yield no solid camphor must not be used. Stiff clay soils must be avoided. Not more than 300 trees to the acre should be grown in good average soil, or not less than 12 ft. apart in hedgerows, and a sufficient area (from 100 to 500 acres if possible) for economical distillation. When the trees are four or five years old they can be clipped, and thereafter three or four times a year."

Finally, he expresses the opinion that "the successful cultivation of camphor within the Empire is no longer doubtful," and "the reported depletion of native forests offers great inducements for further efforts," particularly in view of present high prices.

Apparatus for the Determination of the Porosity of Metals

By F. K. Bezzenberger and R. A. Wilkins*

In the making of non-ferrous castings for certain purposes, considerable importance is attached to the ability of the castings to hold pressure without leaking. Various tests are made to determine the applicability of a certain alloy or of a certain type of casting to the particular purpose in view. Such tests give isolated results, and offer no workable basis for a comparison of the porosities of various alloys when cast under the same conditions, or of the same alloy when cast by various methods.

An apparatus and method of testing are herein described, which not only afford a basis of comparison in any particular instance, but by which a numerical expression, denoting degree of porosity, can be assigned to any alloy under any conditions of casting. The advantages of such a method are great, not only in that the results obtained can be filed for future reference and comparison, but also because the basis of tests is standardized.

Apparatus

Fig. 1 shows the test casting use. This piece is cast oversize and machined so as to overcome the surface effect. It is of course necessary when comparing different alloys that the same method of casting the test piece be employed in each case, and when the effect of various types of casting is to be determined, that the alloy used and all other conditions be kept constant.

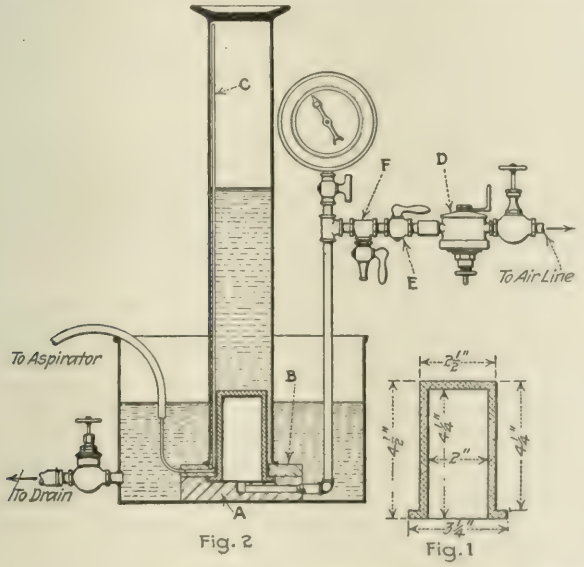


Fig. 2 Fig. 1

APPARATUS FOR THE DETERMINATION OF THE POROSITY OF METALS

Fig. 2 shows the testing apparatus, with the test piece in place. The "test cup" rests on a rubber gasket placed on the base, *A*. This base is made of steel and is drilled so that air may be admitted into the interior of the test piece. The flange, *B*, also made of steel, screws down on the base, holds the test cup in place, and gives an air-tight joint between the cup flange, the rubber gasket and the base. A 2,000-c.c. glass graduate is inverted over the test cup and over the small, rubber-tipped copper tube, *C*. The apparatus rests in a tank partially filled with water. Tube *C* is connected with an aspirator, and is used to remove the air from the graduate, which, of course, is replaced with water. Connections are made, as shown, to a constant-pressure air line. *D* is a reducer, by the use of which any desired pressure is maintained. The cock *E* admits air to the apparatus at the desired pressure. Cock *F* opens the system to the atmosphere, and is used to release the pressure instantly upon completion of the test. A pressure gage is placed in the air line, as shown, and a thermometer is hung in the water tank.

*Research Chemists, Lynite Laboratories of the Aluminum Castings Co.

Method of Testing

Testing procedure is as follows:

The test cup with gasket is placed in position on the base *A*. Flange *B* is then screwed down in place to give a tight joint, and the water tank is filled until the water level is about halfway up the test cup. Cock *E* is opened to test the apparatus for leaks, and the pressure gage is read. If necessary, the reducer is adjusted until the gage indicates the desired pressure. Air is then shut off and exhaust cock *F* opened until the pressure is reduced to atmospheric, and then closed. The glass graduate is then placed in position, and filled with water by means of an aspirator connected to the tube *C*. The apparatus is now ready for the test proper.

The cock *E* is opened at an observed time, and air, leaking through the casting, is collected in the graduate, When the volume of gas collected is sufficient to be read easily, the cock *E* is closed, cock *F* opened, and the time observed. These three operations should be simultaneous. It is well to collect 500 to 1,000 c.c. of air before stopping the test, as the relative error decreases as the volume increases. The difference in level between the water in the graduate and in the tank is measured, and the temperature of the water observed. The test is then complete, when the following data should have been taken:

1. Volume of gas collected.
2. Pressure of air used.
3. Difference in water levels.
4. Time of test.
5. Temperature of water.
6. Barometric pressure.

Calculation of Results

The measure of porosity, called *K*, is equal, numerically, to the number of c.c. of gas, under standard conditions, leaking through the standard test cup per minute per atmosphere of pressure, and is calculated from the formula:

$$K = V \times \frac{273}{Ta} \qquad B - Vp \qquad \frac{H}{13.6} \times \frac{1}{Tm \times Pa}$$

The literal quantities have the following meaning:

V = volume of gas collected, in c.c.
Ta = absolute temperature of water, in deg. C.
B = barometer, in mm. of mercury
Vp = vapor tension of water at observed temperature, in mm. Hg.
H = difference in water levels, in mm.
Tm = time of rest, in minutes
Pa = pressure used, in atmospheres.

The term Pa is introduced into the formula for the sake of simplifying the unit K. For comparative results, however, Pa should be maintained constant. The proportion $\frac{V}{V_1} = \frac{Pa}{Pa_1}$ although approximate, is not exact.

It is obvious that if so desired, the standard test cups be altered in design to permit of the study of the effect on porosity of thickness and of area exposed.

This apparatus and method of testing have been found very valuable in the study of the properties of various alloys. When castings are being made which are required to hold pressure, the incorporation of this porosity determination as a part of the standard testing practice gives data which are of great value in the maintenance of careful technical control.

Cleveland, Ohio.

Output and Shipments of Chilean Nitrate of Soda

The production of nitrate of soda in Chile during January, 1920, was 4,034,517 quintals of 101.4 lb. each and the exports were 9,039,403 quintals. The figures for the same month in 1919 were 4,276,498 quintals and 1,308,951 quintals, respectively. The exportation of 9,039,403 quintals, or about 409,000 long tons, was the largest in any one month in the history of the nitrate trade. It was brought about through the existence of fair stocks on the coast ready for shipment and the arrival of sufficient tonnage to load that quantity. It will not be possible to maintain shipments at that figure constantly owing to the inability of the railroads connecting the elaborating plants in the interior with the ports to transport that quantity regularly.

It is reported that the Asociacion de Productores del Salitre (Nitrate Producers' Association), which controls the sale of most of the nitrate produced, has recently received orders from Europe, and especially from Great Britain, for large quantities of nitrate for delivery before the end of 1920, the totals amounting to over a million tons. Prices are at present in the neighborhood of 15 shillings f.a.s.

The German steamers which were in Chilean ports during the war are being utilized to carry nitrate to Europe. Several have sailed, and three of those which had their machinery disabled are now being loaded with nitrate for Europe. These vessels are to be towed to destination by tugs sent out from Europe for that purpose. The use of the German steamers and sailing vessels will greatly facilitate the movement of the large quantities of nitrate which are now so urgently desired in Europe.

The large shipments of nitrate are reducing the stocks at the oficinas in the pampa, though there is still sufficient quantity to supply what is needed for exportation for several months. In view of the increased demand, five oficinas which were closed down for some time are preparing to start operation soon and are advertising for employees.

Forecast of India's 1919-20 Oilseed Crop

The March forecast of India's winter oilseed (rape, mustard and linseed) crop of the 1919-20 season places the area under rape and mustard at 3,563,000 acres, against 2,964,000 for 1918-19; and that under linseed at 2,323,000 acres, against 1,890,000 acres last year. The condition of this season's crops is, on the whole, considered good.

Legal Notes

By Wellington Gustin

The Chute Process for the Manufacture of Wood Alcohol Valid

In a recent suit for infringement instituted by Harry O. Chute against the Wisconsin Chemical Co., the action was based on claims 1, 5, 6 and 10 of the Chute patent, No. 824,906, for an improvement in the process of making wood alcohol, issued July 3, 1906.

These four claims of the patent are more or less typical of the six other claims of the patent, and are herewith given:

"1. The process of preparing wood alcohol from crude pyroligneous acid, which consists in distilling from said acid a concentrated distillate of between 10 and 25 per cent alcoholic content and of acid nature, allowing said distillate to stand to permit separation of impurities, and decanting off the clear liquid.

"1. The process of preparing wood alcohol from crude pyroligneous acid, which consists in distilling from said acid a concentrated distillate of between 10 and 25 per cent alcoholic content and of acid nature, allowing said distillate to stand to permit separation of impurities, decanting off the clear liquid, adding thereto an excess of alkali, decanting and refractionating the decanting liquid to produce perfectly miscible alcohol of above 80 per cent.

"6. The process of preparing wood alcohol from crude pyroligneous acid, which consists in distilling from acid an acid product of an alcoholic strength wherein oily impurities are insoluble, allowing the same to stand to permit separation of such impurities, and decanting off the clear liquid.

"10. The process of preparing wood alcohol from crude pyroligneous acid, which consists in distilling from such acid an acid product of an alcoholic strength wherein oily impurities are insoluble, allowing the same to stand to permit separation of such impurities, decanting off the clear liquid, adding an excess of alkali, decanting away from the resinous deposit formed, and refractionating the decanted liquid to form a strong alcohol of above 80 per cent and perfectly miscible with water."

Court Holds the Chute Patent Is Merely an Improvement of an Old Process

These claims were held valid and infringed in the United States District Court, and the chemical company attacked the decree of this court in its appeal, relying on alleged invalidity and non-infringement of the Chute patent. In passing on the questions involved, the United States Circuit Court of Appeals, Seventh Circuit, sets out Chute's method. The making of alcohol, it remarks, from wood was old in 1906, therefore the patent relates merely to an improvement of the process.

The pyroligneous acid is obtained from condensing the vapor or smoke from the burning wood to a liquid by means commonly practiced before 1906. This base is used in the Chute method. Chute's problem was to reduce the cost of producing the alcohol from this acid. It contains many ingredients, and it is by retain-

ing some and eliminating others that manufacturers are enabled to produce a merchantable wood alcohol, that is, an alcohol of at least 82 per cent strength and miscible with water. Chute claims to have reduced the cost by eliminating some of the steps previously taken. By his first step he obtained a distillate with a greater alcoholic strength than was formerly sought. By his third step he used an "excess of lime" to (*a*) neutralize the acid and (*b*) remove the resinous ingredient. He describes this step in his specification, as follows:

Practical Results Obtained by the Use of an Excess of Lime

"Therefore, after decanting the alcohol from the separated oily bodies, I add an excess of an alkali, as lime. Reaction soon sets in, as is shown by the development of yellow color, the familiar color known and carefully avoided in working with pyroligneous acid as an evidence of overliming. It is here, however, advantageous and not detrimental. As the reaction progresses, alkali-resinous matters separate and form a precipitate. These resinous bodies formed by the action of the alkali on the aldehydic and ketonic impurities form a mass of novel and useful characteristics, it being substantially a dye resin, being susceptible of use as a dyestuff, as it stains organic matters bright yellow when properly applied, and also of use as a resin. Being formed from a liquid from which the oily and tarry impurities have been removed by previous treatments, it is substantially pure. I do not claim this material herein specifically, but reserve the right to file a separate application therefor. The spirit decanted from this precipitate will be found much improved in quality, having been freed from these two classes of impurities, and I am therefore enabled to directly rectify in any rectifying continuous column, producing by this one redistillation alcohol of standard 82 per cent strength, but of such purity that it is miscible with water in all proportions and cannot be refractionated into portions 'milking' with water."

What Determines the Validity of a Process Patent

An older process in common use was first to free-treat the pyroligneous acid of tar (alcoholic content then being about 5 per cent) so that it might be thereafter neutralized with lime to make a merchantable acetate. By this method the producer was able to market not only wood alcohol (subsequently obtained) but a byproduct of wood alcohol. But repeated distillations were required before wood alcohol, miscible with water, was thus produced. Although Chute's process loses a valuable byproduct, it is an improvement in the art of making wood alcohol; the advance being in the lessened cost of production. But validity of the process, as a patentable invention, does not depend upon the question of whether the wood alcohol plus the value of the byproduct in combination is greater than the wood alcohol alone. These values may vary.

The validity of the process was attacked because of the prior art as disclosed in an article written by Vincent, a French chemist. In his first distillation, Vincent, using a multiple still, stopped "at the point where the methyl alcohol has all been distilled over." He also says, "A rich alcoholic liquid which abridges later operations is obtained." It was contended that this step is equivalent to the first step in Chute's claim 1, above given, "which consists in distilling from the said acid a concentrated distillate of between 10 and 25 per cent alcohol content and of acid nature." But the court held there was a difference between the Vincent and Chute processes. Vincent's description of his primary distillate failed to set forth the specific statement of the per cent of alcohol in the distillate, and it completely failed to provide for the elimination of oils from the acid distillate, and also failed to describe a process whereby wood alcohol of 82 per cent strength was obtainable by two distillations from a pyroligneous acid base. Even if the first step were fully disclosed by Vincent, anticipation of the process would not appear. For invention is recognized in this process not because of any one step alone, but because "a particular step" is taken in connection with other particular steps. The use of "an excess of lime" is important only as a step taken with and after the first step that resulted in "a distillation of between 10 and 25 per cent alcoholic content and of acid nature."

Now, the validity of a process patent containing several steps cannot be assailed by showing any one of the steps to be old. Even where all the steps are old, anticipation is not established, unless it further appears that the steps (old individually) were previously employed in relation to one another as disclosed in the patent the validity of which is disputed.

Validity of Chute Patent Affirmed

The chemical company further attacked the process patent, contending that the use of the words "excess of lime" in Chute's process is too indefinite and vague to apply. But Chute, while speaking to the public, was addressing himself primarily to those educated in the art under consideration. He was dealing with chemistry and to those familiar with the manufacture of wood alcohol. The court was of the opinion that such a class would have no misunderstanding from the use of the term and would experience no difficulty in following the directions given by Chute. Then the specifications of the process remove any doubt. The purpose of "over-liming," as well as its manifestations, clearly appears in the description, and one skilled in the art may follow the directions with comparative ease.

Therefore the validity of the Chute process was affirmed.

New British Dye

After experiments extending over a period of two years it is reported, says the American Chamber of Commerce in London, that the British Dyestuffs Corporation, Ltd., has now discovered at its Huddersfield laboratories the secret of manufacturing alizarine cyanine green dye on a commercial scale.

This green dye was first discovered in Germany at the works of Bayer & Co. in 1894, and was manufactured exclusively by Germany before the war. The exact chemical details were jealously guarded, and no information was given to chemical associations or allowed to appear in German technical journals.

The special characteristics of the dye are that when applied to wool, chromed or unchromed, fine green shades are produced which remain fast. Since the outbreak of the war, woolen manufacturers have not been able to produce varying shades with the fastness of this dye, which is used particularly for tweeds and ladies' dress goods.

The Vegetable-Oil Industry of Hull

FOR a number of years Hull has been known as one of the largest vegetable-oil centers in Europe. Prior to the war Hamburg, Germany, ranked first and Hull had to be content with second place; but during the war Hull so increased its plants and equipment that it is now without doubt the largest center in Europe and, it is thought, will easily retain the trade and position already established.

The industry was completely under government control until the end of March, 1919. This control was worked with the minimum of inconvenience and there were few complaints. The basis of priority allocations upon which the supplies of oil and cake products were distributed was:

1. The manufacture of edible oils, such as margarine and cooking fats.
2. Soap and candles.
3. Industrial uses, including the manufacture of paint, varnish, oilcloth and linoleum.

The greater part of the oil was used for culinary purposes. Linseed oil could be used for industrial consumption only on condition that it be "split" and the glycerine thus obtained delivered to the government.

The war greatly augmented the importance of the vegetable-oil industry owing to the increased demand for glycerine (for explosives), lubricating oil (castor oil for airplane motors), oil cake for cattle food, and oil for the manufacture of margarine. On account of the shortage of butter in the United Kingdom enormous quantities of margarine have been manufactured. Hull plants now turn out an average of ten tons per week, which is retailed at 26c. a lb., against the 98c. a lb. that is obtained for butter.

Imports and Exports

Prior to the war oil nuts from British West Africa were sent mainly to Holland and Germany for crushing. During the war the government requisitioned the entire output of British West Africa and Egypt, but, notwithstanding, the supply of raw material available did not equal the demand.

In tons the weight of the oilseeds imported in 1919 is 1,148,810, against 722,914 tons in 1918 and 1,229,472 tons in 1913, the increase over 1918 being largely due to heavy recipts of linseed, and the falling off as compared with 1913 being due to the smaller quantity of cotton seed received. Approximately three-fifths of the linseed came from the British East Indies in 1919 and practically all of the rest came from Argentina; 247,342 tons of cotton seed came from Egypt, as against 333,435 tons in 1918, and 170,601 tons from India against nil in 1918. Rapeseed and castor beans were practically all from India.

As already stated, oilseeds were controlled by the government until the end of March, 1919. While under control all material was sold at fixed prices, which were changed at intervals by the government, due notice being given. With de-control in view, the Ministry of Food during March made arrangements with the crushers throughout the United Kingdom to take over at fixed prices all stocks and commitments of seed lying in warehouses in different parts of the country. For a short period business was retarded, though such trade as was effected was done at maximum prices. From this time on prices were very flexible.

In addition to the large quantities of raw materials imported from other countries, the United Kingdom makes large purchases of foreign and unrefined vegetable oils, the imports for the past three years aggregating $33,619,642 for 1917, $56,410,494 for 1918 and $104,720,321 for 1919.

The oils and oilseeds imported into the United Kingdom are not all retained in the country for consumption or for manufacturing into commercial products. A certain proportion is reshipped in the form in which received, though such shipments are of minor importance when contrasted with the total imports. These re-exports in 1917 - 1919 amounted to $14,507,663 for 1917, $980,959 for 1918 and $15,141,466 for 1919.

With de-control came a quick revival of the export trade in British-made vegetable oils, shipments in 1919 being nearly seven times those of 1918. The outstanding feature of the year was the phenomenal gain made by pure linseed oil—$31,818,821.

Trade in Oilseed Cake

The imports of oilseed cake (unsweetened) into the United Kingdom for 1919, as compared with 1918 and 1917, were:

	1917		1918		1919	
Oilseed Cake	Tons	Value	Tons	Value	Tons	Value
Cotton seed	131,898	$10,184,616	2,719	$222,024	198,926	$19,527,303
Linseed	76,860	7,221,073	8,109	800,106	71,252	7,977,386
Rapeseed	616	44,850	.....	.....	190	19,466
Unenumerated	3,518	254,489	.....	.....	7,906	806,457
Total	212,892	$17,705,028	10,828	$1,022,130	278,274	$28,330,612

In 1918, for nearly the whole year, the importation of oilseed cake into the United Kingdom was prohibited in the interest of economy of shipping.

The exports of British-made oilseed cake in 1919 amounted to 5,099 tons, valued at $448,857. The exports in 1918 were only seventy tons, value $7,397; and in 1917, eighty-five tons, value $7,499. There were no re-exports of foreign or colonial cake.

Labor Conditions—Profits—Outlook for 1920

During 1919 labor conditions were anything but good. Although there were no strikes in any of the vegetable-oil mills, there was a general dissatisfaction on the part of the workers. Numerous strikes of dockers and a general strike of the railway employees lasting ten days caused great congestion upon the docks, and the crushers were a number of times practically without seed. Furthermore, they had enormous quantities of oilseed cake in their warehouses which buyers were unable to secure because of a shortage of barges and freight cars. Conditions are now practically normal.

During the first quarter of 1919, while the industry was under government control, the profit to the mills averaged 10 per cent. After control was removed there was considerable speculation, and, as before stated, prices soared. During this period and for the last half of the year profits averaged 25 per cent.

The outlook of the British vegetable-oil industry for 1920 is very promising. A new plant of enormous size, consisting of an extraction mill, chemical laboratory, deodorizing plant, refinery, and margarine, lard and soap factories, is erected by a local company. During January and February 596,939 gal. of linseed oil, valued at $999,770, was invoiced through the Hull consulate for shipment to the United States. Shipments promise to exceed this amount later in the year.

Experimental Briquetting Plant

Briquetting of Fuels and Ores Presents a Series of Problems Which Can Be Solved Satisfactorily Only in a Commercial Size Operating Plant—An Outline of the Briquetting Research Work in the General Briquetting Co.'s Experimental Plant

BY ALBERT L. STILLMAN

OF COURSE it will work—*in the laboratory!* What research man has not encountered skepticism expressed by emphasis on the last three words of the above comment?

It is the laboratory result multiplied in plant design and operation that makes industrial progress. It is not unusual to see an excellent product, painstakingly evolved by the research department, fail in commercial production, not from anybody's fault, but because some unforeseen quirk developed in quantity production.

The science of briquet manufacture, perhaps more than other chemical and metallurgical industries, has many problems still in the experimental or laboratory stage.

The science of briquet manufacture does not confine itself to the conversion of anthracite culm into merchantable fuel, although that problem has indeed held the center of the stage for years. Wherever and whenever a fine material is produced as an incident to operation—a fine material whose return to coarser size would be of benefit—a field is open to this most modern of sciences. Such problems are becoming increasingly numerous in these days of enforced economies. Wherever the blast furnace operates, whether on ferrous or non-ferrous reduction, fine ores and flue dust are a detriment, clogging the blast and slowing down operation. Wherever fuel is sized, whether anthracite or non-coking soft coal, the agglomeration of the fines into domestic size is highly desirable. Wherever a saw or planing mill is operated, the sawdust and planings present a conundrum for salvage. Wherever lathes, drill-presses or milling cutters are shaping metal product, a pile of fine metal turnings or millings develops whose disposition has heretofore proved vexatious to the melter. Fine metal, whether iron, brass, aluminum or what not, whether borings, spinnings, turnings or trimmings, suffers vaporization and oxidation loss in melting not sustained by heavy scrap, and the melting requires much more time and care.

PROGRESS OF BRIQUETTING

There is need for specialized research in briquetting. The field has become wide enough to constitute an engineering specialty. It cannot be said that anyone can at a glance advise a method for returning a low-value fine residue to a high-value larger size—still less the best method. Certain problems in the field are now adequately answered—that is, commercial equipment, thoroughly standardized, has been installed, and has made quantity production at a cost well below the selling figure of the briquetted product. The specific instances cover a wide field. The Ohio Metal Briquetting Co. of Cleveland, Ohio, is making 16 to 20 briquets of steel turnings per minute—the briquets running about 12 to 20 lb. each. The light steel is bought at the market price for machine shop turnings and sold at a premium over the market price for heavy melting steel. The product is bought for open-hearth melting, and the open-hearth operators cannot get enough of them. Anthracite coal fines are being briquetted at many plants; notably that of the Lehigh Coal & Navigation Co., Bamford, Pa. This plant was recently enlarged from 200 to 1,000 tons per day capacity. The Berwind Fuel Co. maintains a highly successful operation at Superior, Wis., where Pocahontas—bituminous—coal is pressed into briquets for the Northwest trade. In Buffalo the Wickwire Steel Co. has installed a large toggle press operating at a capacity of eight tons per hour to briquet the daily production of iron flue dust, while in another part of the city the Buffalo Slag Co. operates a similar layout to briquet the flue dust of the Buffalo Union Furnace.

These installations are mentioned to show the progress of the commercialization of briquetting processes to date. Summarized, we find hard and soft coal, blast-furnace flue dust, certain ores and the light scrap of steel and brass alloys are today being briquetted successfully on a commercial scale, while foreign practice shows in addition peat, lignites, sawdust and the light scrap of iron, aluminum and other metals. Indications are that these latter will shortly enter into commercial operation in the United States.

RESEARCH ON BRIQUETTING

Metallurgists and fuel experts conducting their own briquetting experiments have found a scant bibliography to help them and a paucity of available apparatus and experience. Industry has needed a research laboratory specializing in briquet manufacture for a long time. The General Briquetting Co., with all the European experience in the art readily available, none the less appreciated the necessity of such research to meet the special needs of this continent. A trained personnel, the primary requisite, was carefully acquired. A research laboratory was installed wherein pioneer work on many classes of material was done. This undertaking was simply a chemical and physical laboratory with appliances added for the purpose of experimentation in briquet making. Much of value was accomplished.

Foreign experience was confirmed and added to. New methods were devised successfully. But still no method was available for proving that laboratory results could be realized on a commercial scale. Moreover, in briquet manufacture probably more than in any other field the laboratory product is of superlative excellence. Whatever the material, a closely supervised preliminary treatment by hand, whether mixing, shredding or mastication, coupled with the painstaking molding and pressing on a laboratory hand press results in an ideal product difficult to reproduce commercially on a large

scale. This fact has been made use of by uninitiated and unscrupulous alike, in the production of high-class samples for use in the flotation of stock sales for briquetting plants. Especially has this been true in the coal game. Clearly a laboratory for research in this field should be equipped to demonstrate the feasibility of production on a commercial scale and that too by actual trial.

Briquet Questionnaire

The first and most important question of all in determining the possibility of briquetting any given substance is the difference in value between the briquets and material from which they were made. In the beginning

FIG. 1. INTERIOR OF LABORATORY

of research a definite answer is impossible until a reasonable quantity of briquets have been made, and their use demonstrated by consumption under existing conditions. For instance, it is well to know, if possible, the price per ton one can obtain for coal briquets as opposed to coal dust, before establishing a manufacturing plant. The other questions which a client of a briquetting engineer might ask and reasonably expect an answer are as follows:

1. Can this material be briquetted at all?
2. Can it be briquetted by pressure only, without the use of binder or catalytic agent?
3. If pressure only suffices, what pressure gives the best commercial briquet?
4. What shape and size briquet is best suited to the requirements?
5. If binder is necessary, what kind is most advisable and in what quantity?
6. If catalytic agent or accelerator[1] is necessary, what kind is most advisable and in what quantity?
7. What is the best method of admixing the binder or catalytic?
8. What other preliminary treatment such as grinding, heating, mixing, mastication or combinations of one and all of them will be advisable before the material goes to the press?
9. What type of press is best adapted to the purpose in hand?
10. What scale of operation would be most lucrative?
11. What methods should be adopted for most economical handling of briquetted material?
12. Under what conditions are the briquets to be consumed?
13. What will be the cost of a plant and its elements?
14. What will be the total cost per ton of briquets produced?

[1]By catalytic agent or accelerator is meant a reagent which while possessing in itself no binding or cementing power produces a chemical action in the material which results in cementation. The use of ferrous sulphate and other oxidizing agents in the briquetting of blast-furnace flue dust is a notable example.

Both Experimental and Operating Test Required

For some of these questions the answer can be found in a small laboratory; market condition, supply and demand answer some others without scientific investigation; but for the remainder, and especially for the points 8, 9, 11 and 14, a tonnage run under conditions closely approximating commercial is exceedingly desirable. How to obtain facilities for such "runs" in order to supplement laboratory results without excessive expense was the "meat" of the problem. The obvious answer was the installation of an operating plant making briquets of material whose commercial briquetting was already recognized as a market proposition, yet whose machinery was of sufficient variety to meet, at least approximately, any new requirement.

Accordingly the General Briquetting Co. established in New York City, together with a completely equipped research laboratory, an operating plant which divided its activities between coal briquets for the domestic market and the fabrication of brass and bronze turnings into briquets for remelting.

Briquetting Coal by the Dutch Process

For the manufacture of coal briquets, the method known as the Dutch process, made famous by its success at the Lehigh Coal & Navigation Co.'s plant, was adopted. Coal dust requires a binder. The binder used in this case is a heavy oil residuum of a melting point of 160 deg. F. It is melted and piped to a horizontal

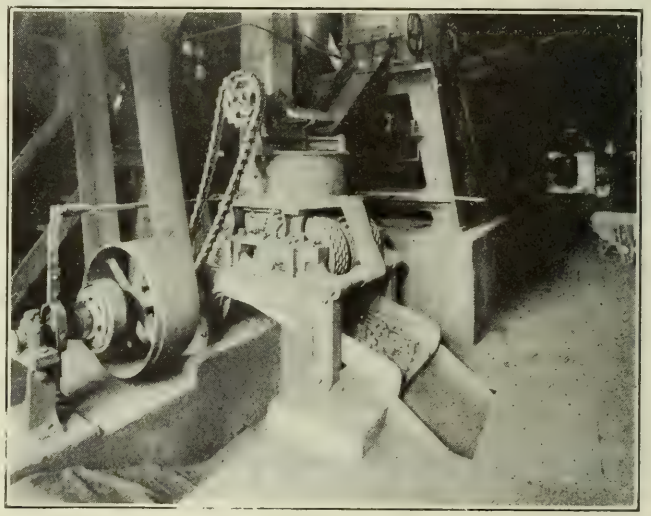


FIG. 2. COAL BRIQUETTING PRESS IN OPERATION

paddle mixer, there meeting a measured flow of dried coal dust, the ratio being about 95 per cent coal and about 5 per cent oil. From the mixer the coal oil flux drops into a great mill, known as the masticator, where heavy rollers grind the oil into the coal to a state, in fact, approaching dryness. From the masticator, the now thoroughly digested flux goes to a roll press, which molds it into 2-oz. eggettes, which are carried over a cooling conveyor to the bins.

The metal briquetting department is designed for the cleansing and briquetting of light brass scrap into clean briquets, 6 in. in diameter, 3 to 5 in. high—ingots in appearance and melting value. The waste metal trade of the East has long recognized the value of briquetted brass as opposed to loose turnings. Briefly, briquets of brass returned to the crucible show a marked decrease in volatilization and oxidation losses, a saving of a great percentage of melting time, and a consequent better control of melting mixtures.

The Vogel system of reclaiming metal, together with the large Ronay metal briquetting press, has been adopted.

In general this process involves the breaking up of the turnings in order that they may be fed to a press without choking the hopper; the removal of machine shop oil, whose presence impairs the strength of the finished briquet; and in the case of brass briquets, the removal of iron.

Installation of the Plant

Specifically at this plant, the installation consists of:

A Gilmore Shredder and Breaker wherein the turnings are broken up from long lengths to less than 5-in. lengths.

A Rockwell Rotary Furnace wherein the broken turnings are submitted to a temperature which has been determined as the proper temperature for burning out oil and waste without impairing the composition of the metal, or annealing the metal, for softening, where necessary.

A Cutler-Hammer Belt Magnetic Separator for the removal of iron filings, and in fact any ferrous admixture.

A Ronay three-stage vertical hydraulic metal briquetting press.

In addition a horizontal hydraulic press has been installed. The press is fulfilling a dual capacity. Where quantities of metal shipments are small and the vertical hydraulic press is at work on a large run, the horizontal hydraulic press works for the operating department, making metal briquets 4 in. in diameter and 3 to 4 in. high. The capacity is about 500 lb. per hour on such work, and the cost is, of course, higher than similar operation in the vertical press. Primarily, however, this press is a laboratory adjunct, and works on research material whenever indications point to a requirement for a pressure briquet approximately of the shape and size for which the mold is adapted. The working pressure can be varied from 3,000 to 20,000 lb. per sq.in.

Supplementing this small press the laboratory carries a small capacity edge runner or grinding mill for breaking or masticating material, and in addition a small rotating gas furnace for purifying purposes with a capacity of 200 lb. an hour.

Procedure of Investigations

Let us assume that this research laboratory is faced with three concrete problems—namely, the briquetting of materials marked A, B, C. Let us further presume that none of these materials has ever been briquetted at all. It is required to determine whether their briquetting could be accomplished with satisfactory commercial results.

The following procedure on the part of the laboratory is characteristic. As no previous experience in briquetting applies to these materials, one and all are tried on the laboratory hand press, using pressure only without admixture, to see whether or not a binder is required.

Let us suppose that material A is a fine metal and gives a good briquet in the hand press at 10,000 lb. pressure, material B, partaking of the nature of the fuel, gives no briquet under pressure without preliminary treatment or admixture, and material C, designated as a byproduct of chemical manufacturing, also fails to give a good briquet with pressure only. At this point the indications are as follows:

Material A. This material will readily make briquets along the approved commercial lines now adopted for metal briquetting. If the laboratory man has 30 or more pounds of this material at hand he makes a briquet on the horizontal hydraulic press. If more material is available, he makes a series of briquets showing results at varying pressures. A good briquet out of this press would show definitely that metal briquetting practice is adapted to the material at hand. When it is reported that the commercial briquetting of this material is possible, the trial is continued on carload quantities. When the carload has been made satisfactorily into briquets on either the vertical or horizontal press, the report furnished thereon, giving the time, power and labor required with the cost of the proper installation, indicates the solution of the problem for briquetting such material on a commercial basis.

Material B. This material presents a problem not quite so simple. The laboratory man tries all the various known commercial binders, still working with

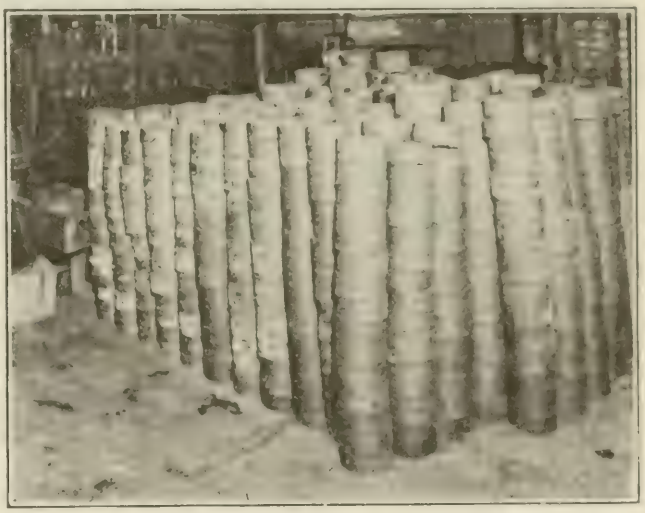


FIG. 3. BRIQUETTED TOBIN BRONZE TURNINGS

laboratory equipment and hand press to find out which binder is best. He further determines the proper treatment—grinding, heating, mastication or the combinations necessary to prepare the materials for pressing. In other words, the best way of mixing the material with its binder. After this mixture is completed short runs are made on the rotary press used in the coal plant turning out 2-oz. eggettes and comparison is made with the product under similar conditions in the horizontal press. If the economic report is satisfactory, work is continued on carload quantity in accordance with the method selected. The report in full on this run will give a correct basis for a commercial installation.

Material C. This material presents an interesting possibility. It is possible that the addition of a cata-

lyzer or accelerator may set up cementing action in the material so that it will bind under pressure. A series of known catalyzers are tried out and briquets made in the hand press. If an action takes place, the situation is probably similar to that of blast-furnace flue dust and the problem will parallel that of the Wickwire Steel Plant at Buffalo. There they briquet eight tons of flue dust an hour on a toggle press—pressure 8,000 lb. per sq.in.—the cementing action being caused by the addition of ½ of 1 per cent ferrous sulphate.

We may presume that one of these catalyzers or accelerators on Material C has shown a result similar to that produced by ferrous sulphate at Wickwire. In the hand press small runs are made by pressures varying from 1,000 to 20,000 lb. per sq.in. to ascertain at what pressure the cementation attains the highest efficiency. On the large Ronay press, as well as

FIG. 4. HORIZONTAL HYDRAULIC BRIQUET PRESS WORKING ON BRASS TURNINGS

the horizontal press, it is possible to vary the pressure within the same ranges. Consequently once the proper pressure is determined a tonnage run can be made in the plant at that pressure. In this case an allowance has to be made for the higher cost of hydraulic operation if the pressure indicated is low; that is, the tonnage run on a carload at the plant with a Ronay or horizontal press would cost more than a commercial installation using the toggle press. However, this deduction is easily ascertained from known practice in other places. The main answer has been obtained; that is, whether or not a merchantable briquet can be produced.

After-Treatment of Briquets

It frequently occurs that questions arise in regard to after-treatment for the purpose of toughening or hardening the briquets after they are produced. In some cases it is preferable, on account of low cost and smelting value, to use an addition of lime to secure binding effect. After-treatment is then often desirable to accelerate the setting of the lime. Such treatment is usually a heat either by direct steam or hot air. For such purposes a small hardening cylinder has been installed which can supply direct flue gas, live steam or super-heated steam to a charge of briquets in the cylinder. This installation has proved particularly useful in investigating the possibilities of ore briquetting.

Range of Usefulness of the Experimental Plant

The plant has already made a number of investigations, some of which are as follows:

Ground Phosphate. For the United States Department of Agriculture. Briquetted successfully in tonnage lots on the rotary press. Preliminary treatment: mastication with small percentage of water.

Carbonized Lignite. For the Lignite Utilization Board of the Dominion of Canada Government. Briquetted successfully in tonnage lots on the rotary press. Preliminary treatment: mixing and mastication with oil residuum binder.

Hard Steel. Briquetted successfully in Ronay press in tonnage lots. Preliminary treatment: annealing in rotary Rockwell furnace.

Hard Bronze. Same as Hard Steel.

Copper Cement. Briquetted successfully in horizontal press without preliminary treatment.

Tin Ore (Cassiterite). Briquetted successfully in roll press. Preliminary treatment: mastication with pitch binder.

Metal Leaf and Paper. Briquetted successfully on horizontal press. Preliminary treatment, low temperature heating in Rockwell furnace.

Complex Copper Ores. Briquetted in rotary press with lime binder. Preliminary treatment: mastication with lime. Final treatment: air-drying 24 hours or steam hardening in cylinder 3½ hours.

Shot Nickel. Briquetted in horizontal press. Preliminary treatment: mixing with sulphite pitch binder in pug mill.

Hardwood Sawdust. For Gas Defense Division, Signal Corps, U. S. A. Briquetted successfully in horizontal press without preliminary treatment.

There has been a host of other investigations, many whose result is still pending. The above serve to show how the supplementing of a laboratory with a commercial plant elastic enough to meet all reasonable requirements is not only desirable but very necessary in this important branch of research. In no other way can the "Fourteen Points of Briquetting" be adequately met.

English Dried-Flowers Industry

In consequence of the shortage during the war of medicinal herbs, an association of women in Suffolk, England, started systematic collection of such plants. From 1916 to 1918 belladonna, henbane and foxglove were the chief herbs handled.

During the year 1919 the demand for medicinal herbs fell off, but in their place arose a request for sweet-smelling herbs and flowers, and it is reported that during the current year collections thereof for the perfumery trade are being organized throughout the county of Suffolk. The new scheme is under the supervision of women botanical experts. It is stated that this rural industry has already resulted in considerable pecuniary benefit to East Anglian villagers, who have been instructed in the proper method of collecting. In April the picking of fresh heads of cowslips commenced, cowslips being used for sachets and pot-pourri as well as a cure for sleeplessness; broom and elder flowers will follow and many others.

A mill at Blackenham purchases the collections and prepares them for the market. The prices per pound at the mill for such dried flowers are: Cowslips (heads only), 2c.; broom flowers, 8c.; elder—heads, 1c., with florets picked off, 5c.; lime, 6c.; mullein and mallow, 8c.; bergamot (flowers without calyx), 12c.; lavender —on stalks, 12c., rubbed off stalks, 61c.; dark-red peony petals, 10c.; dark-red rose petals, 6c.; red field poppy petals, 8c.; mullein leaves, 2c.; raspberry leaves, 1c.; sage, mint, balm, agrimony and woodruff (whole herbs), 2c. Thyme brings 36c. per 14 lb.

Synopsis of Recent Chemical & Metallurgical Literature

Magnetic Properties of Iron Nickel.—In an effort to produce an alloy having higher saturation value than pure iron, for use in construction of electrical machinery, T. D. YENSEN of the Westinghouse E. & M. Co.'s research staff investigated the magnetic properties of very pure iron : nickel alloys made of electrolytic metal in an Arsem furnace.[1] Figs. 1, 2, 3 and 4 give the results of his investigation.

It has been shown by Honda[2] that the properties of the alloys in the neighborhood of 30 per cent nickel are very different after being cooled to liquid air temperature from what they are after being cooled merely to room temperature, and furthermore that this difference is due to the fact that these alloys—in addition to the reversible magnetic transformation points occurring above room temperature—have irreversible transformation points occurring below room temperature.

These transformations have been studied a great deal in recent years, the pioneers in the field being Hopkinson,[3] Le Chatelier,[4] Osmond,[5] Guillaume[6] and Dumas.[7] The alloys investigated by these scientists all contained foreign elements to some extent, particularly carbon and manganese. As a matter of fact, manganese was considered an essential constituent, because without it the alloys could not be forged. It is very unfortunate, however, for the interpretation of the results of the above investigations that these two elements referred to are the ones that affect the transmission points the most. Thus carbon is twenty times as effective as nickel in lowering the transformation points, and manganese, while less effective in this respect than is carbon, still is much more effective than nickel in specific influence. Fig. 5 shows Dumas' results for alloys without C and Mn, and in the region of 30 per cent both revers-

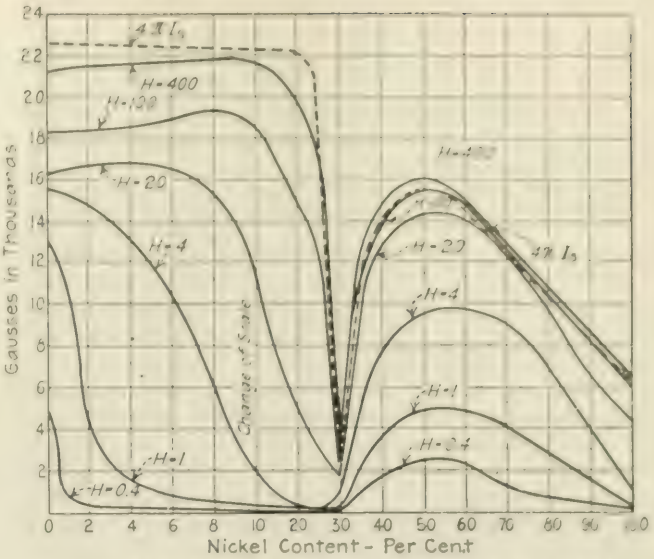


FIG. 1. SATURATION INTENSITY AND ISO-GILBERT CHARACTERISTICS

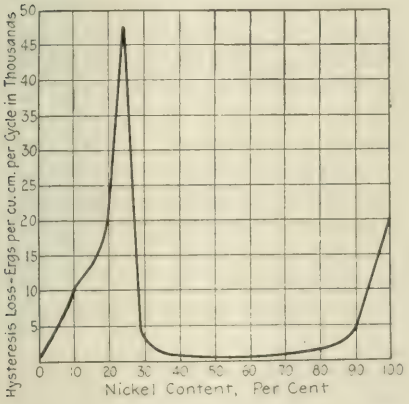


FIG. 2. HYSTERESIS LOSS

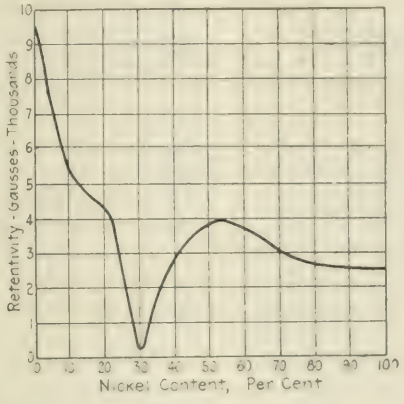


FIG. 3. RETENTIVITY

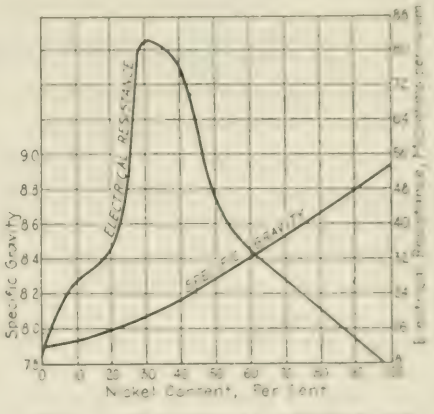


FIG. 4. ELECTRICAL RESISTANCE AND SPECIFIC GRAVITY

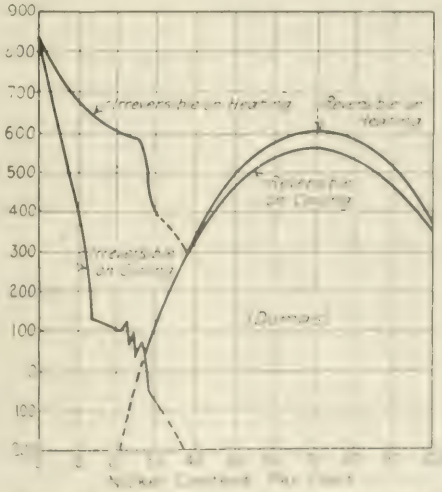


FIG. 5. REVERSIBLE TRANSFORMATIONS AS DETERMINED BY DUMAS' INVESTIGATION

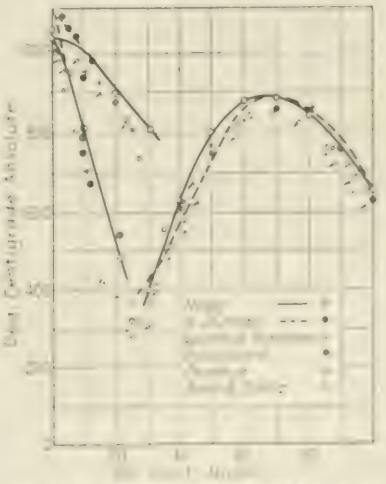


FIG. 6. REVERSIBLE TRANSFORMATIONS AS DETERMINED BY VARIOUS INVESTIGATORS

[1] Paper before joint meetings of American Institute of Electrical Engineers and American Electrochemical Society, Boston, Mass., April, 1920.

[2] The Thermal and Electrical Properties of Nickel Steels, "Science Reports," Tohoku Imp. University, vol. 7, p. 59 (1918).

[3] *Proc. Royal Soc.*, 46 and 47, p. 23, 1889; 48, p. 1, 1890.

[4] *Comptes Rendus*, 90, p. 285, 1890.

[5] *Comptes Rendus*, 118, p. 532, 1894; 121, p. 648, 1895; 128, pp. 306, 1395, 1513; 1899.

[6] *Comptes Rendus*, Jan. 25, April 5, June 18, July 26, 1897.

[7] *Comptes Rendus*, 139, p. 42, 1899; *J. Iron and Steel Inst.*, 11, p. 225.

ible and irreversible transformations were found; the latter, however, are lowered materially by a little C, which does not affect the location of the reversible points. Other investigations[8] are grouped in Fig. 6.

After quenching alloys in the 30 per cent region in liquid air, a remarkable change in magnetic properties at room temperatures ensues.

"Its saturation value was increased from 2,700 to 14,600 by cooling to —80 deg. and 17,800 by cooling to —180 deg. Similarly, the electrical resistance was decreased from 82 to 38 and to 32 by the above treatments. It is probable that the change would have gone to completion at —80 deg. if the test piece had been held there sufficiently long and that the irreversible transformation point therefore lies between 0 deg. and —80 deg., thus confirming Dumas' results.

"While only a few points were determined, they are sufficient to demonstrate that the cusp of both curves, after the completion of the transformations, occurs for approximately 34.5 per cent nickel instead of 30 per cent, as the previous investigation would lead one to believe. This points strongly toward the existence of the compond Fe_2Ni, corresponding to 34.6 per cent nickel, suggested by earlier investigators."

Recent Chemical & Metallurgical Patents

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Citric Acid; Calcium Citrate.—Calcium citrate is purified by treatment with sulphur dioxide in the presence of water, the resulting solution of calcium bisulphite and citric acid being then boiled, after removing organic matter by filtration to drive off the sulphur dioxide and re-form the calcium citrate. The precipitated calcium citrate is filtered off, washed, and again subjected to the preceding treatment until sufficiently pure, when it may be decomposed with sulphuric acid to produce citric acid. The sulphur dioxide driven off is available for the treatment of further calcium citrate. When the raw material consists of lime-juice or lemon-juice, it is directly treated with calcium bisulphite, the subsequent treatment being as before (Br. Pat. 136,979 —1919; H. D. GOLDING, J. RASCHEN and UNITED ALKALI Co., Liverpool; Feb. 18, 1920.)

Ammonium Perchlorate. — Ammonium perchlorate is obtained by double decomposition of ammonium sulphate and sodium perchlorate by a process which is stated to be generally applicable whenever one reaction product has a solubility increasing with temperature while the other has a solubility which rises to a maximum and then declines. An initial solution saturated with ammonium perchlorate and sodium sulphate at a temperature below 33 deg. C. is heated to a temperature above 33 deg. C. and ammonium sulphate and sodium perchlorate are added preferably in equivalent quantities so as to cause precipitation of sodium sulphate and saturation with ammonium perchlorate, the higher temperature being such that the ratio dissolved of sodium sulphate to water in the hot solution is the same as the ratio of sodium sulphate to water in the solution at starting. The precipitated sodium sulphate is removed and the solution is cooled to the starting temperature, when an equivalent amount of ammonium perchlorate separates, and the mother-liquor may be used again. It is not necessary for the starting solution to be wholly saturated with sodium sulphate, so long as the ratios above mentioned are equal, nor for the final solution to be wholly saturated with ammonium perchlorate, but these conditions give the best efficiency. An indifferent substance such as a small excess of one of the initial salts, or sulphuric acid, may be added once for all to the reaction mixture. In carrying out the process, the initial salts may be wholly or partly dissolved in separate portions of the initial solution, which portions are then mixed. (Br. Pat. 137,034—1919; L. M. E. WANG, Christiania; Feb. 18, 1920.)

[8] Bureau of Standards, Circular 86, 58 (1916); "Invar and Related Nickel Steels."

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Solder.—There was, during the war, a demand for solders containing a minimum amount of tin, and cadmium was substituted in certain solders with more or less encouraging results. The higher melting point of these solders was to their disadvantage, but for certain uses solders with a relatively high melting point have certain applications where this property is desirable, such as, for example, soldering commutator leads in electric motors. GEORGE P. LUCKEY, of Wilkinsburg, Pa., has found that a solder containing 8½ per cent cadmium and 91½ per cent lead has a relatively high melting point, beginning to melt at 249 deg. C. and completely melting at 280 deg. C. Solder of this composition has a maximum breaking strength, approximately 3,600 lb. for ½-in. round butt-soldered joint. (1,333,666; March 16, 1920; assigned to the Westinghouse Electric & Manufacturing Co.)

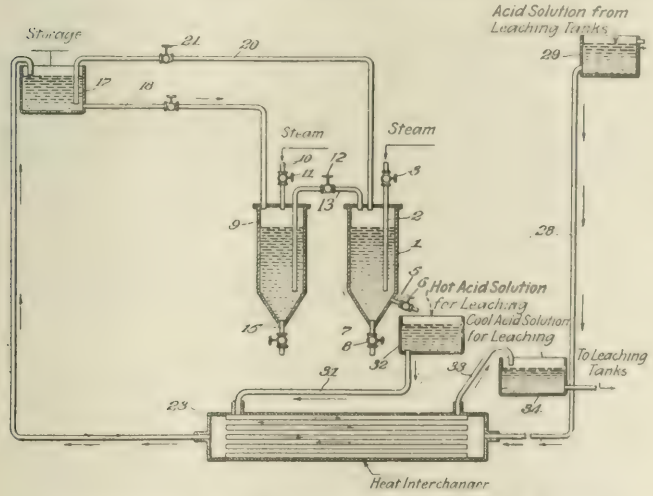
Purification of Zinc Solutions.—Nickel is one of the metals which produces deleterious results when sulphate solutions of zinc are electrolyzed for the recovery of zinc. In practice it is found that to obtain satisfactory results nickel must not be present in excess of one part per million. This element is not removed by the usual method, which consists in agitation with zinc dust at atmospheric temperature. SAMUEL FIELD of London, England, notes that in the presence of copper and at temperature of from 80 to 100 deg. C. zinc fume or blue powder will cause the precipitation of nickel, copper and cadmium and after removing the precipitate, the nickel content of the solution will be reduced to 0.5 part per million or less. (1,337,058; assigned to Metals Extraction Co., Ltd.; April 13, 1920.)

Process for the Extraction and Recovery of Tungsten.—The process consists in crushing the ore, preferably to pass a 120-mesh screen, leaching the comminuted ore with an alkali hydroxide such as caustic soda, filtering and washing the cake, and precipitating the tungsten from the filtrate by means of calcium chloride. Previous to filtering it is desirable to add acetic acid to give a slightly acid reaction to the solution. Suitable apparatus to carry out the process is described. (1,335,277; A. G. DE GOLYER of Ouray and A. E. RUND of Denver, Col.; March 20, 1920.)

Method of and Apparatus for Precipitating Copper From Hot Solutions.—When sulphuric acid is used to dissolve copper from ores or calcines, there usually is obtained a solution which contains iron sulphates. These, if the solution be electrolyzed for the recovery of copper, cause an increase in the amount of power consumed per unit of copper recovered. If the use of the solution be cyclic, the iron salts may accumulate to such an extent as to make uneconomical the continued use of the solution in this manner. Under these circumstances the copper is usually precipitated from the solution by means of iron and the liquor is wasted. This results in a loss of valuable acid. The expense of recovering all of the copper by precipitating on scrap iron is usually prohibitive.

FREDERICK LAIST, of Anaconda, Mont., proposes to precipitate the copper from hot solutions, using sulphur dioxide as the precipitant. It has previously been proposed to precipitate copper by impregnating the solution with sulphur dioxide and heating to a considerable temperature in a closed vessel. This process, while feasible, is not economical, due to the excessive cost of heating the dilute solution. It is desirable in using the process to heat the solution to a high temperature, since as a general rule the higher the temperature to which the solution is heated the greater the percentage of copper precipitated. The improvements proposed that result in a practical and economical process are in the conservation and utilization of the heat remaining in the solution from which the copper has been precipitated.

In the figure is illustrated, diagrammatically, apparatus suitable for carrying out the improved process. The



APPARATUS FOR PRECIPITATING COPPER FROM HOT SOLUTIONS

closed precipitating tank 1 has a steam supply pipe 2, extending into the solution as shown. Near the top of the conical bottom of the tank is a liquor outlet pipe 5. A pipe 7 is provided for the withdrawal of the precipitated metal. The closed preheater 9 has an inlet pipe 10 supplying steam to the upper part of the tank. A pipe 13 connects the upper part of the precipitating tank with the preheating tank, the outlet of the pipe being close to the bottom of tank 9, as shown. The tank is provided with a draw-off pipe 15. A closed storage tank 17 has an outlet (not shown) leading to an SO_2 compressor for the recovery of excess SO_2. This tank is connected near the bottom with the preheating tank 9, by means of a pipe 18. A pipe 20 connects the top of the precipitating tank 1 with the storage tank, the end of the pipe being near the bottom of the storage tank. Below the level of tanks 1 and 9 and the storage tank 17 is a tubular heat-interchanger, 23, of the counter-current type. This is so designed that cold solution from the elevated tank 29 will flow through pipe 28 through tubes in the heat-interchanger and out through pipe 27 to the storage tank. Hot solution from the receptacle 32 flows through pipe 31 around the tubes in the heat-interchanger and out through pipe 33 to the receptacle 34.

The precipitating operation is carried out in the apparatus as follows:

The precipitating tank 1 is filled approximately three-fourths full of the copper-bearing solution from which the copper is to be precipitated, such solution being heated in the manner to be described to about 125 deg. C. From this temperature the heating to about 155 deg. C. is completed by admitting live steam from a boiler through valve 3. Prior to the treatment with live steam SO_2 has been added to the solution. The precipitation having been completed and a final temperature of 155 deg. C. having been attained, the valve 3 is closed and the valve 12 opened, thus releasing the pressure in tank 1 of about 100 lb. per sq.in. and causing the liquid to boil. The steam passes through pipe 13 into the solution contained in tank 9. In about 30 min. an equalization of pressure between tanks 9 and 1 is accomplished and also an approximate equalization of temperature results. What actually happens is that the pressure in tank 1 falls from about 100 lb. to about 30 lb. and the pressure in tank 9 rises from zero to about 30 lb., at the same time the temperature of the liquid in tank 1 falls from 155 deg. C. to about 130 deg. C. while the temperature in tank 9 rises from about 100 to 125 deg. C.

This having been accomplished, valve 12 is closed and valve 21 opened, permitting the steam to flow into the solution contained in tank 17, which has been raised within a few degrees of the boiling point by passage through the heat-interchanger. At the same time the acid liquor in tank 1 falls in temperature to about 100 deg. C. and is allowed to flow into the hot solution receptacle 32 by opening valve 6, whence it flows through the heat-interchanger to receptacle 34 and thence to the leaching plant. The copper which has been precipitated is drawn off by opening valve 8.

Valve 12 is now again opened and at the same time high-pressure steam is admitted through valve 11, forcing solution in tank 9 into tank 1 for treatment. Tank 9 is recharged with boiling solution from tank 17. The acid liquor which is received from the leaching vats into tank 29, in passing through the heat-exchanger, is heated from about 20 to about 90 deg. C. and delivered to tank 17 at this temperature.

In the manner described the process is economical and in certain circumstances to be preferred to the electrolytic method of recovering copper from solutions. The copper recovered is of wire-bar grade. (1,333,985; March 16, 1920.)

Preserving Hydrosulphite Solutions.—Solutions of hydrosulphites used in the indigo dyeing industry decompose rapidly. It is the usual practice to make up a fresh solution each day. PETER MACINTYRE of Clinton, Mass., has found that stock solutions may be kept for several weeks in tanks cooled with ice water. A layer of oil is poured on the surface of the solutions, forming an air-tight seal which prevents oxidation. (1,333,029; March 9, 1920.)

Current Events

in the Chemical and Metallurgical Industries

Sixth National Exposition of Chemical Industries

The National Exposition of Chemical Industries returns this year to the Grand Central Palace in New York, where it will be given during the week of Sept. 20 to 25.

This Exposition, which is the sixth, will be more pretentious this year than ever, there being now engaged space for 358 exhibitors, which is more than in the last Exposition, in Chicago. The growth of this Exposition is remarkable and in a way indicates the growth and development of the chemical industries in America. In 1915 the first Exposition was composed of 83 exhibitors, the second increased to 188, the third to 288, the fourth to 334, and in the fifth, in which the available space was much restricted, exhibitors were held to a minimum of 351. This year another floor has been obtained in the Grand Central Palace, giving four floors, so that exhibitors may not suffer the cramping felt in the last Exposition.

Increased Attendance and Interest

Quite as remarkable as the growth of the Exposition itself is the increased attendance and interest that is shown in the exhibits. To the first Exposition there came 63,000 visitors, to the second there came 80,000 and the number has steadily increased till at the last there were in excess of 111,000 visitors. One who has watched the development of the Exposition and the interest of the visitors can testify to the great improvement in character of representatives the manufacturers have in attendance with their exhibits. The visitors, too, have undergone a change—one of education. The first Exposition brought forth a small following of the idly curious, but in subsequent Expositions a study of those attending has developed the fact that the interest even of the general public is more vital.

Three Sections Planned

This year the Exposition will have three special sections—the Electric Furnace Section, the Fuel Economy Section and a Materials Handling Section. The two latter are new sections. The first will, as its name implies, be one of electric furnace exhibits; the Fuel Economy Section will consist of exhibits of machinery and apparatus, furnaces, producers, stokers and all devices for the economic utilization or more efficient combustion of fuel. The possible exhaustion of our fuel reserves in the not far distant future and the present high cost of fuel make this section of much interest to all industrial plants. The Materials Handling Section will be a series of exhibits of machinery and equipment for the handling of material such as conveying, transporting and elevating. Included in this will be weighing, measuring and power transmission equipment. So important have these mechanical features become for all industrial plants due to the shortage and high wage for man power that an unusual interest is expected in this new section.

The program for the Exposition will have sessions on subjects the phases of which will be developed in the exhibits of these latter two sections. There will be sessions on chemical engineering, for which an elaborate program is planned. Motion pictures will form part of the program, and there will be popular public addresses as well.

Code of Engineering Ethics

A proposed new code of ethics, prepared by a committee of mechanical engineers, but intended to serve as a basis for a code of principles for all engineers, was discussed at the semi-annual meeting of the American Society of Mechanical Engineers, held in St. Louis, May 24 to 27.

The essential feature of the code is its brevity. It is intended to be a brief, positive statement of the professional relations of engineers to the public, to their clients or employers, and to one another.

The committee formulating the code recommended the establishment of a standing committee on professional conduct to interpret it, and also to judge cases of questionable ethical conduct on the part of engineers.

Proposed Code of Ethics

1. The mechanical engineer should be guided in all his relations by the highest principles of honor, of fidelity to his client, and of loyalty to his country.
2. His first duty is to serve the public with his specialized skill. In promoting the welfare of society as a whole he advances his own best interests, as well as those of the whole engineering profession.
3. He should consider the protection of his client's or employer's interests in professional matters his essential obligation, provided these interests do not conflict with the public welfare.
4. He shall refrain from associating himself or continuing to be associated with any enterprise of questionable or illegitimate character.
5. He can honorably accept compensation, financial or otherwise, from only one interested party unless all parties have agreed to his recompense from other interested parties.
6. He must inform his clients of any business connections, interests or circumstances, such as might influence his judgment or the quality of his services to his clients.
7. He must not receive, directly or indirectly, any royalty, gratuity or commission on any patented article or process used in the work upon which he is retained without the consent of his clients or employers.
8. He should satisfy himself before taking over the work of another consulting engineer that good and sufficient reasons exist for making the change.
9. He must base all reports and expert testimony on facts or upon theories founded only on sound engineering principles and experience.
10. He must not regard as his own any information which is not common knowledge or public property, but which he obtained confidentially from a client or while engaged as an employee. He is, however, justified in using such data or information in his own private practice as forming part of his professional experience.
11. He should do everything in his power to prevent sensational, exaggerated or unwarranted statements about engineering work being made through the public press. First descriptions of new inventions, processes, etc., for publication should be furnished only to the engineering societies or to the technical press.
12. He should not advertise in an undignified, sensational or misleading manner, or offer commissions for professional work, or otherwise improperly solicit it.

Nitrate Distribution

Charges being made on the floor of the House that the War Department is putting all possible obstacles in the way of the distribution of a portion of its nitrate reserve for fertilizing purposes were denied categorically by Major J. H. Hunter, who is in charge of the distribution. To set up the machinery to handle the distribution of this material, he states, has required a few days, but every effort has been made to expedite the work.

Since only twenty-four requests have reached the War Department for this fertilizer since the passage of the bill permitting its distribution, it is anticipated that there will be no demand for the entire 100,000 tons for the distribution of which authority has been granted. It is feared that the season has advanced so far that the demand for fertilizer will not be great, although it is pointed out that Chilean nitrate can be used to particular advantage for a considerable period as a top dressing.

Faraday Society Receives Thanks for Its Assistance During the War

At the last meeting of the Faraday Society the president, Sir Robert Hadfield, made public the important part the society had taken in 1916 and 1917 in the movement which led to the formation of the Nitrogen Products Committee. The occasion of the announcement was the receipt of a letter of thanks from Sir Graham Greene, Secretary of the Ministry of Munitions, acknowledging the assistance received from the society and many of its members.

The letter states that arrangements are now on the point of being concluded whereby the synthetic ammonia factory which had been partially erected is to be transformed into a commercial project on a very large scale, and many other fixation schemes are under consideration throughout the Empire. It concludes that the Faraday Society will doubtless consider the objects it had in view, in bringing the nitrogen problem before the Ministry, have been in a great measure achieved.—*The Engineer*, April 23, 1920.

Government Oil Corporation Proposed

Carrying still further the semi-governmental corporation idea, Senator Phelan of California has proposed in a bill the formation of the United States Oil Corporation to develop oil resources in foreign countries. Control of the concern is to be in the hands of nine directors to be appointed by the President. The corporation "may explore, develop, refine, transport and store petroleum and its products." It may form subsidiary corporations and may solicit subscriptions of stock. The majority of the stock must be owned by American citizens, but foreigners may become minority stockholders. Reports as to the activities of the company may be demanded from time to time.

E. I. du Pont de Nemours Buys Varnish Plant

Announcement has been made that E. I. du Pont de Nemours & Co. and the Flint Varnish Co., of Michigan, have purchased the Chicago Varnish Co., of Chicago, Ill. No radical change of organization is contemplated. W. J. Schlinger, vice-president and general manager of the Flint company, will have charge of the two plants.

Phosphate Deposits for Lease

Secretary Payne has approved rules and regulations for the leasing of phosphate deposits in the public lands. About 2,500,000 acres of lands in Wyoming, Idaho, Utah and Montana have been withdrawn from disposition for a number of years awaiting legislation recently enacted by Congress. These regulations will open them to lease in areas not exceeding 2,560 acres each and should add largely to the fertilizer supply of the United States, phosphate forming an important ingredient in commercial fertilizers. Applications for leases are to be filed with the local land offices for transmission to the Secretary of the Interior, and printed copies of the rules and regulations will be available to those officers and to the public as soon as printed.

Status of Paper Makers' Strike

Leaders of Unity of Workers, an independent organization of paper makers, on strike for 70c. per hour, express themselves as being satisfied with the results of the strike so far, and say that they hope to bring out more men in the course of a week. Effort is being made to call out firemen's helpers in all mills, which if successful will seriously handicap operation. Conferences between the Eagle Lodge of Paper Makers, an organized labor group, and manufacturers have reached a point where it is expected that an agreement will be reached on the Buffalo wage scale. However, the American Writing Paper Co., operating sixteen mills, has disagreed with the independent companies on the individual contract and refuses to institute it.

John Crerar Library Moves to New Quarters

The John Crerar Library at Chicago has closed its doors for four months, during which period it will be moved to the new location at Michigan Ave. and Randolph St., opposite the Chicago Public Library. The long period for which the library will be closed works considerable hardship on the technical men of the city, and is due to the fact that Marshall Field & Co., in whose building it has been located, gave peremptory notice that the library could not remain open another day after April 30, the expiration of its lease. This is in spite of the fact that the library has occupied the quarters for over twenty-five years.

New Wood Reduction Plant at Hattiesburg, Miss.

Plans have been made and contract has been signed for a $500,000 wood reduction plant at Hattiesburg, Miss., for the Hercules Powder Co. of Wilmington, Del. Turpentine, pine oil and rosin will be extracted from pine stumps on 100,000 acres of cut-over pine lands. A 100-acre site has been purchased for reduction works and contracts for erecting sixteen plant buildings have been awarded to A. D. Little, Inc., Cambridge, Mass. About $3,000,000 will be the cost of plant and timber land development.

Publishers Plan to Buy Paper Mills

Fear of Government regulation in the control of paper stock has caused the newspapers to try to work out a plan of salvation. To avoid dealing in the spot market, the smaller publishers are devising a plan to buy and operate their own paper mills. Already two mills of combined output of 28,000 tons per year are under negotiation.

May Meeting of the American Section of the Society of Chemical Industry

Friday evening, May 21, Rumford Hall afforded the usual opportunity for the weekly gathering of chemists. On this occasion, the program attracted many men interested in glue and gelatine and industrial heating with gas. Sumner R. Church presided due to the absence of Charles E. Sholes. He stated that he as an industrial chemist was a firm believer in the Society of Chemical Industry. He said it had a peculiar field and the American Section should be built up to at least twice its present membership of 800.

Robert H. Bogue opened the program with a noteworthy paper on "Properties and Constitution of Glues and Gelatines." As this address embodied some of the subject matter which is to be published more elaborately in this journal during July, no attempt will be made to review the paper.

Research Opportunities in Gas Industry

In discussing "Opportunities Offered to Chemical Industry in the Manufacture of Gas," Robert M. Searle suggested some of the problems confronting the gas engineer to which chemical research could be profitably applied. Mr. Searle felt that some of the problems were of such fundamental importance that they were worthy of the life-long attention of trained scientists, and he made an earnest plea for an endowed foundation where the research man's efforts would not be diverted from the main problem by the routine worries of an operating plant.

Even at the present time, there is much to be learned on the distillation of coal in retorts. Other research opportunities are: the recovery of sulphur and ammonia, possibly in the form of ammonium sulphide; the development of a non-clinkering brick less costly than carborundum; desulphurizing spent oxide, possibly though the use of a solvent.

In conclusion, several views of the modern vertical retort plant of the Rochester Gas & Electric Corporation were shown. Although 450 tons of coal is carbonized per day, the labor required is only six workmen and two foremen per shift. By keeping the CO_2 content of the producer gas constant to within 0.1 per cent, the retort temperature does not vary more than 90 deg. F.

Gas as a Fuel for Industrial Heating

The importance of using gas as a fuel for heating in industrial plants was well presented by Dr. Henry O. Loebell. He considered the various fuels in use at the present time, such as coal, coke, crude oil, fuel oil and gas, and pointed out that not only was gas, particularly blue water gas, cheapest but possessed many other advantages. Storage, which takes up a large portion of space in a plant, is reduced to a minimum. Ashes, together with attendant grate troubles and ash-handling apparatus which accompanies the use of coal or coke, is entirely dispensed with. A finer and more accurate control of flame and temperature is possible and products of combustion leave no residue, thus insuring cleaner operation.

He emphasized the importance of flame temperature as well as B.t.u. content and stated that blue gas was the best fuel due to the fact that it burned more intensely, had a greater heat delivery and was actually the most efficient and economical fuel for most uses.

Canada's Pulp Wood Embargo May Cause Retaliation

The passing of laws by Canada forbidding United States paper companies holding leases entitling them to cut timber on crown lands and from exporting the wood unless made into pulp in Canada has imposed considerable hardship upon the paper manufacturers of this country. The purpose of this action is apparently an attempt to keep the foreign pulp and paper industry on its own resources and thereby give Canadian paper industry an added advantage.

Although opinion hostile to a modification of this measure is known to exist, the refusal will mean, as a matter of course, says Senator Underwood, that an attempt to get through Congress an embargo measure directed at Canada will follow.

Canada's newsprint production has increased from 150,000 tons in 1909 to 808,000 tons in 1919, made possible by imports of sulphur and coal from the United States, on which an embargo may be placed.

Position of Norwegian Industry

At the general meeting of the Industrial Federation of Norway, General Director Platou, who opened the meeting with a speech in which he gave interesting information about the situation of Norwegian industries, made the following statement: While in 1885 there were approximately 1,900 factories and works, the number in 1917 was 7,000. The total paid-up capital stock, which in 1913 amounted to approximately 375,000,000 crowns ($100,500,000), had risen to 782,000,000 crowns ($209,576,000) in 1917, and at the close of 1918 to 1,127,000,000 crowns ($302,036,000). Of the total value of imports into Norway, materials imported for manufacture amounted in the years from 1876 to 1880 to approximately 26 per cent and in 1917 to 65 per cent. At the same time the exports of industrial products rose from 11 per cent of the total value of Norwegian goods exported in 1876-1880 to 65 per cent in 1917. The returns that the speaker had obtained from a number of concerns showed that in the years 1913-1918 an average dividend of 8.87 per cent had been paid, which is considerably under what other trades yielded during the period.

Quebec Has $10,000,000 Maple Sugar Crop

The Quebec province maple sugar crop of this year was from one-fourth to one-half as great again as last year's and the value was estimated at $10,000,000. The number of trees tapped showed an increase of 1,000,000. This is a great increase over former years when one takes into consideration the fact that the value of the 1910 crop was estimated at only $1,000,000. The above does not represent the possible yields, however, as anywhere from one-half to two-thirds of the sap is wasted, either by running over from the sap buckets or by the fact that not all the available trees are tapped.

Another World's Fair Proposed

An international exhibition of arts, industries and manufactures, and the products of the soil, mine and sea, to take place in Philadelphia in 1926 to celebrate the 150th anniversary of the signing of the Declaration of Independence, is proposed in a bill which has been introduced by Representative Darrow of Pennsylvania.

Inventions by Government Employees

In reporting favorably to the Senate the bill increasing the force and salaries in the Patent Office, the Committee on Patents added to the bill, as a new section, the bill outlining a procedure for dealing with inventions and patents developed by Government employees in the course of their official duties. The new section is an exact copy of a bill which had passed the Senate previously. It was made a part of the measure to increase the force and salaries in the Patent Office so as to expedite its enactment into law. It is understood that there is no objection to the bill in the House. The reasons for enacting such legislation are set forth by the committee as follows:

> There is no fixed or general policy dealing with inventions and patents developed by Government employees in the course or as a result of their official duties, and consequently no governmental administrative machinery for translating such inventions and patents into actual public service.
>
> In cases where patents are developed by the combined efforts of Government employees and others, difficulties at present arise concerning the administration of the same because of the conflict between the rights of the inventors and those of the United States.
>
> There is no way at present by which patentees in or outside the Government service can dedicate their patents to the public with the assurance that the public will reap the full benefit therefrom, because an invention covered by a patent so dedicated does not interest capital, and because it may be excluded from public use by patents subsequently taken out by others.
>
> Conditions brought about by the war, causing an unprecedented demand for inventions, and the industrial developments and readjustments now following the war, call imperatively for guidance. Also the host of inventions developed during the war in the many Government bureaus and other organizations, primarily for war purposes, but which have a peace application of inestimable value, should be co-ordinated, conserved and translated into industrial use.
>
> There is provided a means aimed to be acceptable to the medical profession of patenting and consequently properly controlling inventions in the field of medicine and surgery, the control of patents by private interests being contrary to the ethics of the medical profession.
>
> It is desirable to have governmental administration of a certain type of patents, not ordinarily attractive to manufacturers, in order to provide production of needed devices or materials for governmental or public purposes.
>
> Provision is made for some remuneration to patentees, to stimulate invention.

The increases in the Patent Office as provided in the bill will call for an increased expenditure of $511,840.

Insectides and Charcoal

The Walnut Growers' Spray Manufacturing Co., a subsidiary of the California Walnut Growers' Association, has completed its new plant at Los Angeles and is now manufacturing several varieties of its "Nicodust" insecticides. These are preparations of nicotine in various strengths combined with other ingredients, to combat the many insect pests which afflict the trees and vegetables of the vicinity.

In connection with this plant the Arthur R. Maas Laboratories have recently finished the erection of equipment to produce poultry charcoal from the many tons of walnut shells which were formerly a waste product. Three tons of charcoal per day is being produced, a ready demand for the product being found among the large poultry ranches of southern California. Tar and creosote are also being recovered from the walnut shells and will be utilized. Harry L. Glaze is responsible for several successful mechanical engineering innovations in this installation.

Decennial Celebration at Forest Products Laboratory

The celebration of the tenth anniversary of the Forest Products Laboratory will be held at Madison, Wis., on July 22 and 23. Present plans call for a two-day program, including addresses by men prominent in science, industry and commerce, inspection of the laboratory, a banquet and various other forms of instruction and entertainment. It is proposed to make a permanent record of this decennial in the form of a souvenir publication to contain all of the addresses and other relevant matters, including the names of those who can permit a permanent record of their operative contributions to be made.

During the ten years of its existence the efforts of the laboratory have been devoted to the development of improved methods and processes for the better utilization of forest products of all kinds, and to the direct assistance of the industries concerned. Among the major lines of endeavor are the following:

Pulp and paper	Grading lumber
Hardwood and softwood distillation	Laminated construction
Preservation of wood	Chemistry of wood
Decay and decay prevention	Boxing, crating, packing
Mechanical properties of wood	Needle and leaf oils
Glues for wood	Ethyl alcohol from wood waste
Kiln drying and air seasoning	Wood finishes
Grading structural timbers	Aircraft parts
	Veneers and plywood
	Steam bending
	Identification of wood
	Microscopy of wood

During the war direct assistance was rendered the War and Navy Departments and various other branches of the Government in the solution of many important problems, particularly in connection with aircraft, gunstocks, artillery wheels, escort wagons, and the boxing and crating of arms and stores for overseas shipment. It was necessary, throughout this period, to abandon all work on the regular peace-time program.

The committee in charge of the program extends a hearty invitation to CHEMICAL & METALLURGICAL ENGINEERING readers to attend the celebration.

Cottonseed Mills Import Peanuts

A 4,000-ton shipment of shelled peanuts from China has arrived at Galveston, Tex. This is the first of a large consignment contracted for by cottonseed oil manufacturers since the war to keep their mills busy during the off season for cottonseed.

Research work by the Bureau of Chemistry at Washington on peanuts has developed a flour which when added in amounts of 20 to 25 per cent to wheat flour produces a bread containing enough protein for normal growth. This offers increased possibilities in the utilization of peanuts in addition to the extraction of peanut oil. Large shipments of copra to this country are also made. Experiments at Washington on copra press cakes indicate that when mixed with corn an adequate protein mixture for cattle feed can be made at reduced cost.

Pulp Wood Swept Out to Sea

High water broke the booms on the North River at Murray, B. C., Canada, and allowed nearly $500,000 of pulp wood belonging to the Cape Breton Pulp & Paper Co. to be swept out to sea. It is estimated that this will probably be a total loss.

Objections to Patent Bill

In an effort to meet objections raised by the industrial chemical industry, Representative Nolan, chairman of the Committee on Patents of the House of Representatives, has not pressed for consideration the bill authorizing the Federal Trade Commission to administer certain inventions and patents. The bill passed the Senate March 22. It also has been reported favorably by the House committee and is now on the House calendar.

It is feared in some quarters that the bill as drawn at present would give undue advantages to both actual and nominal Government inventors. At the request of the chairman of the committee, F. G. Cottrell, the Director of the Bureau of Mines, Carl L. Alsberg, Chief of the Bureau of Chemistry, and A. Stewart, one of the Bureau of Mines' specialists, have undertaken to draft certain restrictive amendments which will meet objections offered by the industrial chemists. Mr. Nolan has declined to reopen the hearings on the bill, which is as follows:

A Bill authorizing the Federal Trade Commission to accept and administer for the benefit of the public and the encouragement of industry, inventions, patents, and patent rights, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Federal Trade Commission be, and hereby is, authorized and empowered to accept assignment of, or license or other rights or powers under, to develop, to issue or refuse to issue licenses under, to encourage the industrial use and application of, and otherwise to administer, on behalf of the United States, under such regulations and in such manner as the President shall prescribe, inventions, patents and patent rights which said commission deems it to the advantage of the public to be so accepted, as these may from time to time be tendered it by employees of the various departments or other establishments of the Government, or by other individuals or agencies; and to co-operate, as necessity may arise, with scientific or other agencies of the Government in the discharge of the duties herein set out.

Sec. 2. That the Federal Trade Commission be, and is hereby, authorized and empowered to collect fees and royalties for licensing said inventions, patents and patent rights in such amounts and in such manner as the President shall direct, and shall deposit the same with the Treasurer of the United States; and of the total amount of such fees and royalties so deposited a certain per centum, to be determined by the President, shall be reserved, set aside, and appropriated as a special fund to be disbursed as directed by the President to remunerate inventors for such of their inventions, patents and patent rights contemplated by this Act as may prove meritorious and of public benefit.

Sec. 3. That the Commissioner of Patents is hereby directed to grant all patents and record all assignments and licenses contemplated by this Act without the payment of any fee.

Canada to Establish a Research Bureau

To meet the keen competition in the industrial world in a more efficient manner, Canada is planning to establish a Bureau of Scientific Research at a cost of $600,000 for the grounds and building and $50,000 for salaries and upkeep. Mr. Cronyn, chairman of the committee appointed to consider this project, visited the bureaus of the United States, and made a report emphasizing the economies effected in public expenses in that country due to the work of the Bureau.

The standardization of all measures used in Canada for length, weight, volume, etc., and all forms of scientific apparatus and units of energy used in industry and public service will be the main work of the Bureau.

Robert W. Hunt the First Hunt Medallist

Herbert Hoover, speaking for the American Institute of Mining and Metallurgical Engineers, accepted a fund for the establishment of the Robert Woolston Hunt medal and award, before a large gathering May 27, 1920, at the Engineering Societies Building, New York City. The fund was proposed by the iron and steel committee of the Institute some months ago, but the privilege of establishing this memorial to the humanism, skill and learning of the Institute's past president was claimed by his partners and employees in business.

The medal is a very striking tablet, containing on one side a likeness of Captain Hunt, and on the other side a brawny steel-worker standing alongside a roll-train. It will be given not oftener than once yearly to the author of the best paper submitted to the Institute on the metallurgy of iron and steel. An award of a sum of money will also be given to the author of a meritorious paper on the same subject, it being understood that younger men only will receive this award, without being thereby debarred from also receiving the medal.

Mr. Hunt's business associate, John J. Cone, and his old friend Charles M. Schwab spoke at length upon his life, achievements and many good works, which are legion. As a fitting climax, President Hoover announced that the iron and steel committee had decided to award the first medal to its namesake, Captain Robert Woolston Hunt, nestor of steel metallurgists.

Belgians Seek Raw Material for Artificial Silk Here

Representatives of Belgian interests in the manufacture of artificial silk are now in this country negotiating for the purchase of cotton linters and chemicals as raw material used in its manufacture. Dr. Emil Bindschedler and his assistant, Dr. Juger, arrived in New York a few days ago to make tests on American linters and chemicals used in the manufacture of artificial silk.

Belgium is fast recovering from the effects of the war and is rapidly building up her industries, among which the production of artificial silk is very important. As no American material has been imported since before the war, she has had to depend upon surplus stock of the Allies. This supply is now running low and with the resumption of the Hungarian and Polish plants in addition to the main plant at Tubize it is necessary to procure larger quantities of raw material.

The Polish plant of Tubize at Tomazo, now a part of the new Polish state, has been enlarged to supply ammunition for the Polish Government in its war against the bolsheviki. Here, in addition to the manufacture of powder, about 9,000 lb. of artificial silk is produced daily, more than 3,000 workers being employed.

Experiment Station Devoted to Non-Metals

One of the new mining experiment stations for which an appropriation probably will be made, according to present plans, it is understood, will be devoted largely to the non-metals. As the non-metals represent the large raw-material supplies for the chemical industries, it is felt that intensive research of the character provided at mining experiment stations should be arranged for.

At present the Bureau of Mines is conducting six mining experiment stations. Four more have been authorized, but no appropriation for their establishment has been made. The sundry civil bill, which is about to become a law, is expected to provide funds for at least two additional stations.

Present Status of Bureau of Standards Samples

The Bureau of Standards will continue to prepare and issue standard samples during the coming fiscal year, although Congress has refused to continue the appropriation for the work. Since the money received from the sales of standard samples has always reverted directly to the Treasury, and is not available to the Bureau for any purpose whatsoever, the cost of procuring, preparing, standardizing and distributing the samples will necessitate the curtailment of other lines of established Bureau activities.

In the light of the above facts, it is earnestly requested that all users of standard samples refrain from any unnecessary waste of the material, and that educational institutions limit their use strictly to primary standardization and to advanced research.

A list of the standard samples issued by the Bureau, together with charges and ordering and shipping regulations, is given in the Bureau of Standards Supplement to Circular No. 25. In the future, standard samples will be issued only to users direct. This policy has been adopted to avoid, as far as possible, any chance of contamination or mixing of samples. Such chemical supply houses as have, in the past, carried a limited supply of certain standard samples for the accommodation of their customers can still render them service by remitting their orders with the proper fees to the Bureau for shipment.

Sample 50, which is a new chrome (3.6 per cent)-tungsten (17.5 per cent)-vanadium (0.75 per cent) steel sample, will be issued on or before July 1. Samples 23a, 0.8C bessemer steel, and 51, a new 1.2C electric furnace steel, will be issued on or before Sept. 1.

Book Reviews

THE PHYSICAL CHEMISTRY OF THE METALS. By *Rudolph Schenck*, translated and annotated by *Reginald S. Dean*. 1st Edition. John Wiley & Sons, Inc., New York, 1919. 239 pp. Price, $3.

This acceptable translation of what ought to become a very widely studied and extremely useful book is very welcome. The German original first appeared in paper covers, and was the verbatim report of a series of lectures delivered at Aix-la-Chapelle before engineers of the Rhenish industrial district to "deepen their understanding" of smelting operations and metallurgical processes. Doubtless the hearer's curiosity was aroused rather than his understanding deepened, for the subject matter covered is so wide that only a broadly educated and studious engineer could grasp all the different phases, while owing to limitation of space only cursory mention could be made of them—evidently a treatment not calculated to "deepen the understanding" of an expert. For instance, in the introductory chapter or Lecture I, on the Properties of Metals, no less than twenty-six sub-topics are considered, many of them worthy of a lecture or a series of lectures in themselves. Fancy compressing into two or three pages such subjects as Polymorphy, Determination of the Transition Point, Enantiotropy and Monotropy, or Electron Theory!

On the other hand, the few words on all these topics cannot but whet the appetite of any seriously-minded student for more and detailed information furnished in the various footnote references to the literature. In the hands of the expert, however, it will contain, in small compass, comprehensive mention of the wide ramifications of physical chemistry as applied to metals, and many side-lights upon any problem he may have under investigation, often with actual data available for use. Thus, Giolitti in his classical studies on cementation of iron and steel was able to use Schenck's Figs. 102, 103 and 104 in arriving at a rational explanation of the bizarre fact that some alloy steels emerged from the case-hardening operation deeply carburized yet superficially oxidized, and to define the precise limits of pressure and temperature in order to avoid such an unwelcome product.

During war times the original book was excessively rare in the United States. Possibly its form was such as not to attract the attention of the general metallurgical profession quickly, and its importations were therefore few in number. At any rate, for several years it was found impossible to purchase a copy or even to secure a loan. Now its appearance in English should do much to "deepen the understanding" by stimulating the study of physical chemistry as applied to smelting, metallurgical working and heat treatment on the part of all those who are really striving to make good metal better. E. E. THUM.

Personal

Dr. C. L. ALSBERG, Chief of the Bureau of Chemistry, has been attending a conference in Chicago at which he met the Bureau's district chiefs and inspectors. The object of the meeting was to plan the work for the next fiscal year.

Dr. J. H. ANDREW, chief of the metallurgical research department of Sir W. G. Armstrong, Whitworth & Co., Manchester, England, has been appointed to the chair of metallurgy in the Royal Technical College, Glasgow, Scotland, vacant by the transfer of Dr. Desch to the University of Sheffield.

E. J. BARTELLS, manager Wood Pipe Export Co., of Portland, Ore., visited San Francisco during the Seventh National Trade Council convention.

J. H. BECQUE has resigned his fellowship at the Mellon Institute to accept the position of assistant superintendent at the Plasterco, Va., plant of the United States Gypsum Co.

C. E. BEECHER, formerly with the Union Oil Co. of California, has been added to the staff of the Bartlesville station of the Bureau of Mines.

M. E. COOLEY, dean of the department of engineering at the University of Michigan, spoke before the Michigan Manufacturers' Association at its annual meeting at Detroit on a plan of the university for helping the country by doing industrial research work for small concerns.

HOWARD ELLIOTT and L. B. STILLWELL were elected directors of the United States Chamber of Commerce at the recent annual meeting at Atlantic City. Mr. Elliott is a member of the American Society of Civil Engineers and chairman of the board of the Northern Pacific R.R. Mr. Stillwell is past president of the American Institute of Consulting Engineers and of the American Society of Electrical Engineers and a member of the American Society of Civil Engineers. Both are from New York City.

Dr. ARTHUR W. DOX has resigned as chief in chemistry of the Iowa Agricultural Experiment Station to accept the position of research chemist for Parke, Davis & Co., Detroit, Mich.

JOHN B. FERGUSON, formerly of the Geophysical Laboratory of the Carnegie Institution of Washington, D. C., and now a member of the research department of the Western Electric Co. of New York City, has accepted a position as associate professor of chemical research at the University of Toronto.

Dr. WILLARD J. FISHER, assistant professor of physics of the University of the Philippines, and since July, 1919, acting head of the department, will leave the university this summer and return to the United States.

L. F. GORDON, business manager of *Ingeniería Internacional*, read the address prepared by James H. McGraw,

president of McGraw-Hill Co., Inc., on "The Service of the Business Press," at the Seventh National Foreign Trade Council convention in San Francisco, Cal.

F. M. KIRSCH, manager Wood Pipe Export Co., delivered an address in San Francisco at the Seventh National Foreign Trade Council convention on "The Webb Law in Operation."

CHARLES F. LEDERER, until recently superintendent of way of the Milwaukee Electric Railway & Light Co., Milwaukee, Wis., has become associated with the rail welding department of the Metal & Thermit Corporation, New York City.

Dr. A. W. OWENS, who has been at the Bureau of Standards as associate chemist in the metallurgical chemistry section for about two years, has resigned and will take up work as research chemist on the staff of the United States Smelting, Refining & Mining Co., about July 1.

D. H. SIMPSON, who has been a member of the physical chemistry section of the Bureau of Standards, leaves this position about June 10 to take up a new line of work in Chicago. This is the third separation from this section within the last few months and it is being considered whether the work of this section will not have to be discontinued until additional funds are available for the chemistry division of the Bureau.

E. T. STANNARD, vice-president of the Alaska Steamship Co., has been elected a vice-president of the Kennecott Copper Corporation. Mr. Stannard will move his headquarters from the mines at Kennecott to Seattle, Wash.

GEORGE H. TOMLINSON has accepted a position as research chemist with the Riordan Pulp & Paper Co., Ltd., at Hawkesbury, Ont.

CHARLES W. TRIGG has changed his headquarters from the Mellon Institute of Industrial Research, where he has been engaged in coffee investigation for the past four years, to the King Coffee Products Corporation of Detroit, Mich., in the capacity of chief chemist. His connection with the former organization will still be retained.

Current Market Reports

The Non-Ferrous Metal Market

New York, May 31, 1920.—Copper market unchanged from spot to July 31. Mercury again weakened, falling from $92 to $87.50. Markets of rare metals, like other markets, very uncertain. Tin declined 2½c. in the last week.

	Cents per Lb.
Copper, electrolytic	19.25
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	9.37½
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	50.00
Lead, New York, spot	8.80
Lead, E. St. Louis, spot	8.60
Zinc, spot, New York	7.50
Zinc, spot, E. St. Louis	7.50

OTHER METALS

Silver	oz.	$1.02½
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	2.70@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	95.00
Iridium	oz.	300@400
Palladium	oz.	110.00
Mercury	75 lb.	87.50

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	29.50
Copper bottoms	38.00
Copper rods	27.50
High brass wire and sheets	25.25
High brass rods	23.75
Low brass wire and sheets	27.25
Low brass rods	28.00
Brazed brass tubing	37.00
Brazed bronze tubing	41.75
Seamless copper tubing	32.00
Seamless high brass tubing	30.50

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	21.75@22.75
Aluminum, sheet scrap	21.25@22.50
Copper, heavy machinery comp	13.50@14.00
Copper, heavy and wire	13.50@13.75
Copper, light and bottoms	12.25@12.75
Copper, heavy cut and crucible	14.75@15.00
Brass, heavy	7.25@ 7.75
Brass, light	6.75@ 7.25
No. 1 clean brass turnings	8.00@ 8.25
No. 1 comp. turnings	10.00@10.50
Lead, tea	4.25@ 4.75
Lead, heavy	6.75@ 7.00
Zinc, scrap	4.25@ 4.50

The Chemical and Allied Industrial Markets

New York, May 28, 1920.

General indications seem to point to somewhat less strained conditions than have been prevalent for the past few weeks, although there is little to report in the way of actual business or price changes. The supply of *sodium nitrite* is better than it has been for the past few weeks and offerings as low as 19@19½c. per lb. for car lot and 20@20½c. for less than car lot have been heard during the period. One factor in this item has withdrawn all offerings on the grounds that material sold at this figure would mean a loss when the cost of shipment from abroad is considered. There has been no break as yet in the present *glycerine* rise and although 26½@28½c. per lb. still holds as a firm price, sales as high as 30c. have been rumored during the week. Among the heavy chemicals *carbon tetrachloride* is suffering from lack of transportation facilities and prices ranging from 13½@15½c. per lb. are being asked for spot material which is easily accessible.

COAL-TAR PRODUCTS

The seriousness of the Japanese money situation is making itself felt in this market. Contracts that producers have been striving to get for some time back are being cancelled by foreign buyers, who are finding it impossible, in the present situation, to meet the conditions of their original agreements. The transportation tie-up is not as complete as it was two weeks ago, but nothing in the way of relief to the depleted spot market has arrived. *Naphthalene* is still holding up around 15c. per lb., while flake and balls are difficult to find at 15½@17c. and 16@18c., respectively. Surplus Government supplies of *phenol* are still being offered at 12@20c. per lb., while *benzol* continues in very small offerings with quotations ranging between 27@36c. per gal. for pure, water white, and 25@31c. for the 90 per cent grade.

NAVAL STORES

Turpentine has been gradually declining during the period and latest reports have it as low as $2.27 per gal. There is enough material on the New York market to take care of the local demand, but up to the present there has been no attempt made to resume the exporting of this item. The *rosins* failed to come down with turpentine and as far as can be discovered there is no material being offered, even at the listed prices in the table, which are for the most part wholly nominal.

OILS

The vegetable oil market continues in a weak position with indications of still lower offerings in order to draw the buyers back into the market. Very little interest is being displayed in *linseed,* which came down to $1.65 raw, car lots, and $1.67, boiled, car lots, while *palm,* lagos, also dropped to 12½@13½c. per lb. from 13½@14½c. Offerings of *cocoanut,* ceylon grade, at 17½@18½c. and cochin at 18½@19½c. per lb. seem to be the average prices, which are 1c. below the previous report made last week in this journal.

Chicago, May 26, 1920.

More than one dealer and user of chemicals in Chicago has characterized current conditions as "coming back to earth." Conditions in regard to shipping seem to be improving, in that considerable quantities of all sorts of commodities are being received and bills of lading indicating

goods in transit are coming through the mail with increasing regularity. Shipments from a producing point direct to Chicago are coming through with the least interference while those which are routed through any one of the great freight switching yards are invariably delayed. Receipts here indicate the New York yards as the most congested point, import freight through that terminal being the most difficult of clearance.

Two weeks ago we mentioned that the freight tie-up had served to isolate Chicago and to render quotations here independent of conditions in the rest of the world. This is now true in a slight degree only, as receipts are sufficient to bring this market back into correlation with New York. General inactivity is noted. While this is, in a measure, due to the fact that wise buyers stay out of a market when they know available materials are very scarce, it is felt that general business conditions are mostly to blame. Banking interests everywhere are holding credit lines very tight, and slow deliveries have made purchasers slow in paying bills. This limits the amount of money available. Coupled with this, a well defined feeling of uncertainty as to future industrial and trade conditions renders everyone reluctant to accumulate any great stocks. As a result, users of chemical products are operating on a hand to mouth basis, with an eye on the future.

Heavy Chemicals

Improvement in conditions has made itself felt in an increase in the available supply of *alcohol*. It is not yet plentiful but can now be obtained in reasonable quantities. Today's quotation on *ethyl* grade in barrels is $5.57½ per gal. for immediate delivery. Owing to the high price no one is buying more than enough for immediate needs. Second hands in broken package quantities are bringing $6 to $7 a gal. *Methyl* grade seems harder to get than ethyl. A nominal quotation is made on this grade of $2.65 per gal. for 95 per cent, though none was found offered for actual delivery at that figure. Spot goods could command 10c. higher if the buyer had to have the goods. *Denatured*, 190 proof, while obtainable, continues to increase in price, being offered today at $1.09@$1.11. *Formaldehyde* is about the same as when last mentioned, current small transactions ranging around 62@65c.

Cancellation of large orders of alkali products for the Far East have broken the heavy demand on makers and an immediate reaction in price was felt in *soda ash* and *caustic soda*. The former, quoted a fortnight ago at 4½@5c., is now obtainable at 3¾@4c. on contract. *Caustic soda*, worth 7c. on contract two weeks ago, is from ½c. to ¾c. lower. Spots in both these commodities remain unchanged, as the local stock condition remains bad. Lower prices seem only a matter of a little time, therefore trading is inactive. *Bleaching powder* at 5c. per lb. and *sal soda* at $1.60 cwt., f.o.b. Chicago, show no recent appreciable change.

Under lightened demand, spot quotation on *blue vitriol*, large crystals, is off ½c. from former quotation, to 8c. per lb. Prices of makers for contract delivery show no change. *Copperas* is holding firm at $2.75 cwt., which seems high, but is probably justified by existing scarcity of supply. *Mercury*, closely following the New York market, is offered at $95 a flask, which represents a 10 per cent increase in the past month. *Sodium nitrite* has again been subject to violent fluctuation, today's quotation being around 30c. per lb. The past two weeks have seen quotations on this item ranging from 25c. upward.

Coal-Tar Products

As in other chemical lines, the grip of the traffic tie-up seems to be gradually lessening, though the entire market is, as yet, in bad shape. The entire range of prices seems too high and buyers are necessarily not going beyond positive week-to-week requirements. The market has been spotty for some time, quotations being of value for the one day only. The general trend seems to be downward and must remain so for business to resume a healthy tone. Among the crudes, 28@29c. per gal. is quoted on *benzol*, with producers booked up solid for some time to come and local stocks at the minimum. *Cresol* is in readier supply at 16c. and the trade is absorbing production easily. *Toluol* continues strong at 31c., with producers well sold up. *Naphthalene* remains in heavy demand, but buyers refused to close at recent high figures. Flakes as a result are down 2c. to 15c. a lb. and balls to 16c.

The acids, in general, are strongly held, with but little business being done. *Picric* alone seems in good supply, current price being 24c. per lb. for local stock. *Benzoic* is held at 90c. on U.S.P. grade for later delivery, but scant stocks have run dealers' price up to $1. Technical grade is still quoted at 75c. per lb. Manufacturers are holding firm at 60c. per lb. on *salicylic* acid, c.p. grade, for future delivery. Holders of local stocks have been forced by lack of purchasers to reduce prices to 55c. Fluctuations on all these items are of wide range and rapid. Intermediates remain on too high a level to interest buyers. *Aniline oil*, quoted at 37@38c. per lb., has felt a severe slump in demand, as also has *aniline* salt, quoted at 48@50c. Lower prices must prevail before much business is transacted. A market scarcity has developed in *anthracene*, it now being quoted at $1 per lb. for 80 per cent.

Vegetable Oils

Supply is easier but demand continues light. The general tendency to refrain from buying beyond present-day needs is heavily felt in this line, and although prices have held to quotations last given, except for a few fractional declines, the weakness is evident. Current business in *soya bean*, *corn* and *cottonseed* oils is at a minimum. Some *cocoanut oil* is changing hands on a basis of 17c. per lb. for Manila grade in sellers' tanks, f.o.b. coast. Local quotation on *linseed oil* remains at $2.05 for raw, $2.07 for boiled, in barrels, carload lot quotations on bulk falling off a few cents to $1.60@$1.65. Rail troubles have closed some producers and caused a short supply, but consumption in construction operations has likewise fallen off. The future of this particular item is hard to forecast, though lower prices seem probable.

St. Louis, Mo., May 25, 1920.

The transportation situation, as affected by the rail strike, while continuing to show improvement, is still far from normal. Considerable time must elapse before the present depleted local stocks of chemicals are replenished and conditions become stabilized. Especially is this true for chemicals which are not manufactured locally or where local production is limited. The curtailment of production of other industries which are large consumers of chemicals has to a certain extent relieved the situation.

The demand for heavy chemicals continues to be good and in many cases exceeds the supply.

Sulphuric Acid. — The demand is good and prices show little increase in past two weeks. The 60-deg. grade is quoted at $15 to $16 per ton and the 66-deg. grade $22 per ton. Oleum is quoted at $27.50 per ton.

Muriatic Acid.—The demand continues heavy and local supply is sold up. The 18-deg. grade is quoted at $21 per ton. No increase for past two weeks.

Nitric Acid.—Prices unchanged. Quoted in carload lots at $7 per hundred for 36-deg., $8 for 38-deg., $9 for 40-deg., $10 for 42-deg.

Acetic Acid.—The demand is heavy and local stocks low. Prices show increase. Spot transaction for glacial grade 18½c. per lb.

Phenol.—Demand good and supply plentiful due to local firm disposing of surplus Government stock. Quotation unchanged at 12c. per lb. in large quantities.

Zinc Chloride.—Unchanged and quoted at $2.50 to $2.75 per hundred.

Caustic Soda.—Supply very limited and prices unstable. Quoted at 7c. per lb. for 76-per-cent test in drum.

Sodium Carbonate.—Local supplies very low. Sales reported at $2.25 per hundred.

Soda Ash.—Demand exceeds supply. Quoted carload lots in barrels at $4.50 per hundred.

Sodium Nitrate.—Supply limited and prices increasing. Quotations for spot transactions 6c. per lb.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	.....	$0.65 – $0.75
Acetone	lb.	$0.15 – $0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.25
Acetic, 56 per cent	cwt.	6.00 – 6.50	8.75 – 9.00
Acetic, glacial, 99½ per cent, carboy	cwt.	15.50 – 16.00	16.50 – 18.00
Boric, crystals	lb.	.15 – .15½	.15½ – .16½
Boric, powder	lb.	.15 – .15½	.15 – .16
Citric	lb.	1.05 – 1.12	1.17 – 1.18
Hydrochloric (nominal)	cwt.	2.00 – 2.50	3.50 – 4.00
Hydrofluoric, 52 per cent	lb.	.12 – .12½	.13½ – .14
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)		..... –	..... – .....
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.60 – .65
Phosphoric, Ortho, 50 per cent solution	lb.	.22 – .23	.24 – .25
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.50 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 18.00	..... – .....
Sulphuric, 60 deg., drums	ton	..... –	..... – .....
Sulphuric, 66 deg., tank cars	ton	23.00 – 25.00	..... – .....
Sulphuric, 66 deg., drums	ton	35.00 – 40.00	50.00 – 55.00
Sulphuric, 66 deg., carboys	ton	36.00 – 40.00	50.00 – 55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	37.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 – .....
Tannic, U. S. P	lb.	1.50 – 1.60	1.65 – 1.70
Tannic (tech.)	lb.	..... –	.60 – .90
Tartaric, crystals	lb.	..... –	.80 – .85
Tungstic, per lb. of WO	lb.	..... –	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl, 95%	gal.	..... –	2.50 – 2.70
Alcohol, Methyl, pure	gal.	..... –	3.50 – 3.55
Alcohol, denatured, 188 proof (nominal)	gal.	..... –	1.05 – 1.10
Alcohol, denatured, 190 proof (nominal)	gal.	..... –	1.00 – 1.05
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15½ – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.01½ – .02	.02½ – .03½
Aluminum sulphate, iron free	lb.	.02½ – .03	.04 – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – .13½	.13½ – .14½
Ammonium nitrate	lb.	.08¾ – .12	..... – .....
Ammonium sulphate	lb.	.07 – .07½	.08½ – .....
Amylacetate	gal.	..... –	5.00 – .....
Amylacetate tech	gal.	..... –	4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	..... –	.13½ – .14½
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	..... – .....
Barium chloride	ton	150.00–160.00	1.75 – 2.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.09½ – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)		..... –	..... – .....
Blue vitriol (see copper sulphate)		..... –	..... – .....
Borax (see sodium borate)		..... –	..... – .....
Brimstone (see sulphur, roll)		..... –	..... – .....
Bromine	lb.	.70 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	..... – .....
Calcium carbide	lb.	.04½ – .04½	.04¾ – .05½
Calcium chloride, fused, lump	ton	23.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.50 – 5.50
Calcium peroxide	lb.	..... –	1.50 – 1.70
Calcium phosphate, monobasic	lb.	..... –	.75 – .80
Calcium sulphate, pure	lb.	..... –	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.11 – .11½	.12 – .15½
Carbonyl chloride (phosgene)	lb.	..... –	.80 – 1.05
Caustic potash (see potassium hydroxide)		..... –	..... – .....
Caustic soda (see sodium hydroxide)		..... –	..... – .....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	..... –	2.00 – 2.05
Copperas (see iron sulphate)		..... –	..... – .....
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	..... –	.65 – 70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		..... –	..... – .....
Epsom salt (see magnesium sulphate)		..... –	..... – .....
Ethyl Acetate Com. 85%	gal.	1.35 –	1.40 –
Ethyl Acetate pure (acetate ether 98% to 100%)		..... –	1.75 – .....
Formaldehyde, 40 per cent (nominal)	lb.	.36 – .40	.57 – .65
Fusel oil, ref	gal.	..... –	5.25 – 6.00
Fusel oil, crude (nominal)	gal.	..... –	..... – .....
Glauber's salt (see sodium sulphate)		..... –	..... – .....
Glycerine	lb.	..... –	.26½ – .28½
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	..... –	.03 – .20
Iron sulphate (copperas)	cwt.	1.50 – 1.75	1.80 – 2.00
Lead acetate, normal	lb.	..... –	.13⅜ – .15¾
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	..... –	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	..... –	1.50 – .....
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P	100 lb.	3.00 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	..... –	3.25 – 3.60
Nickel salt, double	lb.	..... –	.14 – .16
Nickel salt, single	lb.	..... –	.16 – .18
Phosgene (see carbonyl chloride)		..... –	..... – .....
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	..... –	.35 – .37
Potassium bichromate	lb.	.35 – .37	.45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.52 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – 95
Potassium carbonate, U. S. P	lb.	..... –	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28
Potassium chlorate, crystals	lb.	$0.15 – $0.16	$0.21 – .....
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.31 – .35
Potassium iodide	lb.	..... –	3.35 – 3.60
Potassium nitrate	lb.	.15 – .17	.19 – .21
Potassium permanganate	lb.	.75 – .80	.85 – .95
Potassium prussiate, red	lb.	.90 – 1.00	1.05 – .....
Potassium prussiate, yellow	lb.	.32 – .36	.36½ – .37½
Potassium sulphate (powdered)	ton	$225.00 – 240.00	..... – .....
Rochelle salts (see sodium potas. tartrate)		..... –	..... – .....
Salammoniac (see ammonium chloride)		..... –	..... – .....
Sal soda (see sodium carbonate)		..... –	..... – .....
Salt cake	ton	28.00 – 32.00	..... – .....
Silver cyanide (nominal)	oz.	..... –	1.25 – .....
Silver nitrate (nominal)	oz.	..... –	.74 – .76
Soda ash, light	100 lb.	..... –	3.50 – 3.60
Soda ash, dense	100 lb.	..... –	3.55 – 3.65
Sodium acetate	lb.	.08¾ – .09	.09½ – .12
Sodium bicarbonate	100 lb.	2.25 – 2.60	2.75 – 3.50
Sodium bichromate	lb.	.32 – .35	.36 – .37
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .10½
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	..... –	.10 – .11
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.25 – 6.00	6.25 – 6.50
Sodium hyposulphite	lb.	..... –	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25½ – .....
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.19 – .19½	.20 – .21
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	..... –	.39 – .40
Sodium prussiate, yellow	lb.	.23 – .27	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01¾ – .02	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2.00
Sodium sulphide, crystal, 60–62 per cent (cone)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, crystals	lb.	.20 – .21	.25 – .26
Sulphur chloride	lb.	.05½ –	.06 – .....
Sulphur, crude	ton	22.00 –	..... – .....
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 – .....
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.13 –	.13½ – .17
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ –	.13 – .15
Zinc oxide, U. S. P	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	.....	—	$1.25
Alpha naphthol, refined	lb.	.....	—	1.45
Alpha naphthylamine	lb.	.65	—	.70
Aniline oil, drums extra	lb.	.35	—	.40
Aniline salts	lb.	.45	—	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90	—	1.00
Benzaldehyde (f.f.c.)	lb.	2.00	—	2.10
Benzidine, base	lb.	1.35	—	1.40
Benzidine, sulphate	lb.	1.20	—	1.25
Benzoic acid, U.S.P.	lb.	.90	—	1.10
Benzoate of soda, U.S.P.	lb.	.80	—	1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27	—	.36
Benzol, 90%, in drums (100 lb.)	gal.	.25	—	.31
Benzyl chloride, 95-97%, refined	lb.	.35	—	.40
Benzyl chloride, tech	lb.	.25	—	.35
Beta naphthol benzoate (nominal)	lb.	.50	—	.65
Beta naphthol, sublimed (nominal)	lb.	.....	—	1.00
Beta naphthol, tech (nominal)	lb.	.75	—	.85
Beta naphthylamine, sublimed	lb.	2.25	—	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	—	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10	—	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00	—	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65	—	.75
Dichlorbenzol	lb.	.08	—	.10
Diethylaniline	lb.	.....	—	1.80
Dimethylaniline (nominal)	lb.	1.50	—	1.55
Dinitrobenzol	lb.	.30	—	.37
Dinitroclorbenzol	lb.	.30	—	.35
Dinitronaphthaline	lb.	.45	—	.55
Dinitrophenol	lb.	.40	—	.45
Dinitrotoluol	lb.	.40	—	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38	—	.40
Diphenylamine (nominal)	lb.	.....	—	.85
H-acid (nominal)	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.15	—	1.30
Monochlorbenzol	lb.	.12	—	.15
Monoethylaniline	lb.	1.70	—	1.85
Naphthaline crushed, in bbls. (250 lb.)	lb.	.15	—	.....
Naphthaline, flake	lb.	.15½	—	.17
Naphthaline, balls	lb.	.16	—	.18
Naphthionic acid, crude	lb.	.75	—	.85
Nitrobenzol	lb.	.14	—	.19
Nitro-naphthaline	lb.	.40	—	.50
Nitro-toluol	lb.	.20	—	.30
Ortho-amidophenol	lb.	3.25	—	4.25
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-nitro-phenol	lb.	.80	—	1.25
Ortho-nitro-toluol	lb.	.25	—	.40
Ortho-toluidine	lb.	.35	—	.45
Para-amidophenol, base	lb.	2.50	—	3.50
Para-amidophenol, HCl	lb.	2.50	—	3.25
Para-dichlor-benzol	lb.	.08	—	.12
Paranitraniline	lb.	.....	—	1.65
Para-nitro-toluol	lb.	1.35	—	1.50
Paraphenylenediamine	lb.	2.60	—	3.00
Paratoluidine	lb.	2.00	—	2.50
Phthalic anhydride	lb.	.65	—	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12	—	.20
Pyridin	gal.	2.00	—	3.50
Resorcin, technical	lb.	4.25	—	4.50
Resorcin, pure	lb.	6.25	—	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0 50 —	$0 52
Salicylic acid, U. S. P.	lb.	55 —	60
Salol	lb.	90 —	1 66
Solvent naphtha, water-white, in drums, 100 gal.	gal.	25 —	34
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	19 —	24
Sulphanilic acid, crude	lb.	.28 —	32
Toluidine	lb.	1 70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	
Toluol, in drums	gal.	.29 —	32
Xylidine, drums, 100 gal.	lb	.44 —	.50
Xylol, pure, in drums	gal	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0 36 —	$0.39
Beeswax, refined, light	lb.	39 —	.40
Beeswax, white pure	lb	.63 —	.68
Carnauba, No. 1, (nominal)	lb.	.93 —	.95
Carnauba, No. 2, regular (nominal)	lb.	.85 —	.88
Carnauba, No. 3, North Country (nominal)	lb.	.44 —	.45
Japan	lb.	.21 —	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09½ —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 128-130 m.p.	lb.	.13 —	.14
Paraffine waxes, refined, 133-135 m.p.	lb.	.15½ —	.16½
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½ —	.18½
Stearic acid, single pressed	lb.	.25 —	.26
Stearic acid, double pressed	lb.	.26 —	.27
Stearic acid, triple pressed	lb.	.28 —	.29

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.75
Pine oil, pure, dest. dist.	gal.	1.60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$19 50 —	$20 30
Rosin E-I	280 lb.	20 30 —	20.50
Rosin K-N	280 lb.	21 00 —	23 00
Rosin W. G.-W. W.	280 lb.	23.50 —	24.00
Wood rosin, bbl.	280 lb.	17 80 —	18.50
Spirits of turpentine	gal.	2 27 —	2 30
Wood turpentine, steam dist.	gal.	2 30 —	2.35
Wood turpentine, dest. dist.	gal.	1.90 —	2.00
Pine tar pitch, bbl.	200 lb.	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl.	500 lb.	15.00 —	15.50
Rosin oil, first run	gal.	.87 —	.89
Rosin oil, second run	gal.	.89 —	.92
Rosin oil, third run	gal.	1.04 —	1.05
Rosin oil, fourth run	gal.	1.12 —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.38 —	$0.38½
Upriver coarse	lb.	28½ —	29½
Upriver caucho ball	lb.	30½ —	
Plantation—First latex crepe	lb.	—	38
Ribbed smoked sheets	lb.	.37½ —	38
Brown crepe, thin, clean	lb.	—	35
Amber crepe No. 1	lb.	—	40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½ —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.22
China wood oil, in bbls.	lb.	.22½ —	.23½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17 —	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½ —	19½
Corn oil, crude, in bbls.	lb.	.17½ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½ —	.16
Cottonseed oil, summer yellow	lb.	.19 —	19½
Coteonseed oil, winter yellow	lb.	.21 —	.22
Linsed oil, raw, car lots (domestic)	gal.	1.65	
Linseed oil, raw, tank cars (domestic)	gal.	1.60	
Linseed oil, boiled, car lots (domestic)	gal.	1.67	
Olive oil, commercial	gal.	3.10 —	3.25
Palm, Lagos	lb.	.12½ —	13½
Palm, bright red	lb.	.13 —	13½
Palm, Niger	lb.	11 —	12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.16½ —	17½
Peanut oil, refined, in bbls.	lb.	.22 —	.24
Rapeseed oil, refined in bbls.	gal.	1.70 —	1 72
Rapeseed oil, blown, in bbls.	gal.	1.80 —	1 85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17 —	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.13 —	13½

FISH

Winter pressed Menhaden	gal.	$1 17 —	$1 18
Yellow bleached Menhaden	gal.	1.20 —	1 22
White bleached Menhaden	gal.	1 23 —	1 24
Blown Menhaden	gal.	1 30 —	1 32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$20 00 —	$22 00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	16 00 —	18 00
Barytes, crude, 88% to 94% ba., Kings Creek	net ton	8 00 —	10 00
Blanc fixe, dry	lb.	05½ —	06
Blanc fixe, pulp	ton	60 00 —	80 00
Casein	lb.	15 —	18
Chalk, English, extra light	lb.	07 —	.07
Chalk, English, light	lb.	.05 —	.06
Chalk, English, dense	lb.	04½ —	05
China clay (Kaolin) crude, f.o.b. Pkin, Va	net ton	8 00 —	12 00
China clay (Kaolin), imported, lump	ton	25 00 —	35 00
China clay (Kaolin), imported, powdered	ton	30 00 —	60 00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50 —	18.00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7 50 —	8 00
Feldspar, ground, f.o.b. Baltimore	net ton	18 00 —	25 00
Fire clay, f.o.b. Baltimore	net ton	5 00 —	7 00
Fuller's earth, domestic, powdered	ton	25 00 —	30 00
Fuller's earth, imported, powdered	ton	35.00 —	40 00
Graphite (dust polish grade 30%) Ashland, Ala.	lb	—	0 01
Graphite (dust facing grade 50%) Ashland, Ala.	lb	—	0 01½
Graphite, crucible, 85% carbon Ashland, Ala.	lb.	—	.07
Graphite, crucible, 90% carbon Ashland, Ala.	lb.	—	08½
Pumice stone, imported	lb	03 —	.06
Pumice stone, domestic	lb	02½ —	
Quartz (acid tower) list to head, f.o.b. Baltimore	net ton	—	10 00
Quartz (acid tower) 1½ @ 2 in., f.o.b. Baltimore	net ton	—	14 00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	—	17 00
Shellac, orange, fine nominal	lb	1 50 —	
Shellac, orange, superfine	lb	1 60 —	1 65
Shellac, A. C. garnet	lb	1 30 —	1 35
Soapstone	ton	15 00 —	25 00
Talc, domestic	ton	20 00 —	60 00
Talc, imported	ton	60 00 —	70.00

Refractories

Following prices are f.o.b. Works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-90 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250 00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	200 00 —	250 00
Spiegeleisen, 16-20% Mn	gross ton	73 00 —	75 00
Ferro-molybdenum, per lb. of Mo.	lb	2 25 —	2 75
Ferro-silicon, 50%	gross ton	80 00 —	90 00
Ferro-silicon, 75%	gross ton	150 00 —	200 00
Ferro-silicon, 10-15%	gross ton	60 00 —	65 00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb	90 —	1 10
Ferro-uranium, 35-50% of U	lb	7 00 —	
Ferro-vanadium, 30-40% per lb. of contained V	lb	6 50 —	7 75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3, f.o.b. Atlantic Seaboard	unit	$0 70 —	$0 85
Coke, foundry, f.o.b. ovens	net ton	15 50 —	16 50
Coke, furnace, f.o.b. ovens	net ton	14 50 —	15 50
Petroleum coke, refinery, Atlantic seaboard	net ton	—	24 00
Fluor spar, gravel, f. o. b. mines	net ton	25 00 —	30 00
*Fluor spar, acid grade, lump, f. o. b. Tonuco, Mex.	net ton	30 00 —	45 00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00 —	65 00
Manganese ore, 45% Mn and over	unit	80 —	85
Manganese ore, chemical (MnO_2)	gross ton	80 00 —	90 00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	75 —	85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7 00 —	10 00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6 50 —	7 50
Uranium oxide, 96%	lb	2 75 —	3 00
Vanadium pentoxide, 99%	lb	12 00 —	14 00
Vanadium Ore	lb.	1 00 —	3 00
Pyrites, foreign, lump	unit	17 —	
Pyrites, foreign, fine	unit	17 —	
Pyrites, domestic, fine	unit	16 —	17½
Ilmenite, 52% TiO_2	lb.	12 —	
Rutile, 95% TiO_2	lb	11 —	
Carnotite, minimum 2% U_3O_8, per lb of U_3O_8	lb.	2 75 —	00
Zircon, washed, iron free	lb.	16 —	..
Monazite, per unit of ThO_2	unit	42 00 —	..

*Nominal

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 14-in.	100 lb	$2 45 —	$4 00
Angles, 3 to 6 in., ¼-in. thick	100 lb	2 45 —	4 00
Tees, 3-in. and larger	100 lb	2 45 —	4 00
Plates	100 lb	4 00	
Rivets, structural, ½-in. and larger	100 lb	4 00	
Rivets, cupheaded for boilers, ½-in. and larger	100 lb	4 50 —	4 50
Sheets, No. 28 black	100 lb	5 50 —	6 00
Sheets, No. 10 blue annealed	100 lb	3 75 —	4 00
Sheets, No. 28 galvanized	100 lb	5 75 —	8 50

For painted corrugated sheets, add 30c. per 100 lb. for 24 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 10c. to 40 cents

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

EL SEGUNDO—The General Chemical Co., 25 Broad St., New York City, has awarded the contract for a group of factory buildings, to the J. G. White Eng. Corp., 43 East Exch. Pl. Estimated cost, $2,000,000.

LOS ANGELES—Wilson & Co., 1000 Lyons St., plans to build an oleomargerine factory. Estimated cost, $100,000.

Colorado

BURLINGTON — The School Bd. plans to build a 2-story, 90x90-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $60,000. H. G. Hoskin, secy.

Connecticut

ELMWOOD (Hartford P. O.)—The Abbot Ball Co. has awarded the contract for the construction of a 1-story, 50x80-ft. factory for the manufacture of steel balls, to the J. H. Grazier Co., 721 Main St., Hartford. Estimated cost, $18,000.

HARTFORD—The Bd. Educ. plans to construct a 2-story, 160x200-ft. high school in the western section of the city. A chemical laboratory will be installed in same. Estimated cost, $500,000. W. Marchant, archt.

MANSFIELD DEPOT—The Mansfield State Training School has awarded the contract for the construction of a 1-story, 40x50-ft. filter plant, etc., to Canning & Leary, Harris Bldg., New London. Estimated cost, $35,000. Noted May 19.

District of Columbia

WASHINGTON—J. A. Wetmore, supervising archt., will receive bids until June 22 for furnishing the labor and materials in connection with the proposed extension to the animal house for the Hygienic Laboratory, United States Public Health Service, here.

Florida

PALATKA—The McGuire Fertilizer Co., Morristown, plans to construct a fertilizer mixing plant in St. John's County near here. Estimated cost, $200,000.

Illinois

AUGUSTA—The Bd. Educ. will soon award the contract for the construction of a 2-story high school here. Laboratory equipment will be installed in same. Estimated cost, $100,000. H. R. Temple, Champaign, archt.

CHICAGO—The Chicago Solder Co., 218 North Union Ave., has awarded the contract for the construction of a 2-story, 50x250-ft. addition to factory, to the E. L. Scheidenhelm Co., 111 West Monroe St. Estimated cost, $100,000. Noted Feb. 4.

Maryland

BALTIMORE — The Maryland Color Printing Co., Holliday and Hillen Sts., has awarded the contract for the construction of a 17-story, 100x110x135-ft. plant, to the Consolidated Eng. Co., 243 Calvert Bldg. Estimated cost, $2,000,000.

CUMBERLAND — The Kelly-Springfield Tire Co., has awarded the contract for the construction of a 3- and 4-story, 575x620-ft. rubber tire plant on River Rd., to the Hunken Conky Constr. Co., Cleveland, Ohio. Estimated cost, $2,000,000.

Minnesota

MINNEAPOLIS—The Modern Fdry. & Machine Co., 4725 Dupont Ave. S., is having plans prepared for the construction of a 1-story, 80x150-ft. steel foundry. Estimated cost, $60,000. L. J. Bedard, pres.

Missouri

ST. LOUIS—The Amer. Bed Co., 1820 McNulty St., has awarded the contract for the construction of a 2-story, 75x130-ft. paint shop on Park Ave., to the Fruin-Colnon Contg. Co., Merchants Laclede Bldg. Estimated cost, $30,000.

New Hampshire

MANCHESTER — The Notre Dame Hospital plans to build a chemical diagnosis building on Concord St. Plans include a surgical, genito-urinary, orthopedic, X-ray, oral surgery, dentistry, and various other departments. Estimated cost, $60,000. G. S. Foster, 967 Elm St., secy.

New Jersey

SAYREVILLE—The borough plans to construct a water supply system which will have a daily capacity of 250,000 gal. Plans include filters, etc. Waldo S. Coulter, 114 Liberty St., New York City, engr.

TRENTON — The Ajax Rubber Co., Breunig Ave., has awarded the contract for the construction of a 4-story, 60x100-ft. rubber factory on North Olden Ave., to the N. A. K. Bugbee Co., 206 East Hanover St. Estimated cost, $60,000.

TRENTON—The Thermoid Rubber Co., Whitehead Rd., has awarded the contract for the construction of a rubber factory addition, to Karno-Smith Co., Broad St. Bank. cost, $175,000. The company is in the market for $100,000 worth of machinery for same.

North Carolina

GASTONIA—The mayor will receive bids until June 8 for the construction of a waterworks extension and sewer system including a 2,000,000-gal. filtration tank and a purification plant. W. M. Piatt, Durham, engr.

Ohio

AKRON—The Supreme Cord Tire & Rubber Co. plans to construct a factory on a 9½-acre site on Home Ave.

CLEVELAND—The Cleveland Welding & Mfg. Co., West 117th St. and Berea Rd., will soon award the contract for the construction of a 1-story, 90x155-ft. factory. Estimated cost, $75,000.

CLEVELAND—The Modern Aluminum Fdry. Co., 4613 Payne Ave., has awarded the contract for the construction of a 1-story, 50x143-ft. factory addition, to H. G. Claxton, Vickers Bldg. Estimated cost, $50,000.

CUYAHOGA FALLS—The Falls Rubber Co. has awarded the contract for the construction of a 3-story, 61x84-ft. factory addition, to the A. A. Lane Constr. Co., 1836 Euclid Ave., Cleveland. Estimated cost, $60,000. Noted May 4.

Pennsylvania

PHILADELPHIA—The Yarnall Paint Co., 1026 Race St., has awarded the contract for altering a paint factory, to R. C. Ballinger & Co., 218 North 13th St. Estimated cost, $30,000.

West Virginia

BARRACKSVILLE—The Bd. Educ. plans to build a high school. A chemical and physical laboratory will be installed in same. L. L. Friend, state supervisor of high school buildings.

BLUEFIELD—The Bd. Educ. plans to build a junior high school. A chemical and physical laboratory will be installed in same. Total estimated cost, $200,000. L. L. Friend, state supervisor of high school buildings.

FAIRMONT — The Union Independent School Bd. plans to build a high school in the eastern section of the city. A chemical and physical laboratory will be installed in same. Estimated cost, $125,000. L. L. Friend, state supervisor of high school buildings.

HUNTINGTON—The Bd. Educ. plans to build a junior high school. A chemical and physical laboratory will be installed in same. A $62,000 bond issue has been passed for the project. L. L. Friend, state supervisor of high school buildings.

MONTGOMERY—The Bd. Educ. plans to build a high school. A chemical and physical laboratory will be installed in same. Estimated cost, $125,000. L. L. Friend, state supervisor of high school buildings.

RAVENSWOOD—The Bd. Educ. plans to build a high school. A chemical and physical laboratory will be installed in same. A $62,000 bond issue has been passed for the project. L. L. Friend, state supervisor of high school buildings.

Ontario

CHATHAM—The city plans to install 3 mechanical pressure filters in connection with its waterworks system. Estimated cost, $30,000. F. Adams, City Hall, engr.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold a regular meeting June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE CANADIAN INDUSTRIAL CONGRESS will be held at Victoria, B. C., June 2 to 10.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City. Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE NEW JERSEY CHEMICAL SOCIETY will hold a regular meeting and ladies' day Saturday afternoon and evening, June 5, at Rutgers College, New Brunswick, N. J.

THE NORTHERN OHIO SECTION OF THE AMERICAN CERAMIC SOCIETY will hold its summer meeting June 7 at Sandusky, Ohio. Visits will be made to the Sandusky Bulb Works of the General Electric Co., and the business meetings will be held at Cedar Point.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

J. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. BLATCHLEY
Editorial Editors
J. S. NEGRU
Managing Editor

Volume 22 New York, June 9, 1920 *Number* 23

The Federated American Engineering Societies

SELDOM does the habitué of technical and general gatherings absorb so many inspirational thoughts tumbling fast through a medium electrified with a sharp clash of intense purpose as at Washington last week. This alone would mark the recent organization of The Federated American Engineering Societies. Not only were the brief and pithy addresses from eminent engineers in various walks of life full of allusion to the widespread value of engineering thought and achievements, but even the sharpest discussion was based entirely upon the best and most effective method of giving service. Service was the keynote—not struck by the first speaker of the meeting and then forgotten, but animating the proceedings to the end.

As already noted in these columns, very divergent views may readily be held by any two men as to the proper way to effect a national organization through which the engineer collectively may exert the influence his technical training and moral integrity deserve. (It is perhaps unnecessary to argue that at no recent instant has the need for unselfish and competent service to the public been so pressing.) Unsatisfied with the apparent conservatism of the old-established national and regional engineering societies, the American Association of Engineers has gathered together in a democratic organization many thousand men—from engineers of highest technical achievement to neophites—and has already executed difficult and salutary undertakings most creditably. Leavened by this yeast, or in the natural course of events—it does not matter—even the most conservative of the older organizations recognized the insistent desire on the part of an engineer to become an influential citizen, and actively sponsored the idea of federating themselves together to promote this consummation.

At the organizing conference there was consequently much inflammable material. It was only natural to doubt whether the democratic idea was so fundamentally divergent from the federation idea that the societies embracing these tenets could find no common ground. Those who could not measure the bigness of the individual delegates freely predicted steam roller methods on the part of the founder societies and their satellites, and last-ditch obstruction from the A.A.E. and its sympathizers. However, the event confirmed the optimistic. The activity of an impromptu steering committee was instantly halted by the absolute impartiality of CALVERT TOWNLEY, the permanent chairman, and the bitterness which is inseparable in a losing fight never even approached the petty devices it so often encourages.

This happy condition was possible only because it was the instinctive desire of the hundred or more individuals present to organize nationally for service—service to the public and the engineering profession. This was the evident common ground. Debate as to the most nearly perfect method of reaching this end never descended to the acrimonious, and often approached the inspiring. Particularly it was evident at the climax of the meeting, when on the first roll call taken on the resolution "that it is the sense of this convention that the proposed organization should be an organization of societies or affiliations and not of individuals," the A.A.E. representatives, responding first, voted yes to a motion which the casual observer might think would submerge their individuality, simply stating that they were present not as obstructionists, but as co-operators, to aid in the work in any way possible.

This, it seems apparent, should be the principal thought carried home by the various delegates. Many provisions of the proposed constitution and bylaws may not appeal strongly to individual societies or individual members of the societies. The whole plan of operations may appear fundamentally wrong. Frankly, we may confess that we are yet to be convinced that a federation is better than a democracy, for reasons some of which have already been given in these columns. But every one, it seems certain, should approach the debatable points from the standpoint so clearly seen at Washington, that the common ground is service, and that engineers should co-operate and not obstruct. The least each individual can do is to consider carefully the debatable features from the standpoint that the general movement is desirable. If any detail is wrong, co-operate in a sincere effort to correct it! Help as far as you can! The least which that involves is a sincere hope that any finally accepted organization may succeed, and will not need to overcome active enmity.

Make It Definite

THE work of the American Chemical Society Committee on Standardized Apparatus has led the chairman to make a very excellent suggestion which the authors of technical articles should heed. He recommends that the description and illustration of apparatus should be made as definite as possible, particularly including the complete dimensions. Anyone who has undertaken to reproduce the results of physical measurements or organic reactions in the laboratory as described by other investigators knows how frequently he is at a loss to know just how some essential detail of the apparatus was cared for. All too much of our scientific literature is seriously lacking in definiteness and every author who wishes to make his record of investigation of greatest value to posterity should bear in mind the need of giving all essential dimensions of apparatus very clearly.

The Haber Process In the United States

WHILE it is conceded that the Haber process of nitrogen fixation is still in the experimental stage in this country, as evidenced by the fact that continuous production on any considerable scale has not been accomplished, much progress has been made toward its ultimate commercial development. Within the next few years we should witness the successful completion of experimental work on catalysts by the Army Ordnance and the General Chemical Co.; the reconstruction of U. S. N. P. No. 1 at Sheffield, Ala., and the completion of the plant of the Atmospheric Nitrogen Corporation at Syracuse, N. Y. When these two small plants are producing ammonia without interruption the demonstration of the American adaptation of the method will have been successfully made.

We are surfeited these days with the output of the professional muckrakers who make the mistake of attacking legitimate governmental activities along with the projects, very few in number, which really deserve investigation. The large enterprises started during the war and temporarily abandoned because we were blessed with an earlier suspension of hostilities than was expected are still as important to the nation as if the fighting had continued. The efforts expended will be just as valuable in the prosecution or, let us hope, prevention of the next war. For the person who believes that wars may be ended for all time is neither a student of history nor of human nature as manifested collectively by national existence.

It is further very fortunate that the nitrogen industry may serve the interests of peace while keeping pace with the progress of other nations in the art of war. It excels the Army and Navy in this regard and is quite as essential for national preparedness.

Let not the efforts of those technical men who would have preferred to be heroes in actual combat be in vain! They labored sleeplessly in the hope of supporting the men at the front and when the Armistice was signed said, "Well, anyway, we've done a devil of a lot for the next time!"

The nitrogen fixation business must be carried on by the Government first as a measure of preparedness and second to meet the needs of the fertilizer industry. The question of wasteful expenditures or graft in the building of the plants is a matter for prosecution in the courts and has nothing to do with proposed operation and development by the Government of a scientific process for manufacturing a commodity that can be turned to the uses of war or peace.

The Compleat Letter Writer

WHEN the Extraordinary Grand Jury of the County of New York was investigating the curious charge made by Mayor HYLAN that the officers of the subway had conspired with their employees to induce them to strike last August, it was discovered that the Mayor's appeal to the striking men to put no faith in their employers but rather to rally round him was written in a certain familiar yellow-newspaper style. Persistent investigation brought out the fact that the manifesto was prepared for him by the city editor of WILLIAM RANDOLPH HEARST'S notorious New York *American*.

When Captain VON PAPEN of unpleasant memory left Nazareth in Palestine in great haste, owing to the advent of the British forces there, he left behind him a case known in naval parlance as a ditty box, which contained his papers. Among these were letters from his erstwhile companion in the United States, Kapitan zur See BOY-ED. In one of these BOY-ED recalled his manifesto to the American people which he issued on his enforced departure from these shores, and which reflected, to put it mildly, what he considered the unfairness of the public in regard to his precious activities—more particularly with firebugs and dynamiters. Most of our readers will recall a feeling of warmth about the neck on reading it. In a letter found in the box he explained to VON PAPEN, according to *The English Review*, that he had had the aid of SAMUEL UNTERMYER of the New York Bar in preparing the precious document.

Now we have no idea what meditations take place in Mayor HYLAN'S mind, because nearly three years' experience as citizens under his rule have proved this to be impossible. But in turning the matter over to the bureau of his friend HEARST he issued what was no less than an incitement to riot. And whatever excuse Captain BOY-ED may have thought to warrant him in his efforts at destruction, his expression resulted in one of the most remarkable and impertinent harangues ever offered to a justly offended people. And although in each case it was dirty work, it cannot be denied that both HEARST and UNTERMYER are men of unusual attainments and signal ability.

The point we want to bring out by these two examples of vicarious fulmination is that if one does not know what to say, it is better not to get somebody else to say anything. It pays to advertise, because the advertiser is sure to have an idea, and he is abundantly warranted in getting help to give his idea competent expression. But if he has only a grouch and is so angry as to be incoherent, there isn't any kind of ability that can translate his anger into reasonableness. The best HEARST'S man could do was to preach his employer's gospel of riot, and the best even SAMUEL UNTERMYER could do was to scold.

Honorary Degrees In Chemistry

HONORARY degrees are very pleasant to receive, and once in a while a chemist gets one. The occasions are, however, rather rare. The University of Pittsburgh nearly every year confers the degree of Doctor of Chemistry upon some man of great achievement and distinction, but this, we believe, is the only institution in the United States that confers the degree at all. Otherwise such chemists as answer to the appellation "Doctor" without a disturbing twinge are usually Doctors of Philosophy, for which they have labored long, either here or abroad. Most German chemists also seem to be Doctors of Philosophy, and time was when, at all events at some universities, an "inaugural dissertation" on almost any subject was enough to pass them, while the oral examination was but little more than a formality. In other universities such doctorates required as much work as they do here. But the *mores* are different. Our technical schools, unless associated with a university, do not confer doctorates, and the great majority of chemists do not take them. Many of the

leaders in chemical thought in this country are undoctored. It has been proposed lately that certain colleges and universities could do a considerable service by setting aside, as it were, three honorary doctorates in science to be awarded to men resident in that state in which the institution is located, who have contributed important and distinguished work in chemistry or physics. This would require the appointment of a high commission consisting of three or four men of exalted standing in science who would recommend to the trustees the names of men entitled to such distinction. It would require, of course, that the trustees work in harmony with the commission appointed by them, and that politics be avoided. As soon as politics get into the thing the whole plan would be ruined. There is no Republican or Democratic science. But granted the proper appointment of such a commission, there is no reason why the plan should not work very well.

In the first place, it would add to the alumni of the conferring institution a body of men of science who, by their works, would do honor to it. Such alumni, being neighbors, would be disposed to contribute lectures and talks on scientific subjects to the inspiration of its students. It is fair to assume that such a commission would see to it that its candidates be men of worth in other respects, in addition to their achievements in science; but their scientific achievements would have to be genuine. It would bring the progress of chemistry and physics into the public eye and explain to the world why achievement in science is worthy of honor.

The title of Doctor, like that of Professor, has a variable application. In France a dancing master is a professor and here a chiropodist usually has the courtesy title of "Doc," but these are not official. There is a pleasant dignity to the title of Doctor of Science, as there is to that of Laws, and the plan to confer a limited number of these, *honoris causa*, to men who have achieved merit sounds reasonable to us.

Steel Prices And Other Prices

THE steel industry has long distinguished itself for exhibiting kaleidoscopic changes. Now it outdoes itself in one respect. It eliminates time entirely and exhibits different phases at the same instant. "Declines in commodity prices" are being discussed by almost everyone, with all sorts of opinions expressed. A very reasonable opinion is that in the readjustment now occurring in the markets it is not chiefly a case of a horizontal reduction all along the line, but rather of readjustment, through improper alignments in prices having arisen. The net result of the whole thing may be a decline in the average of all prices, but the most pronounced changes will be in relations. One commodity may advance in relation to another commodity by remaining stationary while the other declines, or by declining less than the other.

Behold what the steel industry presents! One asks which commodities will remain stationary and which will decline. Does steel belong to the one class or the other? It does both. For months it has presented several different markets. There are a few men in the iron and steel business who have lived a longer business life than has the steel market, for excepting the part played by the bessemer rail many years ago steel as the dominant factor in the market for wrought ferrous products is only between twenty-five and thirty years old. One of the old-timers, whose experience covered years of the old wrought iron or puddled iron market, remarks that never before had he seen the spectacle of there being more than one distinct market.

There is the Steel Corporation market, the Steel Corporation adhering rigidly to the Industrial Board schedule of prices which became effective March 21, 1919. On bars, shapes and plates the prices are respectively 2.35c., 2.45c. and 2.65c. Then there is the market of certain large independents, for delivery in say from two to five months, the prices being approximately 3c., 3.10c. and 3.25c. Finally, there has been a prompt or spot shipment market at prices much higher still, both bars and shapes having sold at 4.50c. in mill lots.

For some time the question was whether Mahomet would go to the mountain or the reverse. Should the prompt market continue, the Steel Corporation would have to advance its prices or become hopelessly oversold, thus extinguishing itself as a market factor. Otherwise the prompt market would have to drop to a lower level.

Considering the great increase in the volume of money and credit since before the war, high wage rates and high costs everywhere, there can be no such thing as an early return, if there ever can be a return, to prewar levels. One may conclude that some prices are not too high and that other prices are altogether too high. Illustrations can be found. For instance, comparisons of certain descriptions of hardware and tools, made from substantially the same raw materials and by substantially the same classes of workmen, show that some articles have advanced much more than others, when the change in cost of production must have been substantially the same.

If the highest prices are to come down and the lowest prices are to remain as they have been, this interesting steel industry is prepared. It has had three markets, all ready provided. The laws of economics, of supply and demand, of sentiment or whatever it may be that is to make the markets that are to come out of the present readjustment can take their choice of these steel markets, picking out the one that suits the conditions under which American business is to go ahead for the long pull.

The Industrial Board steel prices are about 80 per cent above the ten-year pre-war average of steel prices. That is quite moderate, considering that Bradstreet's last index number, for May 1, was 139 per cent above its ten-year pre-war average. Some steel, however, has sold within the past few months at about double the Industrial Board schedule, which would make it 160 per cent above the pre-war average, and that is obviously too high.

Pig iron, however, has made a market for itself, and it presents only one market. There is no notable delivery premium. While there is little if any business being done for far forward deliveries, the furnaces would not quote materially different prices from those lately ruling for early deliveries. Pig iron now stands between the low steel market and the high steel market. One would lose money buying pig iron at present prices and converting it into steel to be sold at Industrial Board prices, while he would make a great deal of money by selling at the highest steel market. Not having a collection of markets to select from, pig iron may have to make a new market to conform to whatever market the steel situation crystallizes into.

Readers' Views and Comments

Prolongation of German Patents and Useful Models

To the Editor of Chemical & Metallurgical Engineering

SIR:—Enclosed you will find an abstract of a letter from one of my German associates in regard to the prolongation of German patents and useful models. It may be of interest to your subscribers to know as soon as possible of the advantages offered by the new law.

A law has been passed rather abruptly by the German Nationalversammlung allowing the prolongation for five years of patents and useful models suffering from the war. Pending patent applications probably included.

Prolongation only on special motion to the patent office.

Term for filing the motion two months for patents and models already lapsed; six months for all other patents and models, beginning with May 14, 1920.

Motion to show the facts why the patent could not be exploited adequately during the war and prima facie evidence only to prove these facts.

No difference is made between German and foreign patentees.

Procedure before the patent office secret, no opposition from interested parties.

Rules for the execution of the law not yet issued.

The law is of a very liberal spirit, so that all patentees of German patents who were handicapped by the war should make use of it.

As to the lapsed patents, it is necessary to have the instructions to file motions at once, as an overcrowding of all patent attorneys' offices is sure to come very soon.

OTTO K. ZWINGENBERGER.

New York City.

A Rapid Method for the Determination of Tin in Brass and Bronze

To the Editor of Chemical & Metallurgical Engineering

SIR:—The following method was worked out by the writer in an attempt to avoid the troublesome process of purifying the precipitate of metastannic acid by fusion with sodium carbonate and sulphur. The method is simply a modification of the well-known method for the determination of tin in ores. It has proven quite as accurate and much less troublesome than any of the gravimetric methods the writer has used.

Weigh out 0.5 to 5.0 g. of the sample (according to the amount of tin present) into a 250-c.c. beaker and dissolve in 10 to 25 c.c. of aqua regia. Dilute with water, heat to boiling and precipitate the tin with a slight excess of ammonium hydroxide. Filter off the precipitate of stannic acid and wash with hot water. Place a 500-c.c. Erlenmeyer flask under the funnel and dissolve the precipitate on the filter with hot (1 : 1) hydrochloric acid, washing the filter thoroughly with hot water. To the filtrate in the flask, add enough conc. hydrochloric acid to bring the total acid present in the solution up to 100 c.c. Dilute to 300 to 350 c.c., place a coil of pure nickel in the flask and boil for one hour, the flask being covered with a small watch glass. At the end of this time, remove from the hot-plate, drop in a small lump of marble or calcite and cool to room temperature or cooler. Remove the nickel coil, washing the adhering solution back into the flask, add a few c.c. of starch solution and titrate to a blue color with standard iodine solution.

The standard iodine solution is prepared by dissolving 11 g. of pure, resublimed iodine and 20 g. of potassium iodide in a little water and diluting to one liter. One c.c. of this solution is equivalent to approximately 0.005 g. of tin. The exact value of the solution is best determined by titrating a solution of pure tin.

As stannous chloride is quite readily oxdized, it is very important that the flask be kept full of CO_2 after removing from the source of heat in order to exclude the air. This end is quite satisfactorily accomplished by the use of marble or calcite, of which about 1 c.c. is usually sufficient. It should be completely dissolved when the solution is titrated. The writer has found that if care is exercised, the elaborate CO_2 generating apparatus described by some authors is entirely unnecessary for technical work. The operator should determine the amount of iodine necessary to give an end point with a solution containing no tin and should deduct this blank from each burette reading.

The nickel coil is made by cutting a strip about 1 in. wide from a sheet of pure nickel foil about $\frac{1}{32}$ thick and rolling it into a coil small enough to pass easily through the mouth of the flask. This coil is removed from the solution by means of a nickel wire about 6 in. in length and having about $\frac{1}{4}$ in. of one end bent at right angles. The other end may be fused into a length of glass tubing which serves as a handle.

The titration should be performed as rapidly as possible to avoid oxidation by the air. There are no interferences when the solution is cooled below 40 deg. C., though the copper, if left in the solution, obscures the end point.

The acid strength of the solution should be at least 25 per cent by volume. L. R. RAYMOND.

Flat River, Mo.

Industrial Alcohol Regulations

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am pleased to forward you the following changes which have been made in the formulas for specially denatured alcohol, since the publication of my article on them in your issue of March 17, vol. 22, No. 11, pp. 513-518.

Formula 25 has been changed so that it is now composed of 100 gal. of ethyl alcohol, 20 lb. iodine and 15 lb. potassium iodide.

Formula 34 has been authorized, which consists of 100 gal. of ethyl alcohol and 5 gal. of tetrachlorethane. This formula is authorized for use in the manufacture of artificial silk.

Formula 35 has been authorized, which consists of 100 gal. of ethyl alcohol and 35 gal. of ethyl acetate. This formula has been authorized for use in the manufacture of acetparamidophenolsalol.

These formulas, you understand, are specially denatured alcohol and are subject to supervision as to distribution and use by the U. S. Internal Revenue Bureau.

B. R. TUNISON.

U. S. Industrial Alcohol Co.
New York City.

Separation of Fixed Oils From Soap-Water Emulsions

A Study of the Phenomena Exhibited by Emulsions of Oils in Aqueous Soap Solutions—Classification of Emulsions—Effects of Dilution, Salting and Various Physical Forces and Their Possible Application in Oil-Recovery Processes

By EUGENE E. AYRES, JR.

THE following discussion of emulsions of oils and soap-waters is not based upon any purposed and consecutive research, nor is any reference made to the rather copious literature. Each year the writer comes in contact with hundreds of men, each keenly intent upon some emulsion problem. To ninety-nine out of each hundred the science of colloids and of physical chemistry is exceedingly vague, and yet these men are often successful in solving their problems. They work in the dark, and they are to that extent handicapped, but often the freshest ideas come from those whose points of view are naïve. The following discussion is an attempt to analyze and interpret the collective observations of these "practical investigators."

It is convenient at the outset to make several reservations. Only the types of emulsions encountered in industrial manufacture are included in this discussion. Naturally, it has not been attempted to completely cover the types of practical importance. Zinc and lime soaps, for example, or rosin soaps, or the "soaps," so called, derived by neutralization of organic acids in petroleum, or the soaps of volatile fatty acids—none of these cases is discussed. By "soap" is meant the caustic alkali soaps of the common higher fatty acids. Similarly, the sulphonated fatty compounds and the amides of fatty compounds have been ignored.

Classification of Emulsions

Simple emulsions of oil and water may be classified as

1. Those in which water is suspended in oil, and
2. Those in which oil is suspended in water.

Many industrial emulsions are not "simple," but may be technically classed as "complex." A complex emulsion is one in which the dispersed liquid does not consist merely of globules of oil or of water, but in which the suspended globules are themselves emulsions with tiny globules of liquid suspended in them.

Some emulsions are much more complicated in structure than this, especially when suspended particles are ultra-microscopic, but our definition of "complex" emulsions has the advantage of serving our purpose without confusing the issue.

We may make a complex emulsion of the mutually insoluble liquids A and B. The bulk of the mixture is A. The globules suspended in A consist primarily of B, but still smaller globules of A are suspended in each globule of B. A concrete illustration is found in the emulsion obtained when a saponifiable oil is warmed and agitated with a solution of caustic soda sufficient in amount to saponify only a small proportion of the oil. The oil is the A liquid, and the aqueous soap solution is the B liquid. An example of the opposite type is formed when crude petroleum is thoroughly agitated with two or more volumes of water. Here water is the A liquid, while oil is the B liquid.

A "saturated" emulsion is one in which the globules are packed together as tightly as possible in the space provided by the continuous liquid. If small spheres of uniform size are crowded into a given space, the volume taken up by the spheres will be a definite percentage of the volume of the given space. This percentage is independent of the size of the spheres. But if, in such a system, we should insert smaller spheres in the spaces still available, the percentage will be higher. Mathematically speaking, the function is a variable which approaches but can never reach a limit of 100 per cent. The emulsions met with in practice always contain globules of various size—some larger, and some smaller than average. But industrial emulsions rarely contain more than 50 per cent of the dispersed phase. The writer has never seen an industrial emulsion containing more than 80 per cent of the dispersed phase.

A "dilute" emulsion is obviously one that contains only a small percentage of dispersed liquid. To "concentrate" an emulsion is to separate from a dilute emulsion as much of the continuous liquid as possible, leaving a saturated emulsion.

Concentration of dilute emulsions is practiced commonly in many industries.

Simple and Complex Oil-Soap-Water Emulsions

While the definitions suggested above are still fresh in mind, consider the soap-water emulsion as a type. If the emulsion is simple, the aqueous soap solution is the continuous liquid with the oil suspended as globules. If the emulsion is complex, the oil is continuous with suspended globules of simple emulsion wherein water is continuous. The writer has seen no exceptions to this rule. If we were to take, for example, a liter of oil and agitate with one c.c. of soap solution, the emulsion would be invariably complex. As the oil is present in such large proportion, the oil is obviously continuous. If the suspended soap-water is separated (say by gravity settling), it will be found that oil globules are suspended in the soap-water unless gravity has also separated the simple emulsion. There are few cases where soap-water can be completely freed from suspended oil globules by subsidence (gravity or centrifugal), while it is a general rule that the continuous oil of a complex emulsion can be freed with relative ease from the suspended emulsions by subsidence.

Take the converse example of one liter of soap-water with one c.c. of oil. This emulsion will always be a simple emulsion.

If an emulsion of oil and soap-water contains more than 80 per cent oil, it is reasonably safe to conclude that the emulsion is complex. If the oil content is below 20 per cent, the emulsion must be simple. The range between 20 and 80 per cent may belong to either

class, but in nearly every case up to 50 per cent it will be found that the emulsion is simple.

Without recourse to microscopic examination it is easy enough to determine whether oil or water is continuous in an emulsion. If the emulsion is miscible with water, water must be the continuous phase of the emulsion. If oil is continuous, the emulsion will be miscible with oil. Of course, there are cases of true emulsoids where we find miscibility with both oil and water, but this discussion has nothing to do with such cases. The true emulsoid must be ruled out forthwith.

For industrial emulsions, a convenient test is to pour a few drops of the emulsion into a beaker of water. If the emulsion diffuses through the water, water must be continuous in the emulsion. In the case of a soap-water emulsion, the investigator may draw one other inference—the emulsion is simple, with suspended globules of oil. If the emulsion does not diffuse through the water, oil is continuous, and in the case of soap-water emulsions, the emulsion is complex with suspended globules of simple emulsion.

Super-Saturated Emulsions

There are what may be termed "super-saturated" emulsions, which may be described as imperfect mixtures of oil with a simple saturated emulsion. The excess oil is not present in sufficient amount to form a primary continuous phase, and this oil is not globular. Such a mixture is possible only when the emulsion is of high viscosity, for otherwise this excess oil would immediately separate. In the diffusion test, the presence of such oil is indicated by a diffusion of the emulsion proper while the excess oil remains on the surface of the water.

Super-saturated emulsions are very common in the industries, but inasmuch as the recovery of the excess oil is so simple a matter, no reference to super-saturated emulsions will be hereafter made.

Persistence of Emulsions

The continuous oil may be most easily separated from a complex soap-water emulsion when the aqueous phase contains a high concentration of soap. For this reason, when a rancid vegetable oil is refined with caustic soda, it is desirable to employ a caustic soda solution of high strength. Weak caustic soda solutions tend to give complex emulsions in which it is difficult to produce a "break," with subsequent settling of simple emulsion. The strength of caustic soda solution is limited only by refining conditions that have nothing to do with emulsion stability.

Simple soap-water emulsions may contain oil globules of two sorts:

(1) Globules that are "fixed"—that will remain intact as globules until something happens—chemical or physical—to unite them, and

(2) Globules that are temporary—that have been formed by agitation, precipitation or what not, and that will unite to form larger globules that yield readily to subsidence.

The only requirement for the agglomeration of these "temporary" globules from the soap-water is sufficient elapsed time. To agglomerate the "fixed" globules without chemically changing the character of the soap-water is an extremely difficult matter. The writer knows of no instance where such agglomeration is accomplished on a large scale. It is common practice to allow an emulsion to stand in a tank or to pass through a high-speed centrifugal to skim off the oil that can be so separated. But some oil is left behind, and additional subsidence fails to separate it.

Character of Oil and Soap Solution Important

What governs the percentage of oil removable and of oil fixed? The biggest factor is the character of the oil. In general a glyceride of a fatty acid has a much higher "fixed concentration" than a liquid hydrocarbon. It is possible to incorporate permanently more olive oil than lubricating oil with any given soap solution. But there are some miscellaneous oils and greases and waxes of vegetable or animal origin that give a higher fixed concentration than the fatty acid vegetable and animal oils and fats. Examples may be found in certain constituents of wool grease and in the organic "impurities" in crude vegetable oils. The fixed concentration of any commercial oil as a whole is much the same as the fixed concentration of its worst component. For instance, a little linseed oil dissolved in kerosene will raise the percentage of permanently emulsified impure kerosene almost to the value of linseed oil itself. The trace of organic impurity in crude cottonseed oil makes the latter an easily emulsified oil.

In many cases the fixed concentration is coincident with the saturation point. This is not true of any pure glyceride and even less of any pure hydrocarbon.

Next in importance among the factors involved in fixed concentration is the character of the soap solution. This involves soap concentration, the kind of soap, alkalinity, electrolytes and protective colloids. The lower the soap concentration and the alkalinity, the lower the percentage of permanently emulsified oil. The effect of alkalinity on emulsions of easily saponifiable oils may not be readily noted because of saponification reactions. The effect of electrolytes is erratic and will be discussed later. Soluble electrolytes are of course limited to salts of metals of unit valence because of the insolubility in water of soaps of metals of higher valence. Little difference has been noted between various pure soaps, but commercial soaps differ because of the effect of non-fatty-acid impurities. A trace of a water-insoluble soap (zinc or calcium) may or may not increase the fixed concentration.

The fixed concentration is not greatly influenced by temperature.

Stable Emulsions

When all "temporarily emulsified" oil has been permitted to agglomerate and separate, the residual soap-water emulsion at its fixed concentration of dispersed oil is regarded as a stable emulsion. The stability is of two kinds:

(1) A resistance to agglomeration, or the merging of globules (with accompanying subsidence) to form a continuous oil phase; and

(2) A resistance to a concentration of the emulsion, or the subsidence of globules intact to produce on the one hand a saturated emulsion, and, on the other hand, soap-water with appreciably less oil in suspension.

The stability of emulsions is regarded as a phenomenon of surface tension, and reactions that affect surface tension will likewise affect stability. But it is an odd fact that reactions which diminish the tendency for globules to maintain their uniform distribution throughout the soap-water medium will usually increase their resistance toward agglomeration. The conspicuous example of this interesting effect is found in

soap-water emulsions of increased alkalinity. The higher the alkalinity (caustic soda or normal sodium carbonate, for instance), the less likely we are to succeed in breaking down the globular formation to obtain continuous oil, but the more likely we are to concentrate the globules intact to form a saturated emulsion. Generally speaking, it is much more difficult to agglomerate in a soap-water emulsion than it is to cause a separation by subsidence of globules. It is believed that this is a highly important item to keep in mind. Chemists have been too often accustomed to measure the success of an expedient for separation by the yield of free oil without taking into account the changes that may have taken place in concentration. This naturally arises from the fact that oil is easily recognized from appearance, while emulsions more or less concentrated look much the same. As a case in point, we may quote the following procedure:

A certain soap-water emulsion contained 10 per cent of oil at its fixed concentration. On standing for ten hours, samples of the emulsion from the surface and from the bottom analyzed a uniform oil percentage (because the viscosity was too high for appreciable gravity subsidence in the allotted time). One per cent of caustic soda was added. After standing one hour, no free oil had appeared, but the liquid at the bottom was relatively clear, while the supernatant liquid was thick and opaque. The clear soap-water was drawn off and tested. It contained less than 0.5 per cent oil. The concentrated emulsion was mixed with a quantity of 1 per cent aqueous solution of caustic soda equal to the soap solution withdrawn, and settled again for one hour. No free oil appeared, but a subsidence of globules again took place. After a third similar treatment, the concentration of emulsifying agents had been reduced to such a low point by the successive dilutions that the globules agglomerated and a fairly complete yield of continuous oil was obtained.

Needless to say, such a procedure is impractical for saponifiable oils because of losses of oils by saponification. But though, for this reason, yields are necessarily low, separation is almost as effective as with unsaponifiable oils, in spite of the maintenance of a relatively unform soap concentration (by saponification). This is because a high fixed concentration is not possible with pure glycerides and soaps, and involves the presence of impurities.

In the commercial soap-water emulsion, the most common emulsifying agent is material that, although unsaponifiable (in the sense that fatty acid soaps may not be formed), is clearly acted upon by alkalis to form a substance colloidally "soluble" in water. These substances are regarded as "protective colloids." There are a number of protective colloids that either do not occur commonly, or else are so invariably associated with unsaponifiable greases as to lose individual significance. Such substances are glue, gelatine, albumen, lecithin.

Temporary Globular Dispersion

To refer again to the "temporarily" emulsified globules, when agglomeration and attendent subsidence have proceeded as far as possible under the influence of gravity, an application of high centrifugal force will not cause additional agglomeration. A force higher than gravity will cause a correspondingly more rapid subsidence of agglomerated "temporary" globules, but the fixed concentration remains the same.

Similarly, an emulsion at its fixed concentration (or below) is favorably affected in one way by high centrifugal force—the subsidence of globules is more rapid. It is an interesting fact that the only variable in practice is in the rate of concentration. If the force is increased or diminished, the rate of concentration is correspondingly increased or diminished, but the residual emulsion is likely to be neither more nor less dilute, and the concentrated emulsion is likely to contain neither more nor less oil. In other words, for any given emulsion, the eventual yield is practically constant if the time during which centrifugal force (or gravity) is allowed to act is commensurate with the force applied. In order to increase the rate at which this yield may be obtained, it is sufficient to increase the force, but to increase the yield we must change the emulsion itself.

There is but one change that will increase the yield, and that is an increase in the size of the globules that remain in the dilute residual emulsion. In our use of the word "agglomeration" we have heretofore implied the union of globules to produce a continuous phase. However, agglomeration does not necessarily imply the production of a continuous phase. Almost any physical or chemical change in an emulsion will cause a change in the average and the minimum size of suspended particles, and this change is brought about by the union of several globules or else the splitting up to form smaller globules. It is only under peculiarly favorable circumstances that the change will go all the way to the limiting conditions of continuous oil on the one hand or "soluble" oil on the other hand. Ordinarily the change proceeds only part way—the globules become a little larger but they remain globules, or the globules become smaller but do not approach near enough to molecular dimensions to yield a transparent emulsoid.

Elimination of Protective Colloids

The most important factor in securing this partial agglomeration is a reaction to destroy the effect of the protective colloid. The reaction may not destroy the colloid itself, but it is sufficient to throw the colloid out of aqueous solution either by precipitation or extraction. Extraction may be accomplished by rendering the colloidal substance soluble in the oil of the emulsion. An impurity in the oil phase of a soap-water emulsion does not act as protective colloid. Agitation (within reasonable limits) tends rather to increase than to diminish the size of globules in a soap-water emulsion—an effect comparable to the production of butter from cream by churning. The addition of water will increase the size of the smallest globules.

The simplest chemical methods of causing agglomeration are based on the tendency of weak acids to "decompose" the alkaline protective colloids without splitting the soap. Carbon dioxide and boric acid are examples. The impurities when acidulated dissolve in the oil and thus greatly reduce the stability of the emulsion. It is natural to expect that the oil, when finally recovered, will be tainted with these impurities.

Any treatment based upon the elimination of the protective colloid is likely to be limited in its efficiency to the fixed concentration of the pure oil with a pure soap solution.

A condition that reduces the degree of dissociation of soap in solution will still further increase the yield of oil. As an example of such a condition the laboratory test may be cited where alcohol is added to a soap-water

emulsion to facilitate the separation of a petroleum-ether extraction.

Gelatinous Emulsions Persistent

Commercial soap-water emulsions commonly tend to gelatinize. Pure soap solutions will gel when the soap concentration is high enough, but the gel is rather unstable—a little addition of water or a moderate elevation of temperature is likely to destroy the gel to form a liquid of relatively low viscosity. The gels formed by many commercial soap-water emulsions are more stable. The emulsion is likely to retain its gelatinous character even after considerable dilution with water or the application of boiling temperatures. The stability of the gel appears to be largely influenced by the proportion of protective colloid present, for the non-fatty-acid greases in alkaline aqueous solution form persistent "semi-gels" not so rigid as a pure soap gel but much more stable. The impure industrial emulsion when gelatinous usually has this same persistent semi-gelatinous consistency.

The gelatinous character of an emulsion must be regarded as important in view of the fact that agglomeration to form a continuous oil phase and concentration of globules to form a saturated emulsion is impeded by high viscosity. The viscosity of these "semi-gels" is gradually reduced as the temperature is raised, but even when boiling, the emulsion is likely to retain gelatinous characteristics. The semi-gel can be truly liquefied only by dilution with water or by chemical action. When sufficient water has been added to eliminate gelatinous characteristics, the viscosity of the emulsion is not greatly influenced by temperature changes. The diluted emulsion will usually remain liquid under any circumstances of physical change, though a chemical change (such as that induced by the addition of a little salt) is likely to throw the emulsion back into the semi-gelatinous state. Conversely, when it is attempted to liquefy a gelatinous emulsion by chemical means (instead of dilution with water), the liquid state is likely to be quite unstable, and a reversion will occur with almost any physical change, such as heating or cooling, agitation, addition of small amounts of water, etc. The addition of a trace of mineral acid to a gelatinous emulsion will often cause liquefication. A little agitation will restore the gel. Another trace of acid again liquefies, and another agitation again causes reversion. This cycle may be repeated until the soap is nearly or completely decomposed.

A complex soap-water emulsion is rarely gelatinous, for the dispersed phase, when gelatinous, will readily settle out, yielding the excess of oil and the simple emulsion.

Effect of Dilution

Unless carefully prepared, a gelatinous soap-water emulsion will not contain its oil as suspended globules because the viscosity of the continuous soap solution is too high to permit interfacial surface tension to act. The oil will be in irregular streaks or strata. As soon, however, as the emulsion is liquefied by dilution or by other means, the oil assumes its globular form. In one sense, dilution reacts unfavorably on separation procedures, for dilution increases the stability that resists agglomeration. A gelatinous emulsion that will slowly yield up some of its oil in continuous form by agglomeration and subsidence will not yield this oil after dilution. In other words, some of the oil that is "temporarily" emulsified in the gel assumes the state of fixed globules when water is added. To reduce the percentage of oil permanently held up in gelatinous emulsions has been the subject of many a research.

It has been stated that when the concentration of soap, alkali and protective colloid is reduced, the fixed concentration of emulsified oil will be reduced. Whether or not dilution will cause a separation of oil from an emulsion depends, obviously, upon the mathematical structure of the function involving the variables of dilution and fixed oil percentage. To illustrate, suppose we take an emulsion which contains 10 per cent soap and 20 per cent fixed oil and 70 per cent water. The actual concentration of substances in the aqueous phase will therefore be 14.3 per cent soap, and 28.6 per cent oil. To 100 g. of this emulsion we add 70 g. water. The soap and oil concentrations will be cut in half—7.15 per cent soap and 14.3 per cent oil. If 14.3 per cent represents the fixed oil concentration for this diluted emulsion, we can recover no oil. If the fixed oil concentration is below 14.3 per cent, we can recover some oil. Suppose the value is 10 per cent. The fixed oil in grams will amount to 17. Our recovery will be 3 g., or 15 per cent of theoretical.

Often the fixed concentration will be reduced by larger differentials than the soap concentration up to a certain point beyond which the relation is reversed. The following table illustrates one case. The emulsion was composed as in the above paragraph. The emulsion was progressively diluted, and subjected to a given centrifugal force for a given period. The oil not recovered was regarded as "fixed."

Percentage of Aqueous Phase		Percentage
Soap Per Cent	"Fixed Oil" Per Cent	Recovery Per Cent
14.30	28.60	0
7.13	10.10	15
4.80	5.40	35
3.55	1.95	70
2.80	4.10	25
2.40	4.80	0

The above is an unusual case in that the dilution yielding maximum recovery is so low.

Recovery of Oil by Acidulation

The common method in our industries of recovering oil from soap-water emulsions is to acidulate. The acid reacts with the soap to produce fatty acids and the acid reacts also with the unstable alkaline organic impurities (when these are present). The impurities when acidulated are no longer protective colloids, but are usually quite soluble in oil and in fatty acid. When a commercial soap-water emulsion is acidulated, therefore, the recovered material consists of the mutually soluble oil, fatty acid and certain organic impurities that may have been present in collodial solution in the soap-water. We have seen one case in which the alkali-soluble non-fatty-acid material comprised more than 20 per cent of such an acidulated mixture.

The subsidence of the water-insoluble materials upon acidulation is usually rapid and complete because there exists no longer any soap or any alkaline protective colloid to stabilize the emulsion. Occasionally we run up against stubborn emulsions of fatty acid with dilute mineral acid, but these emulsions are totally different from the soap-water emulsion which constitutes the present subject for discussion. In cases where there is a tendency to form stable fatty-acid emulsions by the acidulation of soap-water emulsions, the stability depends very largely upon the physical conditions under which the acidulation is conducted. This is particularly

true when the alkali-soluble impurities form oil-insoluble solids when acidulated (wool-scouring liquors).

When it is considered satisfactory to obtain the mixture of oil, fatty acid and impurities, the acidulation of a soap-water emulsion is the obviously correct procedure —inexpensive, complete in yield and uniform in operation. The major reason, in fact, that acidulation is considered unsatisfactory is that methods of separation of oil, fatty acid and non-fatty-acid grease, each free from the others, have not received sufficient attention from chemists. The recognized methods for such a separation have involved new soap-water emulsions and yields are negligible.

Salting Out Processes

It is common knowledge that salt tends to throw soap out of aqueous solution. The higher the salt concentration the more complete will be the precipitation. Solutions of the soaps that are most easily salted will dissolve salt in low concentrations, without any actual precipitation. These low salt concentrations are interesting. Suppose we take a stable emulsion and add enough salt water to bring the salt concentration to 0.5 per cent of the aqueous phase. The usual effect will be the increase of stability. It will be more difficult to agglomerate globules or to concentrate globules without agglomeration. When a high concentration of salt is used, the soap will be thrown out of solution, and the oil may or may not be recoverable. This point is enlarged later on.

Breaking an Emulsion Without Precipitating Soap

But there is a certain point in salt concentration where a soap-water emulsion may be completely broken without an actual precipitation of soap, and the oil may be recovered as a continuous phase. It is believed that every soap-water emulsion (if not too viscous) will yield up some of its oil if exactly the right percentage of salt is carefully added, but the procedure is likely to remain an impractical laboratory curiosity on account of the difficulty in formulating any rule by which the correct salt percentage may be estimated. A series of tests on three commercial samples of cottonseed oil soap-water emulsions of nearly the same constitution in oil, soap and water gave the following salt concentrations as necessary for oil recovery—2.1 per cent, 3.6 per cent, 1.2 per cent. These concentrations are based on the water content of the emulsions. In each case when the salt concentration was increased or decreased by a few tenths of 1 per cent, the stability of the salted emulsion appeared much the same as the stability of the unsalted emulsion. This sensitiveness appears to be linked with the tendency for a soap-water emulsion to gel with slight provocation of chemical change. There was no gradual relationship between oil yield and salt concentration, but a sudden change at one definite point.

Moreover, there seemed to be no functional relationship between this point and the percentage of major constituents in the emulsion. A careful research would probably show that the critical salt concentration required to bring about this change is a somewhat complex function of all constituents—in particular the proportion of impurities that constitute the protective colloids. It would be helpful if a simple analytical determination could be devised to show what might be termed "effective alkalinity." Because of hydrolysis, soap solutions are always alkaline; but the alkali is often more loosely combined with the protective colloid than with fatty acid, so loosely, in fact, that it is possible to completely saponify a fixed oil in such an emulsion by the addition of normal sodium carbonate, which appears to displace the caustic alkali from the impurities. The protective colloid acts as a catalytic agent in a saponification of this sort. The non-fatty-acid organic material in colloidal solution may sometimes be extracted from an alkaline solution with ethyl ether or benzol.

The Critical Salt Concentrations

The effect of low salt concentrations on one emulsion is shown in the accompanying curve, (Fig. 1), wherein salt concentration is plotted against yield. The emulsion contained 75 per cent of a 25 per cent soap solution and about 20 per cent oil, with about 5 per cent alkali-soluble impurity. The yield figures represent the percentage of oil recovered as free oil based on a theoretical yield of 100 per cent, by subjecting the emulsion to high centrifugal force for a given period. The critical salt concentration is not nearly so sensitive with emulsions of cocoanut oil soap because this soap is more soluble than others in salt water. To revert to high salt concentrations, when soap is "salted out" the precipitation may occur in one of two ways—with a film of oil adhering to the soap particle, or with a similar film of water. When a salted emulsion is permitted to stand, or is centrifuged to permit immiscible layers to form, the salt water will be found at the bottom, the oil at the top and the soap particles intermediate. The soap layer is not a liquid layer, but a mass of solid particles with interstices occupied by liquid. Whether this liquid be oil or water will depend upon the character of the precipitation—whether the particles are enveloped by films of oil or of water. The settled system may therefore be considered as composed of only two layers—oil and water—with the soap sludge either in the upper portion of the water or else in the lower portion of the oil. (See Fig. 2.)

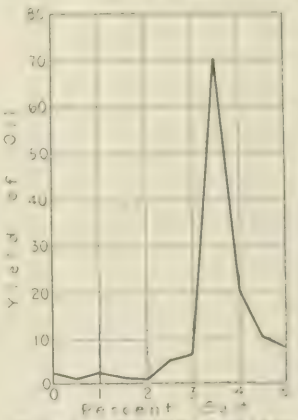


FIG. 1. CRITICAL SALT CONCENTRATION

It is clear that the yield of oil from such a separation is dependent upon the position of the soap sludge. It is highly important that the salting out be accomplished in such a manner as to suspend the soap in salt water. Unfortunately, no generally correct rules can be given here for a proper salting out. The writer has often been unable to secure an aqueous precipitation with some emulsions under any conditions. On the other hand, with other emulsions it has been found an easy matter to so alter the conditions of precipitation as to obtain the soap sludge either in the water or in the oil. An emulsion in which the ratio of oil to soap is high is particularly favorable to the aqueous suspension of the soap. The lower the soap concentration in the aqueous phase, the more likely the soap may be precipitated in the aqueous phase. The higher the concentration of protective colloids, the more likely the soap will be precipitated in the oil phase.

Often when an emulsion contains a high ratio of

soap to oil and an oil recovery by salting out appears impractical, it is feasible to concentrate the emulsion (after appropriate dilution) by gravity or preferably by centrifugal force and to salt out the saturated emulsion. The saturated emulsion contains more oil, less soap, and less organic impurities than does the original emulsion. But unless the soap and protective colloid concentration has been very materially reduced, it is necessary to dilute the saturated emulsion with fresh water to obtain a good yield of oil. The dilution aids the aqueous soap precipitation. When fresh water is added to an unsuccessfully salted emulsion the aqueous phase is diluted, but the soap still remains in the oil phase. In other words, the soap particles remain enveloped by the liquid originally in contact, no matter what changes are made *after precipitation.*

Any proper discussion of correct procedure for the addition of salt to a soap-water emulsion would lead us into the general problem of reactions between immiscible liquids. Such reactions are common in our industries, and the problem would seem to offer an interesting opportunity for further speculation and research. It is sufficient to remark here that emulsions sufficiently low in soap and organic impurities can be satisfactorily salted out by the addition of solid salt, if at least 30 per cent water is present in the emulsion. For water contents as low as 25 per cent, better results are secured by agitation with a saturated salt solution. For lower water contents, it is advisable to obtain a more thorough emulsification of brine with soap-water emulsion than can be ordinarily obtained with a stirring arrangement. A high velocity nozzle or a centrifugal emulsifier will accomplish this purpose.

If an emulsion is complex (i.e., contains some continuous oil), a dilution with fresh water will not greatly improve salting out conditions. Whether or not water is added to such an emulsion, a severe mechanical emulsification with brine is recommended.

The above data relate to sodium chloride. Other neutral salts of unit positive valence act similarly but in different degree. Sodium sulphate, for example, although not as effective as sodium chloride in the salting out of soap, accomplishes in general much the same results. A very low concentration of sulphate tends to stabilize an emulsion. Sodium sulphate has also its critical concentration where the emulsion is broken without soap precipitation, but the curve is apparently not as sharp as the curve shown for common salt. The writer has not noted the specific effect of high concentration of sodium sulphate.

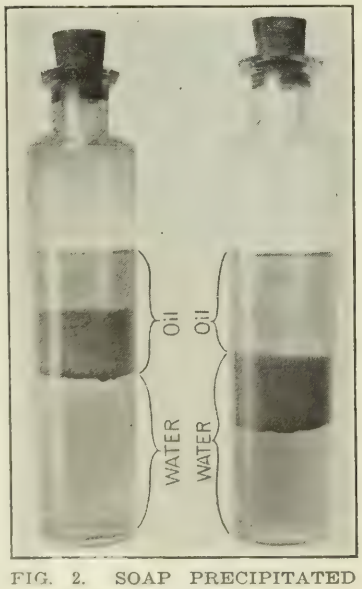


FIG. 2. SOAP PRECIPITATED IN THE OIL AND WATER PHASES

When a simple soap-water emulsion is chilled to a point where the continuous water is frozen, some of the emulsified oil is likely to agglomerate and separate after cautiously melting. This effect has been found to occur in cases of gelatinous emulsions high in soap and oil. The best method of freezing, the best methods of melting, the limiting conditions of emulsion composition and the yields obtainable under correct conditions are not known to the writer.

Simple emulsions of cocoanut oil give an opportunity of observing the opposite phenomenon. At normal temperatures the suspended oil is solid. No agglomeration of practical interest appears to occur when such an emulsion is alternately warmed and cooled except in cases of saturated emulsions, when a partial recovery may be made.

A mention of electrical separation methods will be in order.

Electrostatic Action

The various processes for a.c. and for d.c. current at high and low voltage, developed during the past decade for the separation of emulsions of water with crude petroleum, have proved highly successful in this field where large volumes must be handled at low costs (a few cents per barrel). Different investigators have ascribed different theories for "electrical precipitation," but from the nature of the processes one thing is self-evident—the action depends upon the dielectric property of petroleum, which is invariably continuous in these emulsions. The suspended water is affected by the current in such manner as to cause agglomeration and subsequent subsidence. If an aqueous phase were continuous, the current would be immediately short circuited, and there could be no conceivable agglomerating effect on the suspended dielectric oil.

Unless some entirely different method of electrical precipitation is developed, there would seem to be no possibility of separating oil by this means from a simple soap-water emulsion. On the other hand, there would seem to be no reason why the suspended emulsion in a complex soap-water emulsion could not be precipitated advantageously by means of a modified form of one of the present types of electric treater, because, in this case, the oil constitutes the primary continuous phase.

Perhaps some enterprising refiner of vegetable oils will some day develop an electrical system whereby an "off crude" may be refined with high yield.

In conclusion, we would call attention to an aspect of the soap-water emulsion problem that must be regarded as extremely important and that would require for proper discussion as much space as we have allowed for this entire article. When salts of multiple positive valence are added to a caustic alkali soap-water emulsion, a reaction takes place between the salt and the soap. The products of this reaction determine the stability of the emulsion.

We have attempted to describe and to define a viewpoint. The really difficult step in the development of a colloidal process is to interpret the problem and when an acceptable interpretation is forthcoming, it is not so difficult to find a satisfactory mode of operation. We believe that some of the data given above is rather more than less correct when applied to cases which we have specifically excluded. But if these data are regarded merely as an interpretation, you will not place any mistaken dependence upon what may have been expressed as a formula or rule. Each problem has its peculiarity, and generalizations are so infrequent that each specific case is likely to add to the sum of interesting but difficultly classifiable information.

The Acid Open-Hearth Process for the Manufacture of High-Grade Steel*

A Description of the Acid Open-Hearth Process Used at the Midvale Steel & Ordnance Co.'s Nicetown Works, and of the Conditions Conducive to the Successful Manufacture of High-Grade Steel

By B. E. L. deMARÉ

IN A broad sense, any steel which in a perfectly satisfactory manner serves the purpose for which it is intended may be considered high grade. In the more narrow sense, however, in which it is here used, it may be defined as a steel which, to be accepted, must pass certain more than ordinarily severe tests, where the margin between success and failure is so narrow and the financial loss by failure so great that the steel maker is not only justified but compelled to leave nothing undone which in any possible way may improve the quality of the steel, regardless of quantity or of any reasonable increase in its cost of manufacture, in order to insure a high percentage of acceptance when the steel is finally submitted to the test.

Products From Acid Open-Hearth Steel

The more important products of acid open-hearth steel, manufactured by Midvale, are as follows:

1. Armor-piercing projectiles,
2. Gun forgings, especially of large caliber,
3. Large or intricate forgings, such as marine crankshafts and connecting rods, bucket wheels and pinion shafts for steam turbines, and other forgings, in which transverse strength is required,
4. Forgings which require a hard and polished surface without flaw or blemish, such as hardened rolls,
5. Special grades of bar steel,
6. Locomotive and car-wheel tires.

The order in which the above classes have been enumerated may be considered as indicating the relative severity of the acceptance tests they have to pass, and therefore the relative degree of quality required, the armor-piercing projectiles requiring the highest quality, with gun forgings a close second, and so on.

Acceptance Tests

The test required for the acceptance of projectiles is as follows: From each lot of 500 projectiles four are selected to be fired against a face-hardened armor plate at a certain velocity and angle of impact, of which two must pass through the plate and remain in effective bursting condition. Should this test be a failure, four more projectiles may be selected and fired, of which three must pass through the plate and remain in effective bursting condition. In the case of 16-in. shells, the cost to the contractor of this second test would amount to about $20,000. Should it fail, the whole lot of 500 projectiles may be condemned; or the contractor may be permitted to re-treat it and re-submit it as a new lot, which would entail an extra expense of approximately $100,000. It is thus evident that every possible attention must be paid to the quality of this steel in order to avoid great financial loss, as well as loss in reputation.

Test for Forgings

The chief tests for acceptance of gun forgings are of the tangential test bars taken from the breech and muzzle ends of the rough-machined forgings. As specified, these shall be located with their axes in planes perpendicular to the major axis of the forging, and also with their axes perpendicular to the radii, which pass through the middle points of the lengths of the bars, and for larger gun forgings are to be taken, one from the outer, two from the middle and one from the inner section of wall at each end of the forging. The contractor will be allowed three official tests only. Where the test specimens fail to meet the requirements on the third submission, the piece shall be finally rejected, with certain exceptions.

The minimum physical qualities of nickel steel gun forgings of 3-in. caliber and above are as follows:

	T. S. lb. per sq.in.	L. L. lb. per sq.in.	Elong. Per Cent	Contr. Per Cent
Tubes and liners	90,000	55,000	18	30
Jackets	90,000	60,000	18	30
Hoops	95,000	65,000	15	30

Other causes for rejection of gun forgings are ghost-lines, where careful examination shows any lack of continuity of the metal, slag pockets and sand splits, or cavities containing particles of slag, etc., if, in the opinion of the inspector, they are serious enough. Bearing in mind that the present standard 16-in. 50-caliber Navy rifle is built up of forgings made from ingots up to 63 in. octagon in section and 200,000 lb. in weight, the importance of taking every possible care to avoid defects liable to cause their rejection may be appreciated.

What has been said of gun forgings applies in greater or less degree to the forgings mentioned in class 3, especially where transverse strength is required, as determined by transverse or tangential test bars.

Tests for Other Classes of Acid Open Hearth Steel Products

As regards the fourth class, such as hardened rolls, the difficulty with them is that after having been forged, annealed, machined, hardened, ground and polished, if then a careful inspection should reveal any imperfection in the polished surface, such as a small oxide or slag spot, hardly visible to the naked eye, this would condemn the roll as being unfit for its purpose.

In the remaining two classes, No. 5, special grades of bar steel, and No. 6, locomotive and car-wheel tires, we approach the borderland, where the acid and basic open-hearths compete, and where, except in a few cases, it is largely a matter of cost which one is to be pre-

*A paper read at the American Iron and Steel Institute meeting, May 28, 1920, New York City.

ferred, bearing in mind, however, that even in these classes, as far as quality is concerned, the acid product is superior to the basic, and therefore should command a higher price.

Acid vs. Basic Open-Hearth Steel

The superiority of acid over basic open-hearth steel, especially for any forgings depending on transverse test-bars for their acceptance, has been repeatedly proved, not only by our own experience, but by that of many others in this country as well as in England and France. Every attempt, for instance, to make heavy ordnance of basic open-hearth steel has from all accounts resulted in nothing but failure.

The reason for this is that the quality of the steel is measured by its freedom from oxides, and that acid open-hearth steel is more free from these oxides than basic steel, because acid open-hearth slag is more effective than basic slag by its reactions with the steel to de-oxidize it.

Of course, there is no open-hearth steel, acid or basic, absolutely free from oxides, nor is there any other steel, no matter by what process made, which under the microscope does not show oxide spots.

Therefore, oxidation is only a matter of degree, and the various processes overlap, so that a badly-melted steel, by whatever process produced, may be worse than a well-melted steel produced by any of the other processes. The claim that acid open-hearth steel is better than basic holds good only in so far as full advantage has been taken of the fact just mentioned in regard to acid slag, as compared with basic.

Ingot Defects Caused by Oxides

The effect on the ingot metal by this difference in the degree of oxidation is shown by the following facts:

1. The amount of deoxidizing finals just sufficient to produce an acid ingot free from blow-holes is not sufficient to make a basic ingot of similar composition solid, but will leave it decidedly blowy. For instance, tire-ingots, which are sliced in lathes into several blocks, and where therefore any lack of solidity in the ingot would be discovered, as the blocks are always carefully inspected just for such a defect, have proved beyond doubt that basic are much more liable to be blowy than acid tire-ingots, and that it is absolutely necessary to add more deoxidizing finals to basic than to acid heats, in order to make basic ingots as free from blow-holes as the acid ones. This proves that basic steel is more oxidized than acid steel. Consequently the greater amount of finals required for deoxidizing the basic steel, reacting with the greater amount of oxides in the steel, will produce a greater amount of the non-metallic impurities resulting from this reaction, chiefly silicates of manganese.

2. The ingot crystals of basic steel as shown by tire-ingots, as well as by numerous experiments with other grades of steel, are very much larger than those of acid steel, poured under the same conditions. For this reason and also because basic is more oxidized than acid steel, the finely divided oxides, still retained by the crystallizing steel and to a greater or less degree expelled by the growing crystals into the intercrystalline space, will thus form in the basic ingot a honeycomb of non-metallic impurities much more serious than in the acid ingot. The ferrite envelope surrounding the ingot grain, which marks the intercrystalline space as the ingot is cooled down, will also be far more distinct in size and outline in the basic ingot and harder to break up by subsequent forging and heat treatment, but even if this be eventually done, the non-metallic impurities will still remain and seriously affect the quality of the steel.

3. To bring out additional evidence as to the effect of ingot impurities on the internal structure of the ingot, a longitudinal cross-section may now be finish-machined and etched. As a result, there will appear certain dark lines symmetrically disposed on either side of the center line, and running in an oblique direction inward and upward. These lines are the paths taken by metallic segregations high in phosphorus and sulphur, mixed with silicates and sulphides of manganese, resulting from the reactions in the steel after it has been poured into the mold. These impurities remain fluid during the time of crystallization, part of them becoming entangled among the ingrowing crystals, while the rest are driven inward by the solidifying shell, and upward on account of being lighter than the surrounding mother metal, and as they progress toward the center and top of the ingot they coalesce into larger and larger globules and increase more and more in number. They may later be identified in the forging made from the ingot, the metallic segregations high in phosphorus and sulphur as "ghostlines," especially in the bore of hollow forgings, and the silicates of manganese as "slag pockets" or "sand splits" in the machined forging, and also as streaks of "slag" across transverse test bars.

Composition of Ghostlines

The composition of the "ghostlines" was determined at Midvale some years ago by slicing a transverse section off the end of a large hollow forging, made from an ingot which had been cast in a sand-lined mold and which therefore had a great many well-defined "ghostlines" in the bore. On etching this section the "ghostlines" were plainly seen as bright spots, increasing in number from the outside to the bore. These spots were drilled with a $\frac{3}{32}$-in. drill, and the drillings, as well as the surrounding metal, analyzed with the following result:

	Per Cent C	Per Cent Mn	Per Cent P	Per Cent S	Per Cent Si
Ghostlines	0.497	1.026	0.082	0.116	0.268
Surrounding metal	0.498	0.894	0.030	0.047	0.316

In regard to the silicate of manganese, opportunity was offered for its analysis by finding a large quantity that had escaped to the bottom of the shrinkage cavity in a 63-in. octagon ingot of basic steel which had had the usual finals for this kind of steel of ferromanganese, ferrosilicon and aluminum. The lower part of this silicate was a yellow-blue, solid enamel, while the upper part was very light and porous, and violet-blue and black in color. The compositions were:

	Per Cent SiO_2	Per Cent MnO	Per Cent Al_2O_3	Per Cent FeO, etc.
Lower part	51.60	40.60	7.88	trace
Upper part	50.34	29.94	18.90	trace

The defects in the steel resulting from these lines of ingot impurities will be necessarily more serious in basic steel than in acid, specially in regard to the oxides.

The much less serious effect of the segregations high in phosphorus and sulphur, which are the cause of ghostlines, may be modified in basic steel because of the fact that this, as a rule, is lower in phosphorus and sulphur than acid.

Other points considered here are:

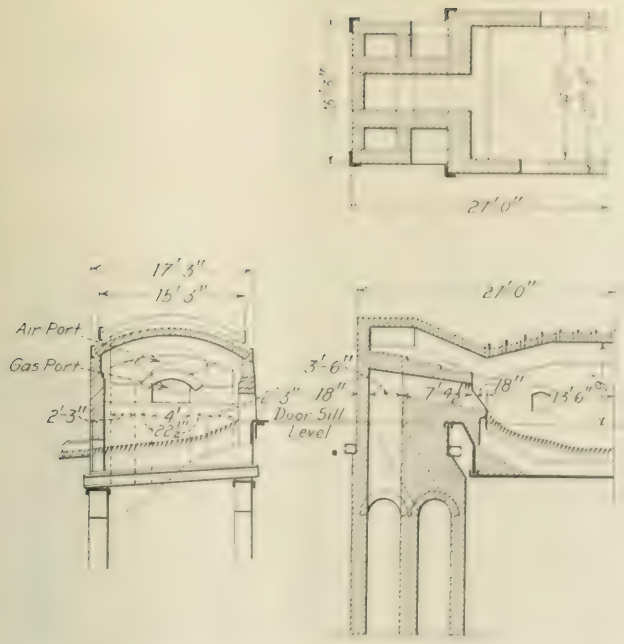


FIG. 1. 50-TON OPEN-HEARTH FURNACE, PRODUCER GAS AS FUEL

The proper design of the furnace for high-grade acid open-hearth steel.

A comparison between producer gas and fuel oil for melting.

An analytical description of the acid open-hearth process as carried out by Midvale.

Proper Furnace for High-Grade Acid Open-Hearth Steel

Two designs of open-hearth furnaces are shown, one as adapted for producer gas (Fig. 1) and the other for fuel oil (Fig. 2). The nominal capacity of both is fifty tons, although charges up to 140,000 lb. may be melted. There is nothing peculiar in the designs, as far as valves, flues, regenerative chambers or stacks are concerned, and these parts are therefore not shown. The only unusual feature is the great height of the furnace roof over the doorsill level. This has been a gradual development, and has been found advantageous on account of the high and long sustained temperature necessary to carry out the chemical reactions during the deoxidizing period of the process. The high roof provides a large combustion chamber, which permits a full and free development of the flame, and at the same time avoids damage by the intense heat to the roof and walls of the hearth. Even so, it is advisable with a new furnace to keep it working a few weeks on the less exacting grades of steel, such as tires and bar steel, in order to harden it, before turning it over on the higher grades, as not even the best quality of silica brick will stand at the beginning the high temperature required for these. Toward the end of its life the furnace as a general rule has again to be put back on lower grades of steel, as on account of impaired condition of checkers and draught it is no longer sharp enough for making high-grade steel.

No water-cooled devices of any kind are used in the walls, roof or ports of the furnace, as it has been found as a result of many trials that even when used to a very limited extent their cooling effect interferes with the sharp working of the furnace. The only water-cooled parts used are the charging doors, as they are far enough removed from the interior not to have a noticeable effect on the heat.

It may be of interest to give here a comparison between the life of acid and basic open-hearth furnaces, when melting with producer gas as well as with fuel oil, as measured by the average number of months from the time of charging the first heat after a general repair, until the time of tapping the last heat before the next general repair. The average number of months is given rather than the average number of heats on account of the great variety of heats made, some requiring twice as long a time as others, and the comparison is based on our records for the last five years.

AVERAGE LIFE OF OPEN-HEARTH FURNACES

	Months
Basic furnaces on producer gas	9.1
Basic furnaces on fuel oil	10.7
Acid furnaces on producer gas	11.2
Acid furnaces on fuel oil	12.8

Producer Gas and Oil as Fuel

Just as good steel can be made with producer gas as with oil as fuel, and vice versa. Oil is more oxidizing than gas and therefore requires a greater proportion of pig iron in the first charge and a higher temperature after the heat is melted to settle up the metal. On the other hand, oil cuts down the repair cost, requires fewer men per furnace, increases the production, permits better control of temperature, and extends that part of the life of the furnace which is available for making high-grade steel almost to the very end, as the direction of its flame is controlled from the outside and it is less affected by the condition of checkers and draught for generating a high temperature.

Taken all in all, oil is, therefore, much to be preferred as long as its price is not prohibitive.

Analytical Description of a Heat for Acid Open-Hearth Steel

The heat considered here, which is marked MK-13-126, was made for steam turbine bucket wheels, which

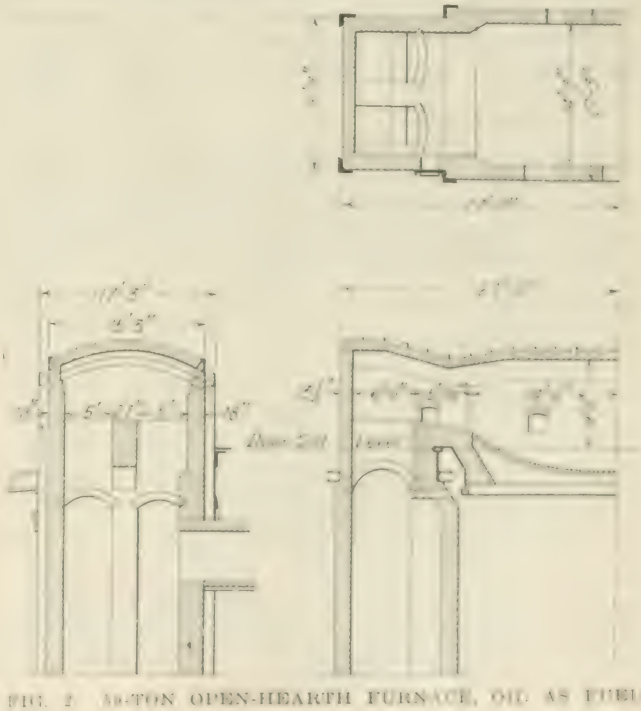


FIG. 2. 50-TON OPEN-HEARTH FURNACE, OIL AS FUEL

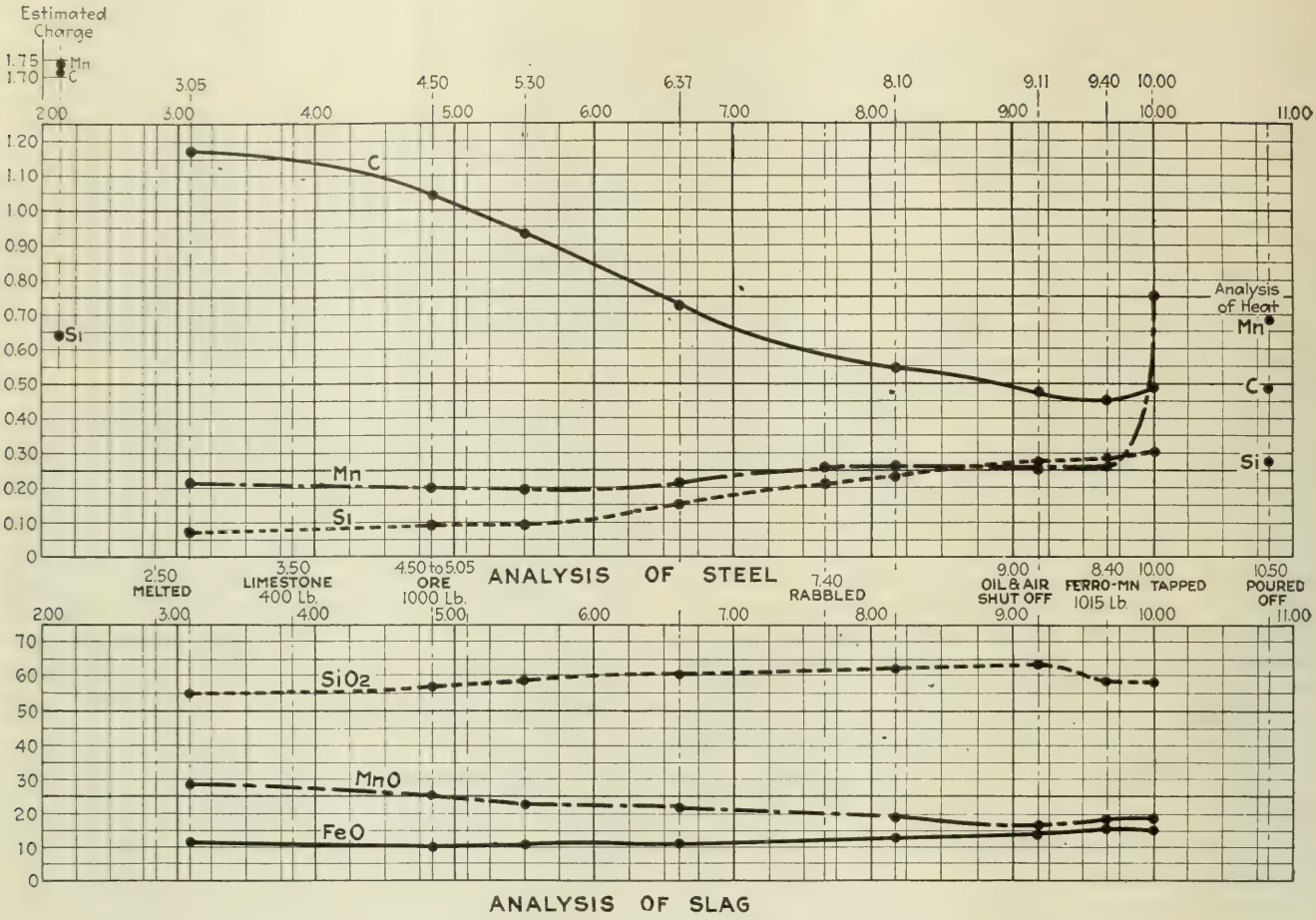


FIG. 3. GRAPHICAL ANALYSIS OF AN ACID OPEN-HEARTH HEAT NO. MK-13-126

require tangential strength, and therefore their acceptance depends on physical properties as shown by tangential test bars. Hence, high-grade acid open-hearth steel is used for their manufacture.

It is a simple heat of plain carbon steel and its treatment is typical of the class of steel to which it belongs. Though not especially selected for this analysis, it may be considered a good, clean heat, without unnecessary complications, and is therefore suitable to illustrate the principles followed in the treatment of the highest grade of steel.

The initial charge of 141,000 lb. melted in a 50-ton acid furnace of the design shown consisted of 35 per cent of pig iron and 65 per cent of scrap. The estimated carbon, manganese and silicon in the charge were C 1.72 per cent, Mn 1.74 per cent, Si 0.64 per cent. Time consumed for heat in furnace follows:

	Hr.	Min.
Time of charging (in two periods)	1	45
Time of melting	5	50
Time in furnace after melting	7	10
Total time in furnace	14	45

The history of the heat, after the initial charge was melted, may be thus summarized:

hr. 0 min. after melted, addition of 400 lb. limestone.
hr. 0 min. after melted, addition of 1,000 lb. iron ore
hr. 50 min. after melted, bath thoroughly rabbled.
" 10 min. after melted, oil and air shut off.
" 50 min. after melted, addition of 1,015 lb. ferromanganese.
" 10 min. after melted, heat tapped
hr. 9 min. after melted, heat poured off.

The analysis of the go-ahead test, taken 1 hr. 10 min. before tapping, and the C, Mn and Si obtained from 1,015 lb. of ferromanganese added 20 min. before tapping are shown in the following table:

	C	Mn	Si
Analysis of go-ahead test	0.49	0.27	0.24 *
Addition of ferromanganese	0.05	0.57	0.01
Total	0.54	0.84	0.25

* Judged by fracture.

The table below shows the chemical composition of the heat as aimed at, and as obtained:

Composition	C	Mn	P	S	Si
Aimed at	0.50	0.65	0.050	0.050	0.25
Obtained	0.49	0.68	0.036	0.038	0.27

On account of the high percentage of Mn in the initial charge the slag remained greenish yellow in color from the time the heat was melted until it was tapped, with only slight variations in shade.

The steel was poured into 23-in. octagon molds, 9 ingots of 10,500 lb., and 3 ingots of 11,400 lb. weight. The ingots, after cooling, were sent to the machine shop to be sliced into blocks, and these blocks were then forged under a steam hammer into bucket wheels for steam turbines.

To facilitate the analytical description of this heat, a graphical analysis chart has been plotted and drawn, showing its chemistry from the time it was melted at 2:50 a.m. until it was tapped at 10 a.m. (Fig. 3).

Eight breaking tests were taken at various times and poured into a standard test mold, about 2 in. deep x 2 in. wide x 6 in. long. These tests were broken and each fracture photographed. At the same time other tests were taken, both of steel and slag, for chemical analysis.

The steel tests were analyzed for C, Mn and Si, and by plotting these determinations on the "Analysis of Steel" chart, curves were obtained showing the changes in these elements.

The slag tests were analyzed for SiO_2, MnO, FeO, Fe_2O_3, CaO, MgO, Cr_2O_3, and Al_2O_3, but to avoid confusion only the three most important of these oxides, SiO_2, MnO and FeO, were plotted on the "Analysis of Slag" chart, to show the changes taking place in the composition of the slag during the progress of the heat. The full analysis of each slag test is:

SLAGS FROM M.K.-13-126

	SiO_2	MnO	FeO*	Fe_2O_3*	CaO	Cr_2O_3	Al_2O_3	MgO	MnO FeO Fe_2O_3 CaO	Total
1	55.0	28.0	11.1	1.4	2.6	0.3	1.4	0.6	43.1	100.4
2	57.0	25.0	10.3	0.6	3.9	0.3	1.4	0.6	39.8	99.1
3	58.7	22.7	11.0	0.7	3.9	0.2	1.9	0.8	37.9	99.9
4	60.7	21.3	10.5	0.9	3.3	0.2	1.5	0.8	36.0	99.3
5	62.2	18.7	12.7	1.0	2.5	0.2	1.5	0.7	34.9	99.5
6	63.0	16.5	13.9	0.9	2.5	0.2	1.5	0.5	33.8	99.0
7	58.5	18.0	15.5	2.1	2.4	0.2	1.6	0.6	38.0	98.9
8	58.4	18.8	15.0	0.4	2.4	0.2	1.5	0.5	36.6	97.2

Test No. 1

Commencing with test No. 1, taken at 3:05 a.m., or 15 min. after the heat was melted, its analysis shows the oxidation of C, Mn and Si during the time of melting by comparing it with the estimated percentage of these three elements in the initial charge. C has dropped from 1.72 to 1.17 per cent, Mn from 1.74 to 0.21 per cent, and Si from 0.64 to 0.07 per cent. A considerable percentage of Mn in the first charge is highly desirable, because by its oxidation during the melting it gives a clean slag, greenish yellow in color, almost from the start, and if the pig iron doesn't contain enough Mn, this deficit is made up for high-grade steel by the addition of ferromanganese to the initial charge. A high percentage of both Mn and Si is also desirable in the initial charge on account of their oxidation being an exothermic reaction, facilitating the melting and giving a bath hotter and less sluggish with iron oxide by the time the charge is melted. Both these elements oxidizing at a lower temperature than carbon, their oxidation, as far as it goes, is practically complete by the time the charge is melted, while the carbon is still comparatively high.

Care is now necessary in the addition of iron ore for de-carburizing the metal, as this is an endothermic reaction, absorbing heat and requiring a high degree of temperature for a vigorous reaction between the oxygen of the ore and the carbon of the steel. If the addition of ore is made too soon, or in too large a quantity, its chilling effect may so retard this reaction that when finally the high temperature required is reached and the bath goes into a boil, this will carry the decarburization so far that by the time the bath is well settled up the carbon in the steel is well below the carbon aimed at. This would necessitate additions of spiegel and pig iron in order to recarburize the heat. Such a condition is almost fatal to the production of high-grade steel, because the lower the carbon in the go-ahead test as compared with the carbon aimed at and therefore the greater the addition of recarburizing finals, the greater will be the amount of silicate of manganese produced. This may quite likely lead later on to the condemnation of the forgings made from such a heat on account of "sand-splits" or "slag-enclosures," or on account of transverse test bars failing in extension and contraction, due to streaks of "greenish slag" or "woody structure" caused by these streaks, or, in the case of projectiles, on account of cracks starting from small slag enclosures during the hardening process, or on account of the projectiles selected for the firing test, breaking up in striking the face hardened armor on account of the weakening effect of these concealed impurities.

Hence the reason for the note on the melting order: "Add no ore until 2 hr. after melted." Except steadily increasing the temperature of the heat during these 2 hr., the only thing done was the addition of 400 lb. of limestone 1 hr. after the charge was melted. By displacing a certain amount of iron oxide in the slag and making it more fluid, the limestone seems to put it in a better condition for subsequent reactions, at least where there is a low manganese content in the initial charge.

This, however, is, in my opinion, the only time when addition of lime is of any value. If done later during the de-oxidizing period of the heat, it will simply undo all the good that has been done, because replacing the FeO in the slag then will drive this into the steel to oxidize the silicon and manganese and make the bath again raw and unsettled.

Tests Nos. 2, 3, 4 and 5

At the end of two hours, test No. 2 was taken. This shows the oxidation of the carbon, slow at first on account of lack in temperature, now well under way. There having been as yet no addition of iron ore, this oxidation is caused by the rust in the initial charge, by oxidation of the charge in melting and by the oxidizing effect of the flame itself.

The higher temperature of the slag is also shown by its slightly higher percentage of SiO_2.

Test No. 3, taken 40 min. after No. 2, shows the oxidation still going at the same rate, due to the addition of 1,000 lb. of iron ore during the interval. The only effect of this addition on the slag is a slight increase in FeO, the SiO_2 continuing to rise and the MnO slowly decreasing by dilution with the SiO_2 taken up by the slag from the bottom along the slag line.

Test No. 4, taken 1 hr. and 7 min. after No. 3, shows the oxidizing period at an end. The SiO_2 in the slag has now gone up from 55.0 per cent, 15 min. after the heat was melted, to 60.7 per cent, while the two chief bases, MnO and FeO, have dropped from a total of 39.1 per cent to 31.8 per cent, in spite of the lower carbon in the steel. But most marked and showing that the de-oxidizing period has set in, is the increased percentage of Si in the steel, caused by the reaction between the carbon of the steel and the SiO_2 of the slag, according to the formula:

$$2C + SiO_2 = Si + 2CO.$$

Whereas during the melting of the charge on account of the low temperature then prevailing, the oxidation of Si was going on at a much greater rate than the oxidation of the carbon, with the steadily increasing temperature this oxidation of Si was first checked, then held, until finally a complete reversal has taken place, the very high temperature now reached having so increased the affinity of carbon for oxygen that it is able to reduce Si out of SiO_2, leaving the Si free, in its nascent and therefore most efficient state, to de-oxidize the steel, as shown by the increasing solidity and freedom from blow-holes of subsequent tests. This reaction is the essential point that accounts for the difference between acid and basic steel and that which makes acid steel superior to basic.

What has just been said in regard to the effect of the increased temperature on the relative affinity of C and Si for oxygen is also shown to have taken place in the relative affinity of C and Mn for oxygen, the C now

*Any metallic Fe present was determined as FeO. This would result in a high figure for FeO and a low figure for Fe_2O_3.

reducing Mn out of the MnO of the slag, the nascent Mn also assisting in the de-oxidation of the steel. This manganese reaction, however, which also may take place in a basic open-hearth heat, is much less effective than Si in de-oxidizing the steel, because the de-oxidizing effect of Mn is much less than that of Si, the latter, according to Brinell, being 5.2 times more effective than the former.

Test No. 5 shows the characteristic "worm-holes" well developed from the increased absorption of Si, which has gone up to 0.23 per cent. The only thing done with the heat between tests Nos. 4 and 5 was to give the bath a thorough rabbling with steel bars to facilitate the liberation of gas. Nothing else is now being done except to keep on pushing the temperature higher and higher to promote the reaction between C and SiO_2.

The reason why the carbon curve is still on a downward slope, in spite of the now well-settled-up condition of the bath, is no longer the reaction between the iron oxide of the slag and the carbon of the steel, which occurred during the oxidizing period of the heat, but the reactions of the de-oxidizing period between the carbon in the steel and the SiO_2 and the MnO of the slag, the Si and Mn, as previously explained, being constantly reduced to act as carriers in de-oxidizing the steel, while the CO resulting from this reaction bubbles slowly up through the slag. Assuming that when No. 5 test was taken the percentages of Si and Mn in the steel were the same as when No. 3 test was taken, it may be shown by a simple calculation that the carbon then would have been about 0.67 per cent, instead of having dropped to 0.54 per cent, so that but for this later reaction of the de-oxidizing period the carbon line would have been almost horizontal.

Tests Nos. 6, 7 and 8

Test No. 6 shows the de-oxidizing process almost complete, the "worm-holes" of the previous test having been nearly obliterated by the steadily increasing percentage of Si. The heat would now have been ready for the final addition of ferromanganese made just before tapping, except for the fact that the carbon, according to the first go-ahead test, was still a little too high or 0.53 per cent. A second go-ahead test had therefore been taken out 10 min. ahead of test No. 6, and on this being reported as being down to 0.49 per cent carbon the ferromanganese was added at 9:40 a.m., and the heat tapped at 10 a.m., or 20 min. later.

Test No. 7, taken just before adding the ferromanganese, is very little different in appearance from test No. 6, while test No. 8, taken after the addition of ferromanganese and just before tapping the heat, is absolutely solid. The Si in this test was 0.30 per cent, while the Si in the heat test, taken while pouring the steel into the molds, was 0.27 per cent, which shows that the Si in the steel while still in the furnace is higher in the stratum close to the slag, from which test No. 8 was taken and where the reduction of Si from the slag is taking place, than the average Si of the whole mass of steel.

Aluminum and titanium are never used for de-oxidizing steel in which transverse strength, as determined by transverse tests, is required, because the oxides of these elements have a very baneful effect on the physical properties of such tests, even when used very sparingly. It is difficult to believe, but it is nevertheless a fact, that this effect of aluminum, added into the ladle at the rate of 1 lb. of aluminum to 10,000 lb. of steel and held 25 min. before pouring, very likely will cause the condemnation, on account of failing test bars, of a gun forging made from this steel.

Influence of Shutting Off the Fuel and Air 1 Hr. Before Tapping

There is one more point in regard to the chemistry of this heat that requires an explanation. That is the shutting off of the oil and air, which also implies the lowering of the stack-damper, 1 hr. before tapping.

It may be noticed on the "Analysis of Steel" chart that this had no effect on the C, Mn and Si curves. On the "Analysis of Slag" chart, however, the result was a sudden drop in the SiO_2 curve, and a corresponding, but less marked, rise in the MnO and FeO curves. This, of course, does not mean a loss of SiO_2, as far as the actual weight of this oxide in the slag is concerned. What has occurred is an absorption by the slag of an additional amount of the two basic oxides, MnO and FeO, from some source, thus making the slag less acid than it was before.

The thermal effect was a very decided cooling of the slag, while, on account of slag being a poor heat-conductor, the temperature of the steel underneath the slag was by comparison only slightly lowered.

The reasoning which first led me to try this treatment with the point in view of still further de-oxidizing the steel was this:

As the temperature of an acid heat rises, by degrees de-oxidizing the bath through the reactions between the slag and the steel made possible by this rise in temperature, a point is finally reached where this reaction has to be stopped, in order not to get the steel too high in Si. If at that point the furnace were suddenly cooled by shutting off the flame, the effect would be a sudden cooling of the slag, while the temperature of steel, protected from radiation of heat by the blanket of slag, would be only slightly affected. This thermal change would have the effect on the slag of considerably increasing its affinity for basic oxides. The only supply of these oxides then available would be the traces still retained by the steel, which would therefore to a greater or less degree be absorbed by the slag. On account of the weight of slag in a heat being only about 7 per cent, while the steel makes up about 93 per cent, or thirteen times the weight of slag, a trace of oxides in the steel if absorbed by the slag would be quite a noticeable amount.

This, I believe, is the explanation of the change in the composition of the slag, resulting from shutting off oil and air for 1 hr. before tapping. This treatment was first tried more than seventeen years ago, since which time it has been in continuous use, especially in the case of carbon and nickel steel for large ingots.

The cooling effect on the steel, although slight compared with that on the slag, is also advantageous in order to lower the temperature for pouring large ingots, as otherwise the high temperature of the steel would make the ingots pull badly in forging. For this reason the steel is still further cooled by holding it from 20 to 30 min. in the ladle before starting to pour.

This ends the difference in the treatment of acid from that of basic open-hearth steel. I only want to add that though this treatment is simple enough, it requires great skill and good judgment on the part of the men in the shop, and that uniformly good results can be obtained only by careful and intelligent men after many years of training.

Similarity of the Magnetic Change in Cementite and Ferrite

By Miss H. G. Movius and Howard Scott *

THE purpose of this paper is to present evidence that the transformation of cementite from the paramagnetic to the non-magnetic state is accompanied by a detectible thermal effect similar to that accompanying the corresponding transition in pure iron. This behavior of cementite as exhibited in steels and cast iron, in which the carbon is in the form of free cementite in its ferrite matrix, was probably discovered by Wologdine[1] and has been studied by means of magnetic methods by Honda[2] and by Smith[3].

Separating the cementite from its matrix of ferrite, its transformation has been studied by Honda and Murakami[4] and by Ishiwara[5]. Honda and Murakami, by means of this method, determined the critical temperature of this transformation of cementite, which they call Ao, to be 215 deg. C., the critical temperature being defined as the temperature at which the transformation ends on heating and begins on cooling.

Chevenard[6] has detected this transformation in steel by means of expansivity measurements and Iitaka[7] by means of resistance measurements.

By obtaining differential cooling curves on white pig iron, Honda and Takagi[8] have shown an obtuse inflection in the neighborhood of 200 deg. C.

The changes in the physical properties of cementite measured by the above-mentioned authors show a strong resemblance between the magnetic transformation of cementite and that of ferrite, so it is not surprising that this resemblance persists in the behavior of the material upon heating as detected by thermal analysis and reported here. For the purpose of the comparison, thermal curves were taken by the inverse rate method in the manner recently described[1]. The materials studied were a pure iron, a eutectoid carbon steel and a 1.94 carbon iron-carbon alloy of the composition given in Table I.

The pure iron and iron-carbon alloy were prepared as described in Bureau of Standards Scientific Paper 266, and hence any impurities other than those given in the table are present only in minute quantities; the total impurities are probably less than 0.04 per cent.

The thermal curves, in which the behavior of the material of these three compositions when heated over the temperature range 100 to 300 deg. C. is recorded, are shown in Fig. 1, while Fig. 2 shows those of the pure iron when heated over the A_2 range. The steels were in the pearlite state and no graphite was present in the 1.94 C steel. It may be noted from the curves that the intensity of the Ao transformation in the 1.94 carbon steel is small in comparison with A_2 of the pure iron, but that it has the same distinguishing characteristics, that is, a gradual approach to the maximum, a lack of definite hysteresis between the maximum on heating and on cooling, and a difference in form between the Ac and Ar inflections which the curve for pure iron shows very clearly. For the sensitivity of the apparatus employed, the transformation Ao is only barely perceptible in the 0.95 carbon steel and cannot be detected in instances where vibrations of the building and other extraneous influences mask the heat effect. The inflection, of course, is not visible in the pure iron curve, which has been plotted mainly to show the furnace characteristics over the temperature range investigated. The intensity of the curve inflection of Ao can be magnified by choice of a more sensitive thermocouple if so desired.

The temperature values of the maximum thermal inflection, as noted on the curves, are given in Table II

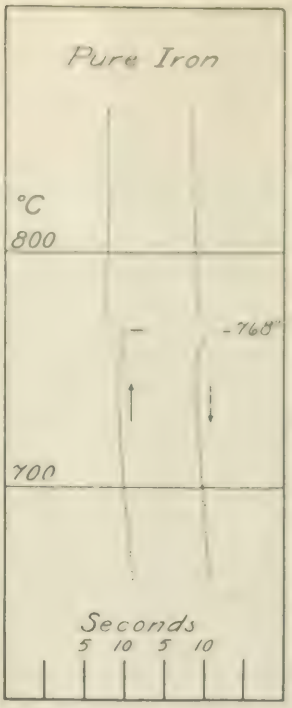


FIG. 2. THERMAL CURVES OF PURE IRON IN REGION OF A_2 TRANSFORMATION

TABLE I. CHEMICAL COMPOSITION OF STEELS

	C	Mn	Si	S	P
Pure iron	0.03	0.005	0.005	0.005	
Eutectoid steel	0.95	0.22	0.24	0.01	0.01
Pure iron-carbon alloy	1.94		0.01	0.005	

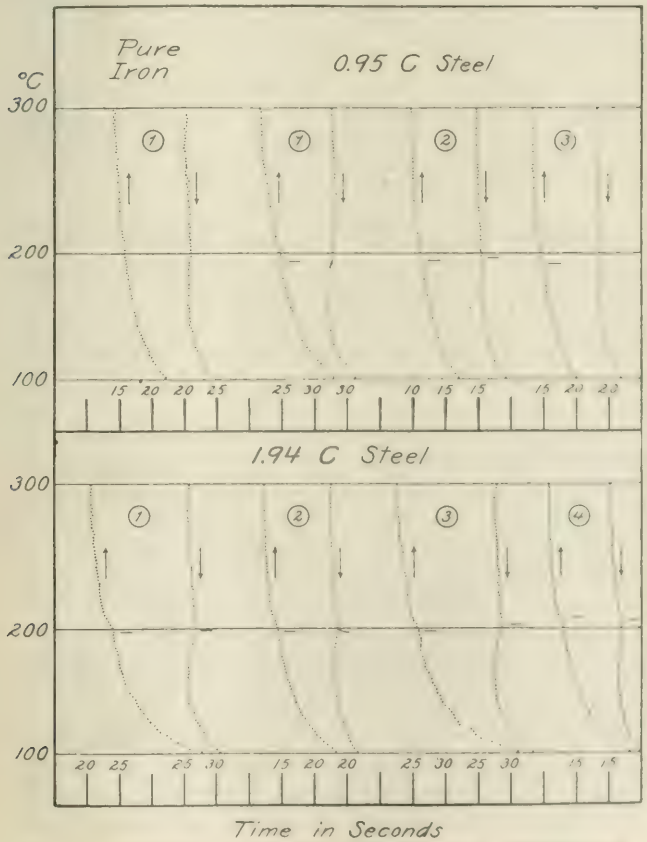


FIG. 1. THERMAL CURVES IN REGION OF CEMENTITE TRANSFORMATION

*Published by permission of the Director, Bureau of Standards.

[1]Wologdine: *Compt. Rend.*, vol. 148, p. 776 (1909).

[2]Honda, *Sci. Rep.*, Tohoku Imp. Univ., vol. 2, p. 203 (1913). Honda & Takagi, *Ibid.*, vol. 4, p. 161 (1915). Honda, *Ibid.*, vol. 6, p. 149 (1917).

[3]Smith: *Proc.* Phys. Soc. of London, vol. 25, p. 77 (1912).

[4]Honda & Murakami, *Sci. Rep.*, Tohoku Imp. Univ., vol. 6, p. 23 (1917).

[5]Ishiwara, *Ibid.*, vol. 6, p. 285 (1918).

[6]Chevenard, *Rev. de Met.*, vol. 16, p. 17 (1919).

[7]Iitaka, *Sci. Rep.*, Tohoku Imp. Univ., vol. 7, p. 167 (1918).

[8]Honda and Takagi, *Sci. Rep.*, Tohoku Imp. Univ., vol. 4, p. 161 (1915).

From this table it appears that the maximum of the transformation occurs at a slightly higher temperature in the higher carbon and steel in which the manganese and silicon are practically nil and that in this case its temperature is in the neighborhood of 200 deg. C. Rate of temperature change has no appreciable effect over the range of rates used on its position, as is also the case with A_2 of pure iron[10].

The difference between the temperature given by Honda (215 deg. C.) and the one given here (200 deg. C.) for Ao does not imply an experimental error in

TABLE II. TEMPERATURES OF CRITICAL POINT OF CEMENTITE

Per Cent C	Curve No.	Rate of Heating Deg. C. per Sec.	Aco Deg. C.	Rate of Cooling Deg. C. per Sec.	Aro Deg. C.
0.95	1	0.09	194	0.08	...
0.95	2	0.16	191	0.12	...
0.95	3	0.21	192	0.14	194
1.94	1	0.10	198	0.09	199
1.94	2	0.18	199	0.12	200
1.94	3	0.09	199	0.08	202
....	4	0.19	207	0.14	205

either case, for the values are taken as previously defined from non-coincident points on curves which represent a transformation of the continuous type.

Thermal curves taken on a eutectoid and a 1.94 carbon steel show the magnetic transformation of cementite in both, but more marked in the latter. It has the thermal characteristics peculiar to the A_2 transformation of pure iron and occurs as a maximum in the pure iron-carbon alloy at approximately 200 deg. C.

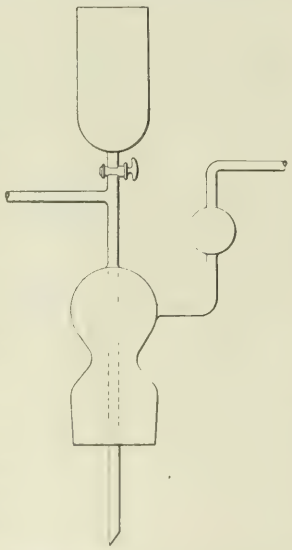
The thermal change at Ao for the carbon tool steel is so small as to be hardly discernible and consequently cannot be confused with the thermal phenomenon observed on heating hardened steels through the same temperature range.

Washington, D. C.

Special Gas Wash-Bottle for Use in the Referee's Test for Sulphur

By A. E. Maze*

In the referee's test for total sulphur in gases the gas is burned in a suitable burner, where the sulphur is converted to sulphur dioxide. The products of combustion are carried into a series of wash bottles containing an alkaline solution of bromine, where sulphur dioxide is absorbed and oxidized to sulphuric acid. If sufficient bromine is added at the beginning to suffice for the entire test a very large excess must be used. To keep the bromine consumption at a minimum only a slight excess is added at the beginning and the bromine is replenished from time to time. To maintain the flame in the burner considerable suction must be applied to the wash bottles. In adding bromine the bottle nearest the burner is opened and in this way the draft is interrupted and frequently the flame is extinguished. At times this may not be noted for some time and the test rendered useless.



To eliminate this difficulty a wash-bottle having a funnel and cock in the inlet is placed directly after the burner. The figure represents the top of such a wash-bottle. Through this funnel the bromine may be added in required quantities without interrupting the draft or endangering the flame.

[10] Burgess and Crowe, Bureau of Standards Scientific Paper 213, also A.I.M.E., Vol. 37, p. 685 (1913).

*Chemist, Denver Gas & Electric Light Co.

Hydro-electric Power Development in France

The hydro-electric resources of France are estimated at from 8,000,000 to 10,000,000 hp., about 4,000,000 of which is in the regions of the Alps; in Massif Central, Vosges, and Jura, 1,500,000; in Pyrenees, 1,700,000; and in other regions, 800,000. Between 1869 and 1899, 150,000 hp. was developed. In September, 1902, statistics presented at a water-power congress held at Grenoble showed that 200,000 hp. had been developed. After 1902 development progressed as follows: By 1905 there was a total of 450,000 hp.; by 1910, 650,000; by 1913, 750,000; by 1914, 800,000.

Between 1916 and 1918 it was estimated that 450,000 hp. was developed, bringing the total development up to the time of the armistice to 1,250,000 hp. Projects started in 1919, totaling 175,000 hp., and projects planned for construction in 1920-1921, developing 225,000 hp., will bring the total development in 1921 to 1,650,000 hp., or about 20 per cent of the total available.

The power development between the end of 1915 and 1921, about 850,000 hp., is divided among the several regions as follows: Alps, 428,000 hp., Pyrenees, 185,000; central France, 200,000; Jura and Vosges, 35,000; West, 2,000.

Thus it will be seen that nearly 50 per cent of the power development of France will have been accomplished in six years. The purposes for which power was developed during this period were: Industrial uses, 308,000 hp.; electrochemistry, 216,000; electrometallurgy, 326,000.

When completed these plants will represent a capital investment of $127,766,000. Prior to 1915, $154,400,000 was invested in power plants in France, making a total investment to date of $282,166,000.

Condition of the Scottish Shale Oil Industry

The reports of the Scottish shale oil concerns, issued in the early months of 1919, showed very satisfactory returns, in one instance the dividend being as high as 40 per cent, including income tax, but later developments, due to labor difficulties and a general increase in operating expenses, placed the industry in a much less favorable position. At meetings of stockholders and directors held later in the year, gloomy forecasts as to the future of the industry were made, and a severe drop took place in all the shares. Negotiations were entered into by the Scotch companies with the Anglo-Persian Oil Co., with the result that a new company was formed, called the Scottish Oils, Ltd., which took over the ordinary shares of the Scotch companies. It is stated that the new development is likely to lead to a largely increased quantity of crude oil being dealt with in the Scottish refineries, for, while the refining of shale oil will continue, it is expected that imported crude oil will be used to supplement the shale oil supplies, thus keeping the refineries fully employed. It is probable that this arrangement will improve the situation of the shale oil companies, although the actual production of shale oil may decrease.

Nitrogen Fixation by the Haber Method

Theoretical Consideration of the Process—Preparation of Gases for Catalysis—Design of Apparatus—Existing Plants—United States Nitrate Plant No. 1—Cost and Difficulties in Operation—Future Development by the Government—Conclusion as Compared With Cyanamide Process

By CHESTER H. JONES

IN REFERRING to the four most important processes discussed in connection with nitrogen fixation—namely, the arc process, the Haber process, the cyanamide process and byproduct ammonia output—it is essential that the characteristic difference of each be noted as distinguishing it from others. Confusion may be avoided by remembering that the arc process delivers nitric acid or some form of nitrate as the primary stable compound, while the three others produce ammonia in the form of a gas.

The Haber process is often called the synthetic process, but is no more truly synthetic than the arc or the cyanamide method. The arc and Haber operations involve the handling of gases and liquids, while the cyanamide deals principally with solids up to the final stage. In the manufacture of byproduct coke and in gas works as well, ammonia is given off as an incidental gas. It is usually absorbed in sulphuric acid to form ammonium sulphate, and this can also be accomplished with the ammonia from either the cyanamide or the Haber process.

Haber Method

The procedure consists in forming synthetic ammonia by passing a mixture of hydrogen and nitrogen, previously purified, over a suitable catalyst under a pressure of 3,000 lb. per sq.in. (20.7 kg. per sq.cm.) at a temperature of 550 deg. C. The composition of the catalyst compound which is commercially successful is a secret known to Germany alone, although it is thought to be a modified iron composition in spongy form.

About 70,000 cu.ft. of hydrogen and 23,500 cu.ft. of nitrogen (1,960 and 458 cu.m. respectively) rated under normal temperature and pressure is required theoretically for every metric ton of ammonia produced. Depending upon the condition of the catalyst and the purity of the gases only a relatively small amount of the total volume passing through the catalyzer bombs or containers is actually converted into ammonia, and it is therefore necessary to separate the latter from the system by refrigeration, returning the excess uncombined gases for recirculation.

FIG. 1. WATER GAS PLANT FOR PRODUCING THE TWO REQUISITE GASES AT U.S.N.P. NO. 1

Production of Gases

While hydrogen may be secured from any one of several sources, such as the electrolytic cell, with its consequent byproduction of oxygen; the steam-iron processes used in connection with the fat hardening industry; or the Linde water-gas method as first attempted and subsequently abandoned, the most promising source of both hydrogen and nitrogen is the water-gas plant well known in the commercial gas industry. In recent developments of the process additional nitrogen is introduced near the end of the operation, as will be later described.

Blue Water-Gas

An ordinary water-gas plant is installed in which steam is blown into a bed of incandescent coal, where it is dissociated into hydrogen and oxygen, the latter immediately reacting with the carbon to produce carbon monoxide. Some carbon dioxide is also formed, the summation of reactions being as follows:

$$N_2 + 3H_2O + 2C = 3H_2 + CO + CO_2 + N_2$$

The nitrogen enters in the form of air and passes into the gas holders with the other gases. It is readily noted that the right hand side of this equation contains the necessary hydrogen and nitrogen to produe ammonia and that further it will be required to remove the carbon monoxide and dioxide before the proper combination can be effected.

Preparation for Catalysis

The blue water-gas is drawn from the gas holders into large compressors, where it is raised to 200 atmospheres pressure and passed into mains leading to the first preheater. It then enters the CO_2 catalyzers, where all the carbon monoxide is converted to carbon dioxide through combination with the oxygen, which entered with the original air, but is not shown in the equation above. The catalyst employed is probably an activated ferric oxide. Some chromium oxide may be present.

The mixed gases coming from these catalyzers, still under high pressure, are carried on to washing towers, where the carbon dioxide is removed by water. Fifty per cent of the energy required for pumping water into these towers is recovered from the high pressure exhaust water by means of a Pelton wheel. It has recently been proposed that the carbon dioxide in this wash water be employed in making soda ash, or for other manufacturing purposes.

The traces of carbon monoxide still remaining in the hydrogen nitrogen mixture are then removed in a puri-

fier containing ammoniacal cuprous chloride solution of such strength as not to attack the iron container. There are said to be other purifiers in series with this one for the removal of oxygen and perhaps some other impurities which may be harmful to the ammonia catalyst, but definite information is not available for publication at this time.

The completely purified gases, and they must be very pure indeed, finally enter drying towers for the removal of all the moisture. These towers employ calcium chloride as a drying agent in at least one plant. Thence they are conducted to a preheater, where the temperature is raised to 550 deg. C., and subsequently into the ammonia catalyzer. The reaction is shown by the equation

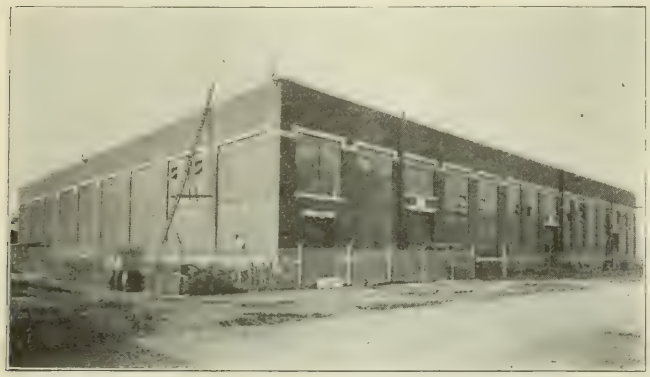


FIG. 2. AMMONIA PROCESS BUILDING, WHERE GASES ARE SYNTHESIZED TO AMMONIA. U.S.N.P. NO. 1

$$3H_2 + N_2 = 2NH_3$$

The ammonia is separated from the uncombined gases in a standard refrigeration system with liquefying arrangement. The residual nitrogen and hydrogen are returned to the system, as previously mentioned. The liquid ammonia is permitted to evaporate and pass into the mains or standard type of gas holders.

Mechanical Design of Apparatus

Because of the high working pressures all apparatus, including catalyzers, preheaters, washing towers, piping and valves, must be of extremely heavy design. The washing towers, for example, are large steel forgings resembling in appearance the huge naval guns. They are made from chrome-vanadium steel and have walls several inches in thickness.

The bombs containing the ammonia catalyst are built for resistance to pressure, lined with a refractory to resist the high temperature and with additional provision against leakage of hydrogen to the atmosphere with consequent explosion. The latter feature is covered in the most recent design by surrounding the container with an atmosphere of pure nitrogen under pressure slightly in excess of that within, so that in case of any leak the inert gas will flow inward and little harm result. The nitrogen is supplied for this purpose from standard Claude or Linde liquid air plants.

Those who have seen the immense installations at Oppau and Merseburg in Germany speak in most complimentary terms of the marvelous mechanical achievements entering into the makeup of these plants. One observer stated it made him feel proud of the human race to view the work even if it had been carried on by an enemy people.

The General Chemical Co. process, also known as the modified Haber or the De Jahn process, after the inventor, is essentially as described in the foregoing paragraphs except the plant is operated under a pressure of 100 atmospheres and a different catalyst is employed in the ammonia plant. The mechanical features are also of a considerably lighter design. The German plants differ in that nitrogen is secured from liquid air apparatus, only hydrogen being used from the water-gas plant.

Existing Plants

There are only three plants using the Haber method in the world today, with a fourth under construction. Only two of these have ever operated successfully. The first is located at Oppau, Germany, with a rated capacity of 400 tons of ammonia per day; the second at Merseburg, rated at 700 tons per day. U. S. Nitrate Plant No. 1, Sheffield, Ala., is designed to produce fifteen tons per day, but has never passed the experimental stage of operation. The Atmospheric Nitrogen Corporation, capitalized for $5,000,000, with a directorate made up of General Chemical Co. and Solvay Process Co. officials, is erecting a plant employing the De Jahn process near Syracuse, N. Y. Ten units are being installed. The total capacity of this plant has not been made public, but it will probably not exceed sixty tons of ammonia per day.

Experimental work was carried forward both in this country and abroad during the war, all on a laboratory scale except the Government plant mentioned above. It is evident that the commercial organizations learned enough through the research at this plant to risk considerable capital in the new venture.

Development in Germany

Although many difficulties were encountered in constructing a commercial catalyst unit capable of withstanding the necessary pressure and temperature, the process was eventually brought to a commercial stage in Germany in 1913. It has been said that the government would never have entered the war without the prospect of explosive output from this process. The production of ammonia from these plants was as follows:

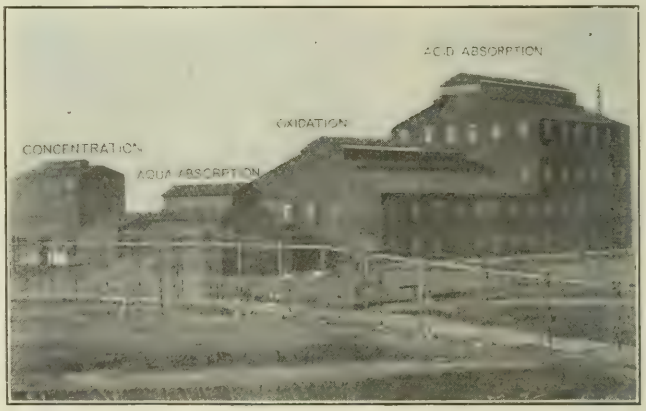


FIG. 3. NITRIC ACID PLANT U.S.N.P. NO. 1. THE AMMONIA MAY BE EITHER ABSORBED IN WATER TO PRODUCE AQUA OR OXIDIZED OVER PLATINUM GAUZES AND SUBSEQUENTLY ABSORBED IN WATER TO PRODUCE NITRIC ACID

	Tons
1913	7,500
1914	15,000
1915	37,500
1916	75,000
1917	125,000
1918	265,000

In terms of ammonium sulphate these quantities are multiplied by a factor of 5.6, giving a production of 1,960,000 tons $(NH_4)_2SO_4$ for 1918.

The Germans have jealously guarded the details of the process and very little real information was brought to this country by our investigators during the war. The samples of catalyst supposedly coming from Germany were never large enough to analyze. Even since the armistice no commercial details have been made available to the Government.

Other Developments

The Nitrogen Products Committee of the British Government has issued a final report which is now a matter of public record. This publication, Cmd. 482, contains a wealth of information relating to the process as investigated by the Ministry for Munitions of War. The committee experienced difficulty in estimating the degree of reliability to be accorded to the evidence on costs that had been obtained, but the results provided assistance in the formation of tentative conclusions.

In view of the claims that the process was capable of producing ammonia and ammonium sulphate at a low cost, and that the power requirements per unit of nitrogen were much smaller than any other process of fixation, information was collected from every available source. The economics of the process are principally governed by (*a*) the cost of the gases, particularly that of hydrogen of the requisite degree of purity, and (*b*) the capital cost of the catalyst or high-pressure section of the plant with the cost of its maintenance.

Because of the doubtful value of the figures and the difficulty of translating them to apply to manufacturing conditions in the United States they are omitted from this article. Modifications recently made in design of plants also alter the manufacturing costs.

Among other recommendations, however, the committee advised that "The synthetic ammonia process should be established forthwith on a commercial unit scale and extended as rapidly as possible, as a post-war measure, up to a minimum manufacturing scale of 10,000 tons of ammonia (equivalent to 40,000 tons of ammonium sulphate) per annum." The United States will not be up to this figure if the plant at Sheffield is operated under the bill now before Congress.

France and Italy have done practically nothing with the Haber process, relying for production on the cyanamide plants.

Construction of U. S. Nitrate Plant No. 1

Official report of the Nitrate Supply Committee and some of the circumstances following its presentation are best described in a document submitted to the Graham House committee by Colonel J. W. Joyes in his testimony, Jan. 3, 1920, as follows:

> With the object of securing an opinion, based upon a comprehensive view of all the facts collected by the several agencies, the Secretary of War appointed the following Committee on Nitrate Supply:
>
> Brigadier General William Crozier, Chief of Ordnance, United States Army, War Department; Rear Admiral Ralph Earle, Chief of Bureau of Ordnance, United States Army, War Department; Brigadier General William M. Black, Chief of Engineers, United States Army, War Department; F. W. Brown, Bureau of Soils, Department of Agriculture; Dr. Leo H. Baekeland, Yonkers, N. Y.; Gano Dunn, 43 Exchange Pl., New York; Dr. Charles H. Herty, 35 East Forty-first St., New York; Dr. William F. Hillebrand, Bureau of Standards, Department of Commerce; Dr. Arthur A. Noyes, Institute of Technology, Boston, Mass.; Dr. Charles L. Parsons, Bureau of Mines, Interior Department; Dr. Willis R. Whitney, Schenectady, N. Y.
>
> This committee gave careful consideration to all the information available, and duly weighed the several purposes stated by the language of the act, recommending the following action:
>
> I. That the Government negotiate with the General Chemical Co. for the right to use its synthetic ammonia processes.
>
> II. That contingent upon satisfactory result of such negotiations, there be set aside from the $20,000,000 appropriated, such sum, estimated as about $5,000,000, as should be necessary to build a plant to produce by that process about 60,000 lb. of ammonia per 24 hr. day; location, southwest Virginia preferably.
>
> III. That out of the same appropriation $600,000, or as much more as needed, be set aside for building a plant for producing by oxidation of ammonia about the equivalent of 24,000 lb. of 100 per cent nitric acid per 24-hr. day.
>
> IV. That the War Department proceed at the earliest practical date with the construction of the oxidation plant and contingent upon satisfactory arrangements with the General Chemical Co. with the construction of the synthetic ammonia plant also.
>
> V. That the Government negotiate with the Nitrogen Products Co. with the view to a contract for the right to use that company's patents and proceed with experimentation looking toward the industrial development of the Bucher process for production of ammonia through cyanide; and that contingent upon satisfactory arrangements as above a sum not over $200,000 be allotted out of the nitrate supply appropriation.

FIG. 4. ONE OF TWO NITRATE HOUSES IN WHICH AMMONIUM NITRATE LIQUOR IS CRYSTALLIZED FOR THE MARKET. THIS LIQUOR HAS BEEN PREVIOUSLY MADE AT THE NITRIC ACID PLANT BY BUBBLING AMMONIA GAS THROUGH NITRIC ACID SOLUTION. U.S.N.P. NO. 1

> VI. That out of the $20,000,000 nitrate supply appropriation $100,000 be allotted to active investigation of processes for the industrial production of nitrogen compounds, useful in the manufacture of explosives or fertilizers—this under supervision of the War Department.
>
> VII. That in order to increase the production of ammonia and toluol the Government promote the installation of byproduct coke ovens by directing priority in production and transportation of materials and parts.
>
> VIII. That the decision as to more extensive installation of nitrogen fixation processes and water-power development in connection with them be postponed until the plants above recommended are in operation or until further need arises.
>
> IX. That while the preceding recommendations include all the measures that can now judiciously be taken for the fixation of ammonia, it is the opinion of the committee that the immediate accumulation and the permanent maintenance of an ample reserve not less than 500,000 tons of Chilean saltpeter is the measure most urgently necessary.
>
> The foregoing report having met with general approval, the Secretary of War has directed the Chief of Ordnance of the Army to proceed to carry out the first six of the recommendations of the Nitrate Supply Committee and has announced that for the present the consideration of development of large water-power installations which had been begun by the interdepartmental

board (Secretaries Baker, Lane, and Houston), appointed by the President, would be suspended.

The outstanding feature of this program for action is the construction of the synthetic ammonia plant, using the General Chemical Co.'s process, which was largely developed by their engineer, Frederick de Jahn. As has been indicated, this process has already had trial upon a sufficient scale to demonstrate the practicability and to indicate as most probable its ability to produce ammonia at a very favorable price. In fact, in the search of the Nitrate Supply Committee for the best, cheapest, and most available means for the production of nitrates and other products that would be of use in the manufacture of munitions and in the manufacture of fertilizers this process appeared to give more promise of affording relief from dependence upon foreign nitrates for the defense of the country and more promise of a reduction in the cost of the nitrogenous constituent of fertilizer than others. Furthermore, this process is one which can be put into operation in a much less time than would be required to develop such a large water power as would be needed for other prominent processes available.

Value of Haber Process

The Bureau of Mines reported to the Ordnance Department, U. S. Army, on Jan. 27, 1917, the following observations in regard to the Haber method:

> The technical control of the Haber process is of such great importance and requires so high a degree of training and skill that it is reported if the Badische people were to lose their present technical staff of experts, familiar with the process, many months would be required to train another staff capable of applying the process in practice.
>
> The Haber process is not at present in use outside of Germany on account of the lack of detailed information regarding plant construction and operation, and also owing to the very large royalty demanded by the Badische Co. for its use by other concerns. It is, however, more than probable that the Badische Co. will itself install and develop the process outside of Germany when the war is ended.
>
> Trustworthy information regarding the costs of production of ammonia by the Haber process indicates that pure anhydrous ammonia can be produced in liquid condition for a cost slightly less than 4c. per lb. It is improbable that any arrangement could be made for the United States Government to use the Haber process pending the conclusion of the European war. It is probable that when the war is ended the Haber process will be installed or will be available for installation in the United States. It is the cheapest process for the production of synthetic ammonia. It is independent of cheap power, the power being a small fraction of its cost. If desirable, it could be readily installed in moderate-sized units in connection with ammonia oxidizing plants at any munitions plant.

Advantages

1. Cheap ammonia.
2. Ammonia in water-free liquid condition ready for oxidation without purification.
3. Availability of raw material (air and coal).
4. Possibility of erecting comparatively small plants wherever needed.
5. Easy availability of product for transportation and for fertilizer.

Disadvantages

1. Inability to procure technical details, use of method, and trained technical force without the assistance of the Badische Co., except as the result of many months and probably years of experimentation. This is largely owing to the difficult engineering problems involved in the use of pressure as high as 150 atmospheres and temperatures of 500 to 600 deg. C.
2. High repair and renewal costs.
3. Undoubtedly high royalty that would be demanded if the Government were to install and operate this process itself. Inability to come to terms with the Badische Co. as to the use of its patents is reported to have been the sole reason for the non-adoption of this method by two large American corporations and one Norwegian corporation.
4. Patents and processes controlled in America by one corporation.

It is presumed that the Bureau of Mines report was prepared by Dr. Parsons. His prediction as outlined with regard to post-war installation in the United States is being fulfilled in the erection of the new plant at Syracuse, N. Y.

Estimated Cost of Plant No. 1

The sum of $3,000,000 estimated by the Nitrate Committee as being necessary for the erection of the process plant at Sheffield, Ala., was not in any sense a construction estimate, but based on figures submitted by the General Chemical Co. They were made by employing the best information available in the United States at the time.

Arrangements were made for the Government to take over the orders which the General Chemical Co. had placed in the market for apparatus to be used in a private plant the company had previously planned. Thus both time and money were saved.

Actual Total Cost

The final value of the property known as U.S.N.P. No. 1 is recorded as $12,689,677, including overhead charges, such as design, administration, freight, insurance, distribution system, roads, walks, etc. The ammonia plant cost about $5,592,000, the acid plant about $2,184,000, the ammonium nitrate plant $386,000, the power plant $1,552,000, land and plant accessory buildings about $1,406,000 and the permanent village for housing employees about $1,852,000.

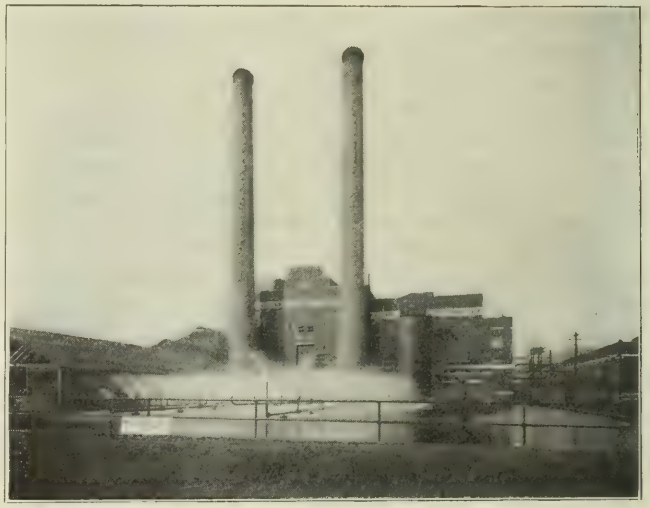


FIG. 5. POWER HOUSE AND COOLING POND. U.S.N.P. NO. 1

The process is practically erected complete, the exception being two units in the ammonia plant, which will await slight changes in design. The work has been discontinued for nearly a year, with only a small force for guard duty and maintenance work located on the property at the present time.

Operation Troubles

In describing the difficulties encountered during the operation period Colonel Joyes said:

> The process depends upon the chemical reactions, which are very delicate. . . . Conditions have to be just about right, and to stimulate it so that the proper portion of the gases are synthesized a catalyst is used, and a catalyst in general is very subject to being poisoned and rendered inoperative by any foreign

FIG. 6. MACHINE SHOP, U.S.N.P. NO. 1, EQUIPPED TO HANDLE REPAIRS ON HEAVY AMMONIA PLANT APPARATUS

substance that may be in the gases. The General Chemical Co. had a catalyst they developed and that had given very good results in the laboratory tests. They had made the active material on a small scale, without much trouble, but when they commenced to produce it in quantities for use as a catalyst at this Government plant considerable difficulty was encountered.

Furthermore when the catalyst was put in the vessel at the plant and operation started, it was found to be very sensitive indeed toward all unfavorable conditions such as a slight amount of moisture or impurities in the gases.

We had trouble also with the apparatus. Some of the valves failed to hold the gases at high pressure. Some of the vessels exploded, especially one heater where the gases had to be brought up to an elevated temperature. Presumably the pipes in the heater were attacked by the gases, and we had a pretty bad explosion; we had a fire from it and so on. . . . The metal is eaten away, and we have samples of tubes which were exposed under those conditions and completely eaten away in a very short time.

The longest period of continuous operation of the ammonia plant was seventy-two hours. The total amount of ammonia produced, including all experimental runs, did not exceed thirty-four tons. The total amount of ammonium nitrate manufactured, including that produced from ammonia liquor shipped from coke plants, did not exceed eighty-five tons.

Future Prospect for Operation of Plant No. 1.

The successful operation of the Haber process at the Government plant is entirely dependent upon the action of Congress on the bills now pending for appropriations to carry on the necessary research work, both at the American University laboratories and at the plant in Sheffield, Ala. Funds are now available for continuation of the laboratory work until June, 1921. This research is very essential in order to determine the best catalytic material for the synthesis of ammonia, and the laboratory organization is now very actively engaged with extensive equipment, as will be described in a later article. The plant must be operated in conjunction with the research to perfect the process for commercial operation.

Henry Wigglesworth of the General Chemical Co. estimates that with the expenditure of less than a quarter of a million dollars for making changes and tuning up, Plant No. 1 can be made to work satisfactorily in producing ammonia. Whether this estimate is low or not makes little difference because the Ordnance will have sufficient funds for vigorous prosecution of the work if the bills providing for the establishing of a Government nitrogen corporation are passed in Congress, according to estimates of George Roberts.

Conclusion

Aside from the opinions of the scientific investigators who have become enthusiastic over the possibilities of the Haber method, it is still considered by the more conservative technical men to be the coming process for nitrogen fixation, because of the lower cost of manufacture combined with the purity of product. This does not mean that the other methods of fixation are obsolete, but rather that if the industry is to be developed to keep pace with other nations we must look for the research in this process to be carried on by the Government.

The cyanamide process is the only practical and commercial method established in the United States today for the direct fixation of atmospheric nitrogen, and this fact should not be clouded by any plans as to the future. It is even possible that it may never be entirely displaced by another method. This may become more evident as new derivatives are discovered in making cyanogen compounds from cyanamide.

The Government officials will doubtless adopt a well-balanced policy with consideration for both present production and future development.

Sources of Information

Final report of Nitrogen Products Committee, British Government.

Testimony before the Graham House committee, U. S. Congress.

Interviews with U. S. scientists and operators.

New National Hydraulic Laboratory Proposed in Buenos Aires

According to Trade Commissioner Brady the Argentine National University at La Plata has petitioned for a hydraulic laboratory to be used in experimental work by the engineering students. Already the Minister of Public Works has reported favorably on the project and has asked that a piece of land 975 ft. x 1,625 ft., in the Buenos Aires port between the East Canal and the Port Railway, be allotted for the construction of the laboratory. Final approval of the project will rest with the Argentine Congress at its next session in May. Efforts of American manufacturers in the past to introduce laboratory apparatus and machinery into the colleges of Argentina have not equaled those of their European competitors. Now an opportunity is offered them through the construction of this national hydraulic laboratory to place their equipment before prospective Argentine engineers.

Unique British Advertising Plan

The Federation of British Industries has devised a unique scheme for advertising home manufactures in all parts of the world. A new steamship, to be called the Federation, is to be constructed by some of the leading firms of the country as an exhibit of British marine engineering. The cargo of the ship will consist of various articles of British manufacture. Representatives of the firms interested will make the voyage for the purpose of showing their goods and interviewing foreign buyers.

Legal Notes

By Wellington Gustin

Conveyance of Property Subject to Mortgage

A victory was recently won by the Virginia Zinc & Chemical Corporation, Ltd., and others, in the suit instituted against them in the Virginia courts by C. B. Van Nostrand & Co. and others, when the Supreme Court of Appeals of Virginia affirmed the decree rendered in the lower court fixing liens and priorities as to claims against the forty acres of land upon which is located a manufacturing plant, situated near Bristol, Va., the property of John T. Williams, and postponing the judgment liens of plaintiffs to those of defendants and decreeing a sale of the property to discharge the liens.

It appears that John T. Williams executed a deed of trust in 1912 to the Windsor Trust Co., conveying the above property to secure seventy-five $1,000 notes, bearing 6 per cent interest, payable semi-annually, for the purpose of negotiation to realize money to discharge his liabilities. At this time there was a prior mortgage on the property to secure a note for $8,500. Both of these deeds were duly admitted to record. On Dec. 31, 1913, by agreement the parties changed the date of the seventy-five notes to Oct. 1, 1913, payable one year after date. This agreement was recorded Jan. 31, 1918.

To relieve his pressing indebtedness, John T. Williams, acting through his son John T. Williams, Jr., induced Mrs. Nellie B. Crouch of St. Louis, Mo., mother-in-law of the son, to purchase his note for $33,000, secured by the seventy-five $1,000 notes, for which she paid $30,000 in cash. Through her husband, Mrs. Crouch became the owner of the note of $8,500. From the cash obtained Williams paid off the $8,500 note, the balance being applied to payment of his other liens and debts. In 1914 Mrs. Crouch purchased an additional note for $5,500 and another for $500, and in 1915 she paid delinquent taxes and insurance premiums on the property for Williams, aggregating $1,417.42, for which he made his note. The total notes of Williams thus held by Mrs. Crouch amounted to $40,417.42, all secured by the same issue of notes as collateral security.

In 1914 John T. Williams and wife executed a deed transferring and conveying the forty acres of land and manufacturing plants to the Virginia Zinc & Chemical Corporation, subject expressly to the deed of trust securing the seventy-five $1,000 notes.

Sale of Property and Contentions of Plaintiffs

The notes given to Mrs. Crouch contained a provision empowering the holder to confess judgment for the maker for the amount due thereon "and to sell or cause to be sold any or all of said collaterals, or any substitutes therefor, or additions thereto, at public sale upon such notes, at such place, and on such terms as the holder of said notes," etc., may deem proper, applying the proceeds to the discharge of the liability due the holder. The holder under any such sale was permitted to become the purchaser without any right of redemption. After default on the notes they were sold at St. Louis, after due notice and publication, and Mrs. Crouch became the purchaser at the price of $10,000. Deducting the expense of the sale, the balance was entered as a credit on the demands due her of $33,000.

John T. Williams, Jr., as trustee of the real property, advertised it for sale under the deed of trust. C. B. Van Nostrand & Co., Packard & Co. and others having judgments against the Virginia Zinc & Chemical Corporation, recovered in the Circuit Court, asked for an injunction preventing the sale as advertised by Williams, Jr., and for an accounting of the property, the liens thereon with their priorities and the sale of the property to satisfy these liens. The court ordered an accounting and fixed the liens and priorities, postponing the judgment liens of plaintiffs to the trust deeds and liens of Mrs. Crouch and the Virginia Zinc & Chemical Corporation. From this decree the plaintiffs appealed, contending (1) that the deed conveying the property in question to the Virginia Zinc & Chemical Corporation vested the title thereto in the chemical company, which could not be affected by the subsequent recording, in 1918, of the agreement of Dec. 31, 1913; and (2) that this agreement of Dec. 31, 1918, as well as the deed of trust covering the seventy-five notes, was fraudulent as to the judgment creditors of Virginia Zinc & Chemical Corporation, and should be declared null and void.

Court Answers Plaintiffs' Contentions

Answering the first contention, the Supreme Court of Appeals said there was no proof that the rights of the plaintiffs were affected by the failure to record until Jan. 31, 1918, the agreement dated Dec. 31, 1913, changing the date of the notes secured by the mortgage. It was not necessary to record this paper at all. The change of date in no way affected the debt secured. The mortgage remains a lien until the debt it was given to secure is satisfied, and is not affected by a change in the note. And, again, it was claimed that as there was no debt at the date of the execution of the seventy-five $1,000 notes, the deed of trust therefor was invalid. But the court said this claim was without merit, for in the business world nothing is more common than the execution of such securities in contemplation of a loan. As soon as a note is negotiated, the liability to take care of it arises, and the holder's right to the security attaches.

On the second contention, that the instruments were fraudulent as to judgment creditors of the corporation, these were subsequent creditors, and, having contracted their debts and recovered their judgments against the purchaser of property conveyed subject to a mortgage of record, their judgments were recovered with constructive notice of the nature and extent of their debtor's interest in the mortgaged property. Hence they cannot complain of the mortgage as being fraudulent as to them.

London Metal Prices for Twenty Years

An interesting and instructive chart has been compiled by Vivian, Younger & Bond, of London, showing the prices on the first day of each month during the past twenty years (1900 to 1919, inclusive) of spelter, standard copper, tin, soft lead without silver, standard silver, and Scotch and Cleveland iron. The chart also shows the British bank rate prevailing at various dates during the same period, and the highest and lowest prices in each year of the metals enumerated—in which very considerable fluctuations are recorded.

Scientific Control of the Filter Station—II

A Discussion on the Rate of Flow of Filtrate—Critical Pressure—Graphical Analysis of Rate and Amounts of Flow—Influence of Temperature and Density Changes—Use of Filter-Aids in Filtering Colloidal Materials*

BY ARTHUR WRIGHT, M. E.

THE maximum capacity of filtrate outflow from a filter is the goal of every ambitious operator, and some ingenious efforts have resulted in failures due to an incomplete comprehension of the underlying principles.

The attack most often pursued is to increase the filtering pressure. This is logical, for the filter medium and the cake can be considered multiple orifices, so that the law applies that the flow through an orifice is proportional to the pressure. That an increase of the pressure thus increases the quantity of filtrate is not universally true. It is practical with almost theoretical accuracy when handling solids of a crystalline or granular texture. It is true to a certain extent with every material, but with some only through a small range of pressure. Those with the smallest limits are flocculent precipitates with which a few feet increased head of gravity feed is all that will increase the flow before a contrary result is obtained.

Increased pressure is identical with increased suction when operating vacuum filters. There have been misconceptions on the difference of pressure and vacuum filtration. Much discussion has arisen over the merit of "pushing" the liquid through the filter as is the case with pressure type machines, and "drawing" it through with vacuum filters. The action here is not analogous to that of the familiar law of mechanics where a cane can be drawn along a pavement easier than it can be pushed along. The action in pressure and suction filters is identical, for the filtering force in either case is the difference of pressure on the two sides of the medium, in the one case it being the pressure due to a pump or head greater than atmospheric pressure; in the other that of the atmosphere compared to a pressure lower than atmospheric. In consequence laws pertaining to pressure filtration apply also to vacuum filters, although the range of difference in pressure is limited to 14.7 lb. per sq.in. as the theoretical maximum with the latter.

CRITICAL PRESSURE

The reason that, in practice, the law of increased pressure does not always increase the flow is found in the fact that for every material there is a pressure above which an increased flow is not obtained, but a decreased flow is had instead. This is known, in filtration parlance, as the critical pressure for that material. Confusion sometimes occurs on this point, for an operator will, after filtering at a given pressure, jump his pressure up and point to the larger stream discharging from the filtrate outlet. Unfortunately for him the flow does not last long. It is occasioned by the fact that the increased force compacts the cakes on the leaves and forces the entrained liquid out through the filter cloth. After this momentary rush, however, the rate is lower. It is difficult to estimate the critical pressure for the various materials handled in industrial filtration or even for any one material, for local conditions surrounding the precipitation of the solids or handling can widely affect its filtering characteristics. It is not, however, difficult to ascertain the critical pressure in any plant if experimental runs be made with periodic readings of the flow filtrate taken and all the other factors as affect the rate of flow maintained constant. With these readings it is simple arithmetic to figure the rate of flow per unit area for the successive periods at which the readings were taken. A graph then can be plotted, the abscissæ being the time of filtration and the ordinates the rate of flow. It is interesting to find how completely experimental observation is corroborated by such a plot.

GRAPHICAL ANALYSIS OF RATES OF FLOW

Representative curves are shown in Fig. 1. *AB* is that of a liquor containing crystalline solids or materials of similar texture which are free filtering products. This is practically a straight line slowly breaking into a hyperbola, and the interpretation is that the rate of flow falls off at equal increments, each increase in thickness of cake causing a corresponding increase in the resistance to the flow. The statement that "it is a straight line" is approximate and true only when applied to the usual working limits. The line eventually bends and resolves itself into a hyperbola, slowly approaching but never reaching zero. This curve represents that of the easiest filtered materials.

The curve *CD* is typical of the vast majority of difficult materials handled. The initial flow is high, with a rapid fall until a low rate is obtained, decrease in which is small. The goal of every filter experimenter is to change the form of this graph and make it approach *AB*. *EF* will represent the fruit of such efforts and in lay language means that by a modification of the material as precipitated or by modifying the method of handling the material it is changed to a more easily filtered liquor.

To some, such a discussion may seem too academic and when incorporated as the results of a test a graph is often somewhat superfluous, but to the experimenter working out the problem it is of inestimable value. It is a big factor in maintaining a broad point of view and prevents premature satisfaction when better results are to be obtained by means of further research.

There is a considerable amount of additional information to be had from a study of these curves, such as a point of flexure indicating the economical length of cycle, computation of capacity by planimeter methods, etc., but such data are better obtained by other methods, as will be elaborated upon. The principal help from

*For Part I, see Chem. & Met. Eng., vol. 22, No. 23, 1920, p. 1111.

these graphs is in noting their general curvature or shape and comparing the curves obtained from modified operation with that of a previous run. In this respect they serve a most useful purpose, for with all factors kept constant, save a modified pressure, these graphs are indelible proof of the existence of a critical pressure and the most definite means of obtaining it.

Influence of Temperature and Density Changes

What is true of pressure being an important factor in the rate of flow is equally true of the temperature of the slurry and density of the liquid at which it is filtered. Here we have to deal not with a critical temperature or density of filtration, for with most materials practical economy dictates this before the limit which filtering efficiency requires is reached. The hotter the

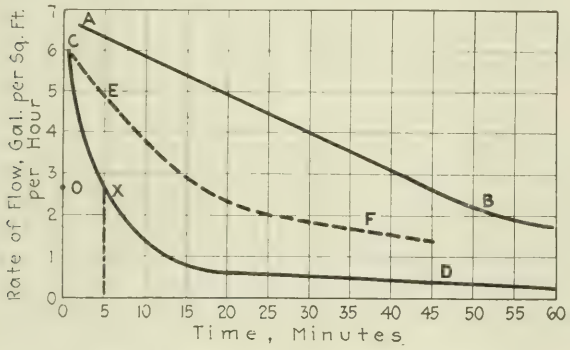


FIG. 1. RATE OF FLOW CURVES

liquid is the thinner it becomes and the better will be the rate of flow. For the proper determination of the right temperature and density the costs of heating, evaporating, and maintaining the heat must be had so as to balance the increased work of the filters. It is, however, too often unappreciated that there is a very rapid rise in the viscosity with increased density and decreased temperature as shown in Figs. 2 and 3. In Fig. 2 it is quite apparent that below *Y* a few degrees difference does not greatly affect the viscosity, but around *X* 2 or 3 degrees difference in tempearture marks a distinct difference. Such information is of course not due to filter development, but is of value to the operator and teaches him the need of a nice control of temperature and density.

The Economical Filtering Period

In practically all phases of filtration discussion the rate of flow is synonymous with cake building. It is apparent that if a dry, hard cake is desired from a plate and frame filter press the frames should be designed so that the cakes on the two sides of each frame shall join together before the rate of flow has fallen off too greatly. If the time required to build the frame solidly full is too prolonged, the cycle is bound to be uneconomical.

A further study of the curve *CD* shows us that if it were possible to work this material only for the time represented by *OX* we would be working at the economical part of its filtration. Such a scheme means, however, short filtering periods and is feasible only in those types of filters wherein automatic discharge and continuous operation are had. Here we find the fundamental principle of continuous vacuum filtration and while possibly in a sense this is not ways and means of bettering the rate of flow, it is basic in that maximum capacity is had not by a modification of the filtering characteristics of the material being handled but by a mechanical device to meet the conditions of the material "as is." This has its importance when materials are not subject to temperature or density variation and it is required only that the deposit of the solids shall have a sensible thickness and be efficiently discharged. It is true that most applications of continuous vacuum filters are on materials of a free-filtering character, but the basic idea is as explained nevertheless.

The total flow curve is often used and from it capacity is read directly. Its curvature is not as sharp as in the rate of flow curve and is consequently not quite as informative as the latter. The curve is the simple plot of time of filtering as abscissa and total flow at time of reading as ordinate as shown in Fig. 4. Too long a filtering period is cumulative in its evil effects. Washing is slower, cake hardness less and the chance of a clean cleavage of the cake from the filter cloth jeopardized. This fault of an uneconomical cycle due to the width of the frames in plate and frame presses being too large is entirely too prevalent throughout industrial filtration and is due to inadequate determination of the filtering characteristics of the material being handled.

One advantage in leaf type filters is that it is not necessary to continue the filtration until a hard cake is obtained. This means then that the filtration can be discontinued at any time without jeopardizing the dryness of the cake. It is in these filters that the operator is afforded the most opportunity to effect best results as regards maximum capacity. The point to be kept in mind is that the rate of flow is constantly decreasing and when working at the low point of the curve the outflow

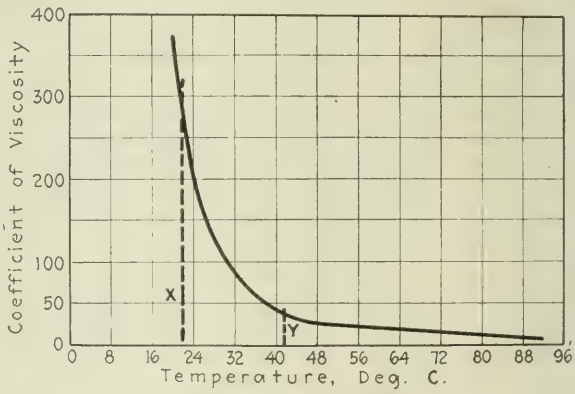


FIG. 2. TEMPERATURE VISCOSITY RELATION

is not commensurate with the time required. There will be discussed in a later paper a mathematical means of determining the economical length of cycle which gives consideration to the washing, drying and discharging periods, but it is well to have in mind the general character of the rate of flow curve.

Homogeneity of Cake Important

Oftentimes liquors have to be handled in which the solids of suspension are a mixture of coarse and fine particles. For maximum rate of flow agitation must be maintained in the filter so that the deposit both at top and bottom of filter medium is made up of the mixture of coarse, free-filtering solids and the fine, more difficult-filtering material. If classification takes place so that the lower part is coated with the coarse material

and the upper part with the fine, then tapering cakes are sure to be formed and all the evils of discharging, warped leaves, etc., will ensue. This leads to a point for further consideration, for if the liquor in the filter classifies and filtration is started, no amount of agitation from that time on is of any practical value. The solids that build up the cake are carried to their positions by their respective stream lines. When a cake becomes highly resistant to filtration so that the flow is cut down, the stream lines of the liquid are weak and can carry particles only that are easily moved. This is the case when the upper part of the leaves become coated with the finer particles of suspension. No amount of uprising current which will carry the coarse particles upward can aid the deposition of the heavier particles at the top of the leaves. The stream lines are at right angles to the filter surface and strong stream lines are necessary if the velocity is to be sufficient to deposit the coarse particles on the cake surface. The above, therefore, emphasizes the fact that the initial deposit on the filter medium is vital if the best rate of flow is to be obtained. There is a corollary to the last statement; that the initial pressure should not be excessive. The reasoning on this is that too high an initial pressure compacts the first deposit so as to make it too resistant and lowers the capacity. Fortunately, low initial pressure is common practice, for if the pump is not too large the initial outflow of filtrate will approximate the throw of the pump and the pressure will rise slowly. It is only when an excessively large pump feeds the filter that the rise in pressure is rapid and this trouble is encountered.

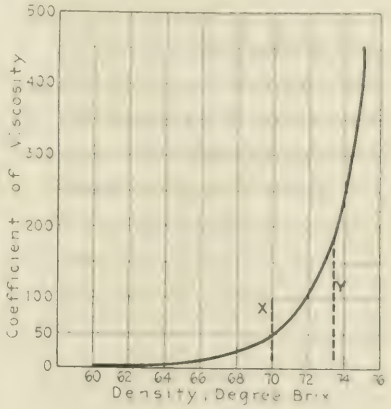


FIG. 3. DENSITY VISCOSITY RELATION

The initial resistance of the filtering fabric, drainage member, etc., should be as low as possible. This fact is apparent but has been over-emphasized in some designs of filters in which excessive drainage has been provided. It must be remembered that the filtrate issues through the fabric in drops, the accumulation of which produces the filtrate flow. The drainage does not have to be very great to meet this requirement, however. In the matter of choice of filter medium, more attention is required. The demand is for one of low resistance to the passage of the liquid through it and if mechanical wear calls for a heavy cloth, then one of open weave is required. If too dense a cloth is used, the velocity of the initial stream lines causes the finer particles of suspension to be forced into the weave of the cloth and to imbed themselves so as to cut off the porosity. With coarser weaves of filter cloth these fine particles pass through the interstices and issue from the filter as cloudy filtrate which must be refiltered. This is far better than having the filter cloth clogged so that it decreases the flow and cannot be effectively cleaned on discharging.

It is quite evident that the filter cloth must be retained in a free-filtering condition if recurring runs are to show the same capacity as the first run. It is idle to point out that thorough discharge of the cakes from the cloth is required for maintaining high rate of flow, but it is a point that experimenters are often too quick to assume when dealing with a new material. Inspection of the surface of the cloth is not an infallible means of determining that the cloth is clean. The rate of flow on succeeding runs is the only safe way.

Steadily Increasing Pressure Desirable

It is becoming better recognized that a constant or steadily increasing pressure is the most desirable for obtaining the best rate of flow. Fluctuations in pressure produce an effect similar to that of tamping wet ground. The cakes are made denser and more resistant by this action. The interval in which the pressure falls is one of inefficient working, for the resistance produced by the high pressure is too great for the lower pressure rapidly to force the liquid through. This point is one of the favorable factors in the use of montejus and pneumatic eggs, gravity feed and vacuum receivers, etc. Centrifugal pumps with rotors easily accessible and with sufficient clearance to allow the pumping of coarse and gritty materials are admirable in that the pressure is in reverse proportion to the amount of filtrate flowing. This type of pump is not best when handling flocculated material, for as soon as the outflow is less than the throw of the pump the rotor has a churning action and breaks up the flocculent precipitate. Every chemist knows how much harder it is to filter such precipitates after agitating and stirring them so as to break up the agglomerated particles than when handling the material with the flocculent condition preserved. By reason of the points above outlined positive discharge rotary pumps are gaining an increased use and have characteristics well suited to filter press work.

Colloidal material or solids so fine as to approximate colloidal conditions are most difficult to handle with any degree of satisfaction or economy. They are difficult to clarify unless an auxiliary filter medium be employed and form so compact a deposit as to be almost impenetrable. Fortunately, in the majority of cases these solids are waste products and can be coagulated or will allow of the introduction of a filter-aid. The usual method of coagulation is by the production of a flocculent precipitate by chemical reactions. Enough attention to this point seems to be lacking, for too often the goal seems to be to add enough reagents to be able to note a sparkling liquor between the separate flocculent particles. It does not seem to be appreciated that an excess precipitate adds to the solids of suspension which are of themselves difficult to filter in pressure filters.

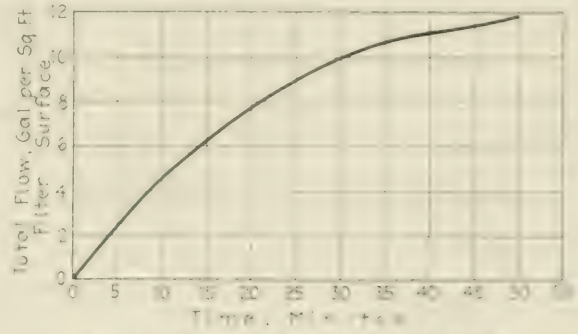


FIG. 4. TYPE CURVE OF TOTAL FLOW

It must not be inferred that the agglomeration of the

particles of suspension does not aid in pressure filtration, although this theory is sometimes advanced. There is no question that flocculation is the best means of obtaining this agglomeration of the colloidal material, but the demand is satisfied when the quantity of reagents produces no excess precipitate. This, of course, has not the same importance when only decantation methods of clarification are employed.

Use of Filter-Aids in Filtering Colloidal Materials

There is a new theory for the clarification of contrary liquors that is demanding more attention and deservedly so. If there is added to the liquor before its filtration a quantity of inert free-filtering material, it is obvious that the deposit on the filter cloth is a mixture of the free-filtering solids and the contrary precipitates. The former build up so as to preserve the porosity to a greater extent than do the latter and consequently admit of a greater flow of filtrate. The material so added is known as a filter-aid and must conform to the three specifications of being (1) inert to the liquor, (2) of a free-filtering character, and (3) of such a specific gravity that it can be handled in the filters without settling or floating.

The filter-aid is added with the idea of decreasing the resistance of the solids deposited and making the liquor free-filtering, similar to that which carries crystalline or granular solids of suspension. It has been demonstrated that only a small percentage is necessary to effect marked results, but true filtering efficiency dictates the use of quantities in excess of that generally added. It is worthy of note that when good capacity flow is obtained from a filter, a corresponding increase in the volume of the cake is obtained. The greater the bulk of the cake, the better its discharge and the filter-aid therefore simultaneously affects not only the rate of flow but the equally important factor, efficient discharge.

It would seem that the combination of the flocculating idea and the filter-aid principle ought to have possibilities. It has. The idea, however, must not be to add the filter-aid as an aid to the filtration of a liquor the solids of which have been agglomerated, for to do so only partly solves the problem. In plant practice but few instances will be found where a flocculent precipitate will not be broken up by the time the liquor enters the filters. The answer is to use the filter-aid to strengthen the structure of the flocculent precipitate by adding it to one of the defecants before its addition to the liquor. This will often require diluting the defecant, and if the water required for this is objectionable on the score of increased evaporation, no objection can be found to substituting clarified effluent for the water.

To thicken the liquor by decantation methods so as to concentrate the solids makes for increased duty of the filter. This is universally true as regards its capacity in cake discharged, although there are instances where the rate of flow is also increased. The latter as explained in that classification is minimized and the granular particles deposit along with the fine so to preserve the porosity to a greater extent. Continuous filters often are applicable on liquors that have been thickened where they are impractical prior to decantation, and there are numerous instances where this has proved the economical means of handling this material.

(Part III, dealing with Washing and Drying, will be published in a subsequent issue.)

Maple-Products Industry of Quebec Province

Official reports show that the maple-products industry in the Province of Quebec has grown markedly during recent years, its development being mainly attributed to the scarcity and increased price of beet and cane sugar. While sugar maples are found chiefly in the central and western sections of the province, the industry has to some extent developed also in the Gaspe Peninsula, the counties of Bonaventure and Gaspe showing in 1919 an output of 59,135 lb. of sugar and 3,101 gal. of sirup, as compared with an output in 1911 of 11,870 lb. of sugar and 512 gal. of sirup. No figures as to quantities are available for the county of Matane, but the products in the three counties of 1919 were valued at $20,665.

The output in the province as a whole in 1919 amounted to 12,353,667 lb. of sugar and 1,470,275 gal. of sirup, of an estimated value of $6,396,535, as compared with the 1911 output of 9,989,443 lb. of sugar and 1,005,330 gal. of sirup, of an estimated value of $1,680,393. Maple sugar ten years ago sold for 7c. to 8c. a lb. and in 1918 at an average price of 15c. a lb. The latter part of 1919 25c. to 30c. a lb. for sugar and from $2 to $2.50 a gal. for sirup were offered. The United States affords the best market for the product.

Private and Government Aid to Industry

An organization known as the Co-operative Society of Pure Maple Sugar and Sirup Makers, organized some years ago, has secured as members thousands of farmers interested in this industry. Its objects are to distribute information among its members as to the best methods for obtaining the highest quality of products and to prevent their adulteration. Through the efforts of this association a Federal act was passed prohibiting adulteration of maple sugar and sirup, and it was also responsible for the establishment of sugar-making schools, and for exhibitions and competitions in Canadian maple products.

The development of the industry has been further stimulated by the provincial Department of Agriculture through demonstrations in sugar making in various parts of the province given by skilled instructors.

The province has three sugar-making schools located at La Minerve, Beauceville and Ste. Louise. These schools provide a fifteen days' course, the Department of Agriculture paying the board of the students. Last season at these three schools 12,000 maple trees were tapped and 808 gal. of sirup, 3,775 lb. of sugar, and 100 lb. of taffy were manufactured. Thirty-three pupils followed the course, and there was an attendance of 786 visitors. The approximate period of the course, depending upon the season and location of the school, is from March 20 to the latter part of April.

Dominion Grant Toward Cost of Instruction

The 1919-20 allotment to Quebec Province from the Dominion Government, under the agricultural instruction act of Canada, for educational purposes in connection with the maple industry was $4,000.

As the farmers depend to a considerable extent upon the lumbering industry for employment in the winter, which employment terminates about the end of March, and as farm work usually does not commence until the middle of May, the maple-products industry fits in nicely with their other work.

Reinforced Lead

By Charles Baskerville and C. M. Wales

LEAD suspended in large sheets or pipes creeps or sags, so that it must be held in position. Frequent supports without (as with sulphuric acid chambers, lead ducts for sulphur gases, tank cars, etc.), lead-coated iron braces within (as in linseed oil refining kettles), or supporting retaining walls of masonry within (as with pulp digesters, petroleum refining tanks, etc.) are necessary to hold the lead in place. Vacuum pans and connections of lead must be of extra thickness ($\frac{3}{4}$ to 1 in.), hence of great weight, to prevent collapsing.

Iron and steel pipe with lead lining is extensively used, the lead protecting the iron or steel, the latter also preventing bulging of the lead when the necessary pressure is applied within to move the liquids thus transported. Lead has been flowed or burned on other metal, but each method fails in one way or another, primarily in the cost of installation.

Many of these troubles in the use of lead have been entirely overcome and others materially diminished by reinforcing lead with iron or steel wire gauze or perforated sheets, which are imbedded within the lead (U. S. pat. 1,280,908 and 1,280,909).

Fig. 1 is a perspective view of an article partially broken away. This figure shows a portion of a lead sheet which is reinforced by a ferrous gauze.

Fig. 2 is a cross-sectional view taken as on the broken line 2—2 of Fig. 1.

Fig. 3 is a perspective view of an article partially broken away. This figure shows a portion of a lead sheet which is reinforced by a perforated ferrous plate.

The elastic limit has been increased four to five fold and the tensile strength has been increased two to three fold. The variations observed were due to differences in gage of wire and mesh of gauze used. Both may be materially increased by increasing (within limits) the gage and looseness of weaving the gauze. When manufactured, the surface of the lead or lead-alloy may be somewhat rough and unnecessarily thick. Both are easily remedied by rolling, as in making sheet lead. Lateral extension of 20 per cent and elongation of 30 per cent have been obtained, the main care being against tearing the reinforcing wire gauze. Sheets 4 ft. 6 in. x 5 ft. 6 in. have been made. For obvious reasons smoothing the surface is advisable only when the reinforcing member is perforated sheet iron or steel.

FIG. 4. BENT PIECE OF REINFORCED LEAD SHEET

The reinforced sheets may be bent or shaped almost at will, as the lead does not fracture when bent (see Fig. 4). The sheets may be cut and joints are easily burned together in the same manner as ordinary sheet lead is burned (see Fig. 5).

The lead may be easily melted from an edge of a sheet and the piece shaped into pipe, the overlapping edge being then burned in position. A pipe, 8 in. in diameter, made up of reinforced lead 0.2 in. thick, collapsed at 85 lb. per sq.in. pressure.

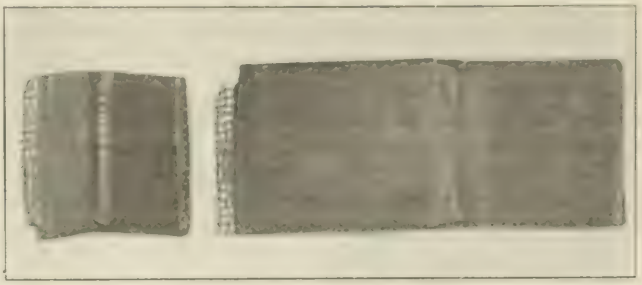
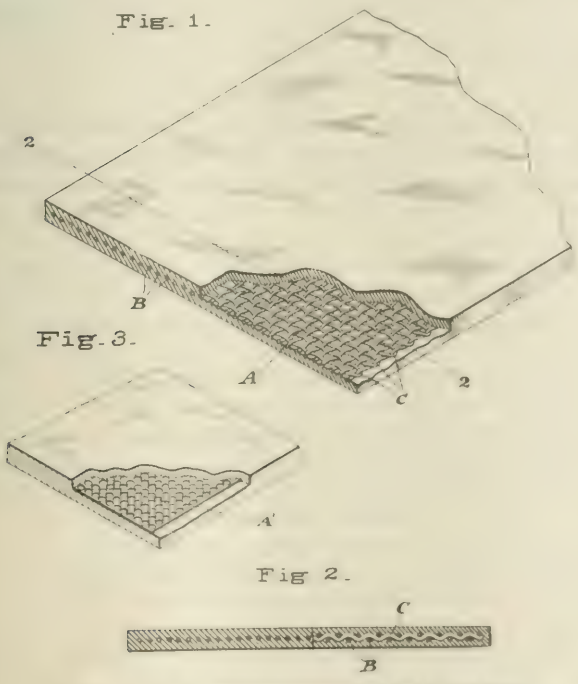


FIG. 5. JOINT PIECES OF REINFORCED LEAD SHEET

The experimental work on this material was carried out by V. A. Belcher.

College of the City of New York



FIGS. 1 TO 3. REINFORCED LEAD SHEET

Fig. 1. Perspective view of a lead sheet reinforced by a ferrous gauze

Fig. 2. Cross-sectional view 2—2 of Fig. 1.

Fig. 3. Perspective view of a lead sheet reinforced by a perforated ferrous plate

American Cotton Seed and Cottonseed Products

The cotton seed received at American mills during the nine-month period Aug. 1, 1919, to April 30, 1920, amounted to 3,963,472 tons, as compared with 4,218,135 tons in the corresponding period of 1919, according to a preliminary report of the Bureau of the Census. This does not include 23,725 tons and 40,438 tons on hand Aug. 1, nor 163,546 tons and 124,743 tons reshipped or destroyed for 1920 and 1919, respectively.

The amount of seed crushed during the nine-month period was 3,883,368 tons in 1920 and 4,084,719 tons in 1919. There was 103,829 tons on hand at the mills on April 30, 1920, as against 173,866 tons on April 30, 1919.

Imports of cottonseed products amounted to 18,285,430 tons during the nine months ended April 30, 1919. figures for the corresponding period of 1920 are not available.

Exports during this period totaled 125,826,786 lb. of oil, 210,641 tons of cake and meal, and 40,436 running bales of linters in 1920, against 129,847,205 lb. of oil, 119,054 tons of cake and meal, and 66,046 running bales of linters in 1919.

Electrochemical Notes From Scandinavia

New Soda Factory in Norway

Recently the Norwegian Hydro-Electric Saltpetre Co., which works the arc process at Notodden and Rjukan, has started a factory to make soda with which to combine the nitrous gases that pass over from the nitric acid absorption towers.

The plant has cost several million kroner and it starts with a production of 27 long tons per day. By it the company will be independent of outside sources of basic material and will be able to secure still further its position in the supply of pure sodium nitrate and sodium nitrite.

It is not generally known that for some years sodium nitrate has been made by the arc process in Norway and sold in England and elsewhere in competition with Chilean nitrate. The Norwegian product is readily absorbed by the market because of its exceptional purity.

Sodium Nitrite for Dye Industry

Sodium nitrite made by the electric arc process in Norway is again coming into the United States in quantity, a firm in New York City having contracted for at least 6,000 tons per annum for several years. The Norwegian Hydro-Electric Saltpetre Co. is easily able to control this trade because the sodium nitrite is of the nature of byproduct, inasmuch as it is made by the gases which are not absorbed to form nitric acid.

The Badische Anilin und Soda Fabrik established a factory at Christiansund about nine years ago for the special purpose of supplying its German dye-making plants with sodium nitrite.

The only factory making nitrites from arc in the United States is the Nitrogen Products Co. of Seattle; its output is in the form of sodium nitrite and most of it goes to dye works in Japan. Needless to say, the plant at Seattle is an arc plant.

Dr. Samuel Eyde

It will be of interest to engineers and electrochemists all over the world to learn that one of the new Ambassadors to Poland is the well-known Norwegian engineer, Dr. Samuel Eyde, whose persistence and large vision has done much to build up the great air nitrate plants at Notodden and Rjukan. Both Poland and Russia require immense quantities of nitrogenous fertilizers and it is not unlikely that this appointment may lead to very intimate trade relations with Norway, especially in these chemical products.

Carbide and Cyanamide Plants in Norway

A new cyanamide plant built in Norway during the war in which the Union Carbide Co. and McKlouman are interested has been closed down. It will probably not be restarted because the power—about 70,000 hp.—is being contracted out to various surrounding municipalities.

The position of carbide and cyanamide plants still running is chaotic and many are partly closed down so as to reduce their operating losses.

There seems to be no doubt that the synthetic methods of producing ammonia and the increasing production of byproduct ammonia will supplant the cyanamide method of making ammonia, a situation which would have occurred some time ago but for the war bringing about abnormal conditions, and preventing information coming from Germany as to the Haber process.

Swedish Cyanamide Co.

Recently there has been a considerable fall in market value of the shares of the Swedish Cyanamide Co. This is probably traceable to an invention of Dr. Cederberg of Stockholm University which has been purchased by the Norwegian Hydro-Electric Saltpeter Co. The invention has to do with the manufacture of ammonia and the Norwegian Hydro-Electric Saltpeter Co. is now working out the process in its experimental laboratories.

Before the war the Norwegian concern depended on England for ammonia with which to make ammonium nitrate and when the war made transport difficult it obtained ammonia from cyanamide made at Odda. It still uses some of this, but byproduct ammonia liquor is again going over from England in considerable quantity.

It is probable that the Norwegian company will some day make its own supply of ammonia.

Wages in Norway

In these days when so many people are wasting their time bewailing the tendency toward higher wages it will come as a surprise to find that some laborers in Norway are probably paid higher wages on the average than those in any other country in the world.

It is only comparatively a short time ago that boatloads of workers were leaving Norway to find homes and better paid occupations in the United States and Canada, and many cities have sprung up which are almost entirely populated by Scandinavian people.

The tendency now, however, is for Norwegians to remain in their own country because it is going ahead at such a very rapid rate and money has accumulated until now Norwegian financiers are prepared to back with ready cash practically any scheme that the electric engineers of that country place before them.

Use of Granulite in the British Glass Industry

The American Chamber of Commerce in London reports that an important discovery of granulite has been made, on the northern borders of Dartmoor, near Okehampton.

Granulite contains not only silica, but potash and soda—all of which are necessary in glass making—and gives the best results in the production of glassware of the highest quality. It is said that glass bottles and jars will be made cheaper here than anywhere in the world, as the cost of the material used on the spot will be only 15s. a ton, in comparison with the price of £2 a ton of the cheapest material ordinarily used. The material is reported as being specially suitable for the manufacture of cast and pressed glass articles and window glass. It is also of value in the manufacture of enameled metal ware and electrical insulators of various shapes. Even the waste heaps can be turned to account, for the black stone which was formerly considered suitable only for road material can now be used for making beer bottles (luckily, "Pussyfoot" has not yet been successful in England).

It is reported that English glass manufacturers will be in a position to compete on favorable terms in the neutral markets of the world.

Synopsis of Recent Chemical & Metallurgical Literature

Dehydrogenation of Primary and Secondary Alcohols by Catalytic Oxidation.—A general method of preparing aldehydes and ketones is given by CHARLES MOUREU and GEORGES MIGNONAC in *Comptes Rendus*, vol. 170, No. 5, pp. 258-261. During their work to transform secondary butyl alcohol into methylethylketone they have worked on the dehydrogenation by catalytic oxidation using first copper and then silver.

They have found that silver acts as an excellent catalyzer and that it can be used indefinitely, and they have generalized its use for the dehydrogenation of different alcohols. The catalyzer is prepared by precipitating the silver in a very finely divided state from the nitrate solution by formaldehyde on asbestos. The operation is as follows:

The catalyzer is placed in a tube and brought to a temperature of 230 to 300 deg. C. A thermocouple is introduced in the mass of the catalyzer to regulate the temperature within the required limits. In the mixture of air and alcohol vapors passing through the catalyzer the proportion of air is somewhat less than that theoretically required. Oxidation takes place immediately. The operation being exothermic, the temperature has to be controlled, because at higher temperatures the products formed are decomposed. To avoid this decomposition and to render the operation more regular they proceed by fractional oxidation with the use of two catalytic masses in series. A mixture of alcohol vapor and air in quantity notably inferior to the calculated quantity needed (40 to 50 per cent only) is passed over the first catalyzer mass; the products resulting are passed over the second catalyzer mass, where they meet the required supplement of air, and the final product is obtained. The operations are thus very regular, and the temperatures easily kept within the most efficient limits. In some cases there may be a series of more than two catalyzing masses.

They have treated nine alcohols and obtained the corresponding aldehydes and ketones with an efficiency of 60 to 96 per cent.

Treatment of Methyl Alcohol: Used two catalyzing masses, temperature maintained at 360-400 deg. C. Efficiency in formaldehyde 62 per cent. Carbon monoxide, hydrogen and carbon dioxide are present in the escaping gases.

Treatment of Ethyl Alcohol: Used two catalyzing masses, temperature maintained at 340-380 deg. C. Efficiency in acetaldehyde 89 per cent without any appreciable formation of acetic acid. In the escaping gases there are present 3 to 5 per cent carbon monoxide and 0.5 to 1 per cent carbon dioxide.

Treatment of Normal Butyl Alcohol: Used two catalyzing masses; temperature maintained at 330-350 deg. C. Efficiency in butanol 93 per cent.

Treatment of Amyl Alcohol: Used two catalyzing masses; temperature maintained at 330-350 deg. C. Efficiency in the corresponding aldehyde 94 per cent.

Treatment of Allyl Alcohol: Used one catalyzing mass, the quantity of air used being only two-thirds of that theoretically required. Efficiency in acrolein 70 to 75 per cent.

Treatment of Benzyl Alcohol: Used one catalyzing mass and a quantity of air less than that theoretically required so as to avoid an excessive increase in temperature of the catalyzer. When working at 300 deg. C. the proportion of the corresponding aldehyde obtained depends on the quantity of air used. During one passage about 40 per cent of the alcohol is transformed into aldehyde with an efficiency of 80 per cent of the transformed alcohol.

Treatment of Cinnamic Alcohol: Treated in the same manner as for benzyl alcohol. Efficiency in the corresponding aldehyde 60 to 70 per cent.

Treatment of Isopropyl Alcohol: Used one catalyzing mass. Efficiency in ketone 90 per cent.

Treatment of Secondary Butyl Alcohol: When using one catalyzing mass the efficiency in ketone is between 90 and 95 per cent. Better results are obtained by fractional catalyzing, when the operation is easier to handle, the production per given apparatus is increased and the efficiency is 2 to 3 per cent better. With a temperature of 350-400 deg. C. of the catalyzing masses, and with a quantity of air 10 per cent less than that theoretically required, the efficiency in ketone is 94 to 96 per cent; the escaping gases are composed of quite pure nitrogen containing only very small quantities of carbon monoxide and carbon dioxide.

Commercial Liquefaction of Gases.—At the April 16 meeting of the Syracuse Section of the American Chemical Society, CHARLES O. BROWN, of the Semet-Solvay Co., presented a paper on "Commercial Liquefaction of Gases." An abstract of this appeared in the April, 1920, issue of the *Syracuse Chemist*, which is the official bulletin of the Syracuse Section.

A short sketch was given of the historical development of the liquefaction of gases. The evolution of the research experiments into commercial apparatus was briefly described and the change from the early cycles used to those on which present theory is based was described in a general way.

In the production of nitrogen or oxygen, air is used as the source of these gases. After removing carbon dioxide by scrubbing, the air is compressed to 500 lb. per sq.in. by some systems, while others use only 350 lb. per sq.in.

Oil and caustic spray are removed from the compressed gas by mechanically baffling the gas after compression and cooling. The compressed gas is then liquefied and the liquid gas boiled, the vapor being separated by rectification in much the same way in which alcohol is produced. In some systems the rectifying column is under full pressure of the compressed gases, while in other systems it is under only a slight pressure, the gas having been expanded to produce the desired refrigeration. This expansion may be carried out by using a needle valve or by making the gas do work while expanding in some form of engine. This second cycle is more efficient for liquefaction than the first described. One system in use in this country uses both expansion accompanied by work for the larger proportion of gas and expansion without accomplishing work to a smaller extent. It was pointed out that by designing a suitable turbine the entire quantity of gas would be expanded in various stages of the turbine, accomplishing useful work and effecting a saving in costs as run at present.

Some costs were given for producing nitrogen, varying under different conditions between 8c. and 18c. per 1,000 cu.ft.

Monel as a Material for Internal Combustion Engine Valves.—To secure a valve material capable of giving satisfactory service under high temperature conditions has been one of the greatest problems in the development of the present-day aviation engine. In a recent paper presented to the English Institution of Automobile Engineers, the merits of different steels for this service are very fully discussed. There is, however, no mention of monel, a material which recent tests at the Bureau of Standards indicate to be deserving of serious consideration in this regard.

Exhaust valves of this material have given satisfactory performance in a 180-hp. Hispano-Suiza engine during 130 hours of running time, when tested by the Engine Section, Bureau of Standards. During the first 90 hours, the engine was devoted to tests made primarily for the study of lubricating oils and was operated for periods of about 6 hours each, during which time it was developing between 130 and 140 b.hp. at 1,800 r.p.m.

Examination of these valves at the end of 45 hours operation showed them to be badly pitted. They were ground just enough to reveal the condition of the valve seats, and these, too, were found badly pitted, although no considerable drop in power had been noted. During the next 45 hours, the horsepower was substantially the same as during the first 45, although a slight increase appeared during the first run following the replacement of the valves.

They were then subjected to 40 hours service under conditions far more severe than those encountered under normal conditions of operation. The engine was being used in a study of pre-ignition and for this purpose was operated at 1,800 r.p.m., full load, for periods of from 4 to 20 minutes. During the greater share of these runs pre-ignition was intentionally produced, resulting in extremely high engine temperatures. An evidence of these high temperatures was furnished in one instance by the fusing of the nichrome electrode of a specially prepared spark plug, the electrode's melting point being 1,500 deg. C. In spite of the severity of these tests, there was no evidence of power drop from leaky valves.

At the end of 130 hours of running time, valves and valve seats appeared to be no worse than at the end of the first 45 hours. The pitted appearance which seems to be a characteristic of this material has little effect on the gas tightness of the valve.

Analysis of Industrial Chlorbenzenes — Chlorbenzenes are of industrial importance not only in the manufacture of melinite, but also in the preparation of dyes. It is therefore necessary to have a practical method for their exact analysis. Raw chlorbenzene consists of a complex mixture in which predominate benzene, monochlorbenzene and paradichlorbenzene, whose boiling points are respectively 80, 130 and 172 deg. C. at normal pressure. F. BOURION has studied the problem of the analysis of the raw chlorbenzene and recommends the determination of its contents in benzene, monochlorbenzene and polychlorated benzenes (*Comptes Rendus*, April 19, 1920, pp. 933-935). He makes three fractional distillations.

The temperature limits for these three fractions are: the first between 80 and 130 deg. C., the second between 130 and 131.5 deg. C., and the third between 131.5 and 172 deg. C.

The residue of the distillation consists manifestly of polychlorated benzenes. The rectified second fraction is the pure chlorbenzene.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Recovery of Potassium Salts From Brines Containing Borax.—In recovering potassium from the types of brines found in Searles Lake or Owens Lake in California, the sodium borate in the solution has offered especial difficulties in the way of separation, owing to the fact that the relative solubilities of the two salts in hot and cold solutions is substantially the same. PARKER C. MCILHINEY of Great Neck, N. Y., effects a separation of potassium from associated salts by converting the chloride into the chlorate. This can be separated in a relatively pure state. In applying the process to water from Owens Lake it is best to remove the sulphate and carbonate of sodium and the major portion of sodium chloride. This is done by evaporation, with subsequent treatment with carbon dioxide, which converts the carbonate into the relatively insoluble bicarbonate, further evaporation causing a separation of practically all the sodium salts with the exception of a small amount of the chloride. The solution, containing potassium chloride and borax, is evaporated to a concentration at 90 to 100 deg. C., which corresponds to a saturated cold solution of potassium chloride. To the hot solution is added chlorate of sodium, calcium or magnesium in proper proportion, either in hot solution or solid form. Upon cooling the solution gradually, crystals of potassium chlorate will be deposited.

It is possible to produce a soluble chlorate within the solution by treating the solution, after removal of the sulphate of sodium, with chlorine. This reacts with the sodium carbonate forming sodium chlorate which in turn reacts to form potassium chlorate. (1,338,234; April 27, 1920.)

Purification of Zinc Solutions.—In order to obtain a successful deposition of zinc by electrolysis of a zinc sulphate solution impurities such as copper, cadmium, arsenic, antimony, iron, cobalt and nickel must be substantially eliminated. Satisfactory methods for the removal of all of the above-mentioned impurities have been developed with the exception of nickel and cobalt, the usual procedure being to agitate the solution with zinc dust at atmospheric temperature with air, or to treat in tube mills with zinc balls. This treatment does not remove nickel and cobalt completely.

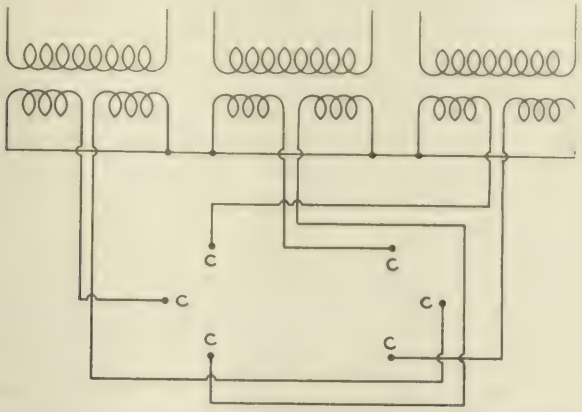
According to the present invention cobalt is removed by agitating the solution with lead peroxide or manganese dioxide. The cobalt is precipitated as the peroxide according to the equation:

$$2CoSO_4 + PbO_2 + H_2O = Co_2O_3 + H_2SO_4 + PbSO_4, \text{ or}$$

$$2CoSO_4 + MnO_2 + H_2O = Co_2O_3 + H_2SO_4 + MnSO_4$$

The solution is heated to between 80 and 100 deg. C., one part of reagent to 200 parts solution being used. Nickel can be removed by agitating with finely divided zinc at an elevated temperature. (1,336,386; H. LIVINGSTONE SULMAN and SAMUEL FIELD of London, England; assigned to Metals Extraction Corporation, Ltd.; April 6, 1920.)

Electric Blast Furnace.—In the operation of electric blast furnaces using three-phase current and producing heat by the ohmic resistance between electrodes entering the charge, one difficulty experienced in practice is that although the tension between any pair of diametrically opposite electrodes is constant, the tension between any other pair varies so that the current will also vary and cause corresponding variations in the heating zones of the furnace. This irregular heating produces deleterious effects on portions of the lining and roof. Also in case of accident



TRANSFORMERS AND CONNECTIONS FOR ELECTRIC BLAST FURNACE

to one electrode or its connections the particular phase between said electrode and the other electrode associated therewith will disappear.

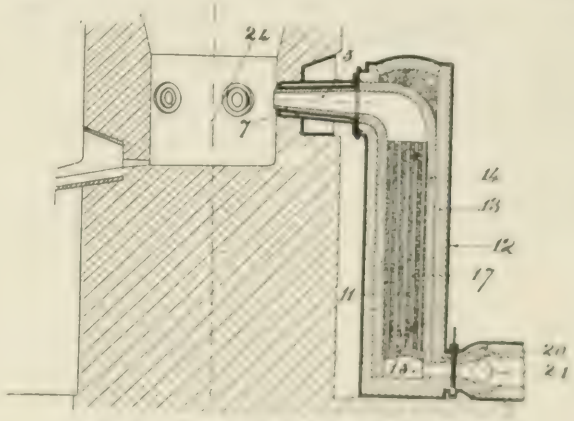
To overcome these disadvantages and also to produce uniform heating effect, JAMES BIBBY and JENS O. BOVING of London, England, utilize transformers and connections as shown in the accompanying sketch.

Three single-phase or a single three-phase transformer is employed and the neutral points of the three secondaries are connected together. Six electrodes *C* are employed, opposite pairs being connected to the same secondary winding. By connecting the windings in this way the several phases are anchored together, so that instead of three single independent phases there are virtually produced six phases of fixed and definite relationship. Consequently under normal conditions the heating is regular throughout the heating zones and the efficiency and life of the furnace are considerably enhanced. The disconnection of one electrode will not be as serious as when but three electrodes are employed. (1,336,017; assigned to Electro-Metals, Ltd.; April 6, 1920.)

Electric-Resistance Alloy.—The addition of approximately 10 per cent of titanium to an alloy consisting of 83 per cent nickel and 17 per cent chromium will produce an alloy having a specific resistance about fifty times that of copper. This alloy is durable and malleable and has a high melting point. Its specific resistance is higher than a nickel chromium alloy. (1,337,276; WILLIAM A. SCHENCH; assigned to Western Electric Co.; April 20, 1920.)

Electrically-Heated Melting Furnace.—Economy in metal and in furnace linings has resulted from the rotating of non-ferrous electric arc furnaces; the results obtained have become particularly apparent when melting brass or other alloys containing volatile constituents. A usual design of arc furnace is where the body of the furnace is in the form of a cylinder rotated in a horizontal axis by means of trunnions. L. C. HARVEY of Malden, England, has developed a furnace in the form of a flask rotated on an inclined axis. The removable electrode with the electrode holder is held stationary. Instead of using an electric arc the heat may be supplied by a heating element composed of resistance material. It is feasible to melt a metal having a high melting point by means of the arc and to continue the operation when alloying metals have been added by the resistance element, both types of electrodes being interchangeable. (1,337,839; April 20, 1920.)

Electric Resistance Furnace.—Cyclic utilization of gas, heated by means of an electric resistance furnace, to bring about endothermic reactions such as take place in blast furnaces or in furnaces for calcining carbonates is the subject of a patent issued to JULES SIMON and PAUL FRANCOIS SARRON of Lyons, France. The crucible, tuyeres and electric-resistance furnace are shown in the sketch. The tuyeres, 5, have a refractory lining, 7, of cast quartz or carborundum to withstand a temperature of 1,800 deg. C. This lining is inserted in a water-cooled jacket, 6. The furnace for heating the gas is formed of an outer metal shell, 12, a refractory lining, 13, and a refractory lining, 14, which is a poor conductor of electricity. Within this lining and resting on the arch, 15, is a resistance element, 11, formed from a highly refractory material and graphite and capable of being strongly heated by an electric current. In this resistance element are channels, 17, through which gas can be forced under pressure, thence through the tuyere into crucible 24 of the blast furnace. The working of the furnace is similar to that of an ordinary blast furnace, but the amount of carbon introduced with the charge is only that necessary to reduce oxides and a part of the carbonic acid, since the heat required is furnished by a cyclic gas, the latter coming from recuperators through conduit 21. On passing through the furnace charge the gas is diluted with the gaseous products



ELECTRIC RESISTANCE FURNACE

of the reactions and is passed through purifying apparatus, an amount of gas constituting the cyclic gas being sucked through heat regenerators and thence forced through the electric furnace.

The principal advantages obtained by this electric furnace are: Reduction of the amount of coke used, smaller consumption of electric energy, absence of nitrogen in cyclic gas, omission of electrodes, independence of the blast furnace proper from the electric furnace, making it possible to convert an ordinary blast furnace by the substitution of special tuyeres and the addition of the electric superheater. (1,334,809; March 23, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Dr. Frederick G. Cottrell Receives the Willard Gibbs Medal

The Chicago Section of the American Chemical Society held its annual banquet and presentation of the Willard Gibbs medal at the City Club, Friday evening, May 21. Dr. L. V. Redman, acting as chairman, in a short address introduced Dr. W. R. Whitney, who made the presentation.

Dr. Whitney did not attempt to recite the list of well-known achievements of Dr. Cottrell, nor call attention to his processes and products, but spoke rather of the high human quality of the recipient. He said that Dr. Cottrell was a pioneer who believed in opening unbeaten trails and keeping the coefficient of success to a high standard. The chemist can well appreciate the qualities of a man who believes in ideals. Dr. Cottrell has started many things which will well outgrow his own anticipation. His appointment as chief of the Bureau of Mines is gratifying to the men of the industry. In his new position we can forgive his mistakes if he keeps to his great ideals.

Dr. Cottrell Responds

"I have been deeply affected by Dr. Whitney's talk," replied Dr. Cottrell. "We have been colleagues many years. Knowing of no fresh piece of chemistry which I could bring as a message to this meeting, and being called upon somewhat hurriedly for a subject, I wired to Chairman Redman that I would speak on 'International Scientific Relations,' which would be broad enough to cover anything I might want to say. I want to express deep appreciation of the receipt of this beautiful medal, set in a wreath of cordial friendship and hearty welcomes as it is.

"The American chemist has a big field outside of his technical work. He is getting well into the activities of correlated subjects. The fact that he has scrambled over the border line and shown a human interest in parallel subjects is a good sign for his future.

"The experience of the war has served to illustrate the importance of the scientist in international affairs. The details of the Chemical Warfare Service are too well known to require mention here. War has furnished a great stimulus to the chemical industry, but this is only a prelude to the international character of the chemist's activities. The world has been awakened to a consciousness of the necessity for international contact. We have previously been isolated, but with 4,000,000 young men who have been thrown in contact with other peoples abroad at an impressionable age a world sense of international problems has been acquired which will form a deeper and more international life in the coming generation.

"The part the chemist plays in international relations is most important in both pure and applied chemistry. The work on international atomic weights is an illustration of the pure side and that of the International Congress of the applied side. The social side is further covered in personal courtesies like those between the New York Chemists' Club and the London and Paris Chemists' clubs. We will eventually have a chain of chemists' clubs in the international capitals of the world, which is a very inspiring thought.

"We must be sympathetic with the different views across the water, and when the American differs from them we must not arbitrarily try to reorganize European ideas. They are getting together in Europe to emulate our example of co-operation within the United States. The new industrial societies, as well as the academic chemists in Europe, are responding. There are many things to be overcome in France, such as the aloofness with which the older men view the younger in the industry.

"A central international patent office is being considered where patents after inspection may be filed in the various countries to operate under the laws of each. This will not interfere with primary patents in the country where they originated and will facilitate establishment abroad.

"The scientist can do much to help standardization throughout the world. There are many features affecting this. It is not so hard to adapt the metric system to the chemical and mining industries, where it is already used, but the civil and mechanical engineers are up against a different problem. These things should not be forced too much by legislation, but rather developed by education. Legislation should ever be confirmatory, as has been shown in the case of the last amendment to the Constitution.

"Another field for the chemist to consider is the question of raw materials. Petroleum is one of the well-known examples of this."

In conclusion Dr. Cottrell said: "Let the younger chemists have not only the technical problems to consider, but also that of public opinion, and the habit of such consideration should be acquired."

Industrial Research at Denver

The Denver Civic and Commercial Association has established an industrial research department in charge of Homer B. Vanderblue, former associate professor of transportation, school of commerce, Northwestern University, Chicago. The first activities of this research department will consist of a general survey of the situation with respect to surrounding territory, raw materials, transportation conditions and other industrial aspects. Investigations will also be undertaken along specific lines of industry, such as the manufacture of brass goods, metals and woolen goods.

Laboratory for Low Temperature Work Established

A cryogenic laboratory is to be established at once in Washington in connection with the helium work being done by the Bureau of Mines. The necessary funds for equipping the laboratory and conducting the work are being allotted to the Bureau of Mines from appropriations made to the Army and Navy Departments. The work in this new laboratory will be directed by R. B. Moore, the chief chemist of the Bureau of Mines.

The Federated American Engineering Societies

What appeared to be a most momentous gathering in engineering annals occurred in Washington June 3 and 4, at which time accredited representatives of nearly seventy national, local, state and regional engineering and allied technical organizations met to organize a permanent federation for welfare work by and for the engineer. It is impossible to recount at length the historical setting, and perhaps unnecessary. At least, it was noted editorially in CHEMICAL & METALLURGICAL ENGINEERING for May 26 that past events lent color to the belief that considerable opposition might be expected to the proposed plan to organize a federation of societies rather than an association of individuals.

Upon convening, however, it appeared essential to determine this debatable and fundamental question first of all. Consequently a very sharp debate occupied several hours' session over the following resolution:

> Resolved, That it is the sense of this conference that an organization be created to further the public welfare where technical knowledge and engineering experience are involved and to consider and act upon matters of common concern to the engineering and allied technical professions, and
>
> Resolved, That it is the sense of the conference that the proper organization should be an organization of societies and affiliations and not of individuals.

Naturally, the prime opposition came from the very able representatives of the American Association of Engineers, the foremost champion of the individualistic idea. As it appeared more and more certain, however, that the convention as a whole was determined to accept the resolution, on final roll call the A.A.E. representatives, leading alphabetically, voted aye. Of the fifty-seven societies represented in this session, five answered "present," and all the rest voted aye, 119 individual unanimous ballots being cast.

Then followed a continuous session of more than twelve hours, where the details of organization were worked out in committee on constitution and bylaws. This committee reported on the morning of the second day, and not until 3 o'clock in the afternoon was the constitution adopted, essentially as reported. Many divisions were taken, however, some determined by a narrow majority of two votes. On final roll call, of the sixty-seven societies represented, ten were absent, eight answered "present," and forty-nine voted to adopt, eighty-eight unanimous individual votes being cast. In answering "present," William J. H. Strong, of the American Association of Engineers, reviewed that body's criticisms of the constitution, but assured the meeting that whether their organization eventually joined the new federation or not they at all times stood ready to co-operate in all ways possible.

The constitution having thus been adopted, the bylaws were adopted as read, subject to editorial and legal revision of phraseology. Important sections of these documents follow:

CONSTITUTION

ART. I. NAME

The name of this organization shall be the Federated American Engineering Societies.

ART. II. OBJECT

The object of this organization is to further the interests of the public through the use of technical knowledge and engineering experience, and to consider and act upon matters common to the engineering and allied technical professions.

ART. III. MEMBERSHIP

Sec. 1. The membership shall consist of national, local, state and regional engineering and allied technical organizations and affiliations, classified as follows:

(1) National engineering and allied technical organizations.

(2) Local, state or regional engineering or allied technical organizations other than local associations, sections, branches or chapters of national organizations.

(3) Affiliations consisting of any one, or a combination of the following constituents.

(*a*) Local sections or associations of members of national organizations included under (1).

(*b*) Local engineering or allied technical societies or clubs, not of national scope.

(*c*) Local engineers and members of allied technical professions and their associates.

ART. IV. MANAGEMENT

American Engineering Council

Sec. 1. The management of this organization shall be vested in a body to be known as the "American Engineering Council," and its Executive Board.

Sec. 2. *Functions.* The American Engineering Council shall consist of representatives of member-societies selected as hereinafter provided. This Council shall co-ordinate the activities of state councils and of local affiliations whenever these activities are of national or general importance or may affect the general interests of engineers.

Sec. 3. *Representation.* Each national, local, state or regional organization or affiliation shall be entitled to one representative on the Council for a membership of 100 to 1,000 inclusive, and one additional representative for every additional 1,000 members or major fraction thereof; provided that in the determination of the representation of local, state or regional organizations or affiliations no count shall be taken of any organization which is represented individually or through another local, state or regional organization or affiliation; and provided further that no organization shall have more than twenty representatives on the Council.

Executive Board

Sec. 7. *Functions.* There shall be an Executive Board of thirty members of the Council charged with conducting the business of the organization under the direction of the Council.

Sec. 8. *Membership.* The Executive Board shall consist of thirty members, of whom six shall be the officers elected by the Council and twenty-four shall be selected, a part by the national societies, and the remainder by the local, state or regional organizations or affiliations according to districts, as provided in the bylaws; provided that the number of representatives of the national societies shall bear as near as may be the same ratio to the number of representatives of local, state or regional organizations or affiliations as the representation of the national societies bears to the representation of the local, state or regional organizations or affiliations.

ART. VI. FUNDS

Sec. 1. Funds for the use of the organization shall be contributed as follows:

(*a*) Each national society represented on the American Engineering Council shall contribute annually $1.50 per member.

(*b*) Each local, state or regional organization or affiliation represented on the Council shall contribute annually $1 per member.

No portion of such funds shall be applied to the use of local affiliations or state councils.

ART. VII. LOCAL AFFILIATIONS

Sec. 1. *Object.* The American Engineering Council shall encourage the formation of local affiliations to consider matters of local public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that these may be united action and that suggestions and advice may be offered to the Council.

ART. VIII. STATE COUNCILS

Sec. 1. *Object.* State councils, consisting of representatives of local affiliations within the state or otherwise representative of the personnel of engineers and

members of allied technical professions in the state, if members of this organization, shall consider state matters of public welfare with which the engineering and allied technical professions are concerned, as well as other matters of common interest to these professions, in order that there may be united action in state affairs.

ART. IX. DELIMITATION OF AUTHORITY

Local affiliations, state councils and the American Engineering Council shall deal with local, state and national matters respectively, and they shall be autonomous with respect thereto.

ART. X. PUBLICITY

This organization shall stand for the principle of publicity and open meetings under such regulations as may be provided for in the bylaws.

BYLAWS

CHAP. I. MEMBERSHIP.

Sec. 1. *Qualifications.* Any society or organization of the engineering or allied technical professions is eligible for membership, the chief object of which is the advancement of the knowledge and practice of engineering or the application of allied sciences, and which is not organized for commercial purposes.

CHAP. II. MANAGEMENT

Sec. 1. *Terms of Representatives.* Representatives on the American Engineering Council shall serve for two years; provided that after the first election, where there is more than one representative from one organization, approximately half shall be elected each year.

Sec. 3. *Votes of Representatives.* Representatives on the Council and on the Executive Board shall each have one vote on these bodies.

Sec. 6. *Duties of Officers.* The Executive Officer shall be appointed and his compensation fixed annually by the Executive Board and shall hold office during its pleasure. He shall be the Secretary of the Council and of its Executive Board. He shall manage the business of the Council under the direction of the Executive Board, and perform such duties as may be assigned to him by the Council or the Executive Board. He shall be the custodian of the property of the Council. He shall collect all moneys due the Council and transfer them to the custody of the Treasurer. He shall scrutinize all expenditures and use his best endeavors to secure economy in the administration of the business of the Council. He shall certify to the accuracy of all bills or vouchers on which money is to be paid. He shall give a bond at the expense of the Council in amount and with surety satisfactory to the Board. He shall pay the current expenses of the office and for this purpose shall have at his disposal a suitable sum of money to be fixed by the Board, which amount shall be periodically replenished under the authority of the Finance Committee upon the representation of an amount of disbursements in the form required by it. He shall mail to the member-societies bills for their annual contributions thirty days prior to the beginning of the fiscal year. He shall perform such other duties as may from time to time be assigned to him by the Council or the Executive Board.

Sec. 8. *Duties of Executive Board.* It shall hold regular monthly meetings except during July and August.

The Executive Board, unless otherwise provided, shall appoint all special committees of the Council and of the Executive Board. The membership of such committees may be drawn from the membership of the Council or of the member-societies.

The Executive Board shall, whenever practicable, provide for the whole or a part of the expenses of representatives attending meetings of the Council and of the Executive Board.

Sec. 9. *Appointment of Committees.* Committees shall be appointed from the membership of the Board annually by the incoming president with the approval of the Executive Board, each member to serve one year, or until his successor is appointed.

Sec. 10. *Duties of Committees:*

The Committee on Publicity and Publication shall, when so requested, prepare all public statements and shall have the direction of publications of the Council.

The Committee on Membership and Representation shall report to the Executive Board on eligibility of each applicant for membership and the number of representatives to which it would be entitled. It shall review and report at least ninety days before each regular meeting of the Council the number of representatives to which each member-society is entitled. It shall review the existing electoral districts and report thereon to the Executive Board, at least once every two years. It shall report on all questions regarding registration and credentials of representatives on the Council.

The Finance Committee shall report an annual budget to the Executive Chairman and he or some other member of the committee shall countersign all checks for the payment of money.

The Committee on Public Affairs shall report to the Executive Board on all public affairs with which the engineer is concerned or which affect the relation of the engineer to the public.

CHAP. IV. PUBLICITY

Sec. 1. The privilege of attendance of all meetings of the American Engineering Council, of the Executive Board and committees, when not in executive session, shall be extended to any proper person, but this privilege does not extend the right to speak or vote. Any proper person shall have the right to inspect and make true copies of the records of all meetings of the Council, Executive Board and committees.

Fixed Nitrogen Corporation Bill Holds Position on Senate Calendar

In order that the bill creating the United States Fixed Nitrogen Corporation might enjoy the prestige of a position on the calendar it was reported favorably to the Senate just prior to adjournment. The original bill was changed in only one particular. Where it provided for the payment of the common stock subscription of $12,500,000 from the Treasury, the committee amended the bill as follows:

"In order to pay such subscription, as and when called, the Secretary of War is hereby authorized to sell so much as may be necessary of the supply of nitrate of soda owned by the United States and held as a reserve by the War Department, at such prices and under such regulations as may be prescribed by the Secretary of War. All sums realized from such sale are hereby appropriated to the use of the Secretary of War for the purchase of the preferred stock of the corporation."

Savannah Section of the A. C. S. Formed

By a waiver of jurisdiction from the Georgia Section of the American Chemical Society, as required by the action of the Council of the society on April 12 at St. Louis, Mo., a charter was granted on May 10 to a new section to be known as the Savannah Section and embracing the counties of Chatham, Effingham, Bryan, Liberty, Wayne, McIntosh, Glynn and Camden, Ga.

On May 27 the section was organized and the following officers were elected to serve for the balance of the year: President, J. J. McManus; vice-president, Maurice Siegel; secretary-treasurer, Herbert P. Strack; councillor, Dr. F. N. Smalley.

Prospects are promising for a live section.

German Dyes Imported

A shipment of German dyes consisting of 515 barrels and eight cases of assorted colors, consigned to the Textile Alliance, arrived recently on the steamer West Wauneke from Antwerp. These dyes had previously been allocated to various consumers and will not be put on the open market.

Nine barrels and forty-three cylinders of Swiss dyes consigned to four concerns arrived on the same ship.

Canadian Meeting Itinerary and Program of the American Institute of Chemical Engineers

Officially the Spring Meeting of the A. I. C. E. will open at 9 o'clock Monday morning, June 28, at the Hotel Windsor, Montreal, but a quorum of the navigators of the society will assemble beforehand on the S.S. Berkshire at Pier 32, North River, New York, sailing up the Hudson at 6 p.m. and arriving at Albany at 6 o'clock Sunday morning. The party will take the 7:20 D. & H. R.R. train to Lake George, where the S.S. Horicon will be boarded for Baldwin, which will give a delightful forenoon excursion. The S.S. Vermont will be taken at Montcalm Landing at 1:15 for Plattsburg, where the 7:15 train for Montreal will be met, giving the entire Sunday afternoon to the enjoyment of the rare beauty of the waters and shores of Lake Champlain.

Following is the program for the meeting:

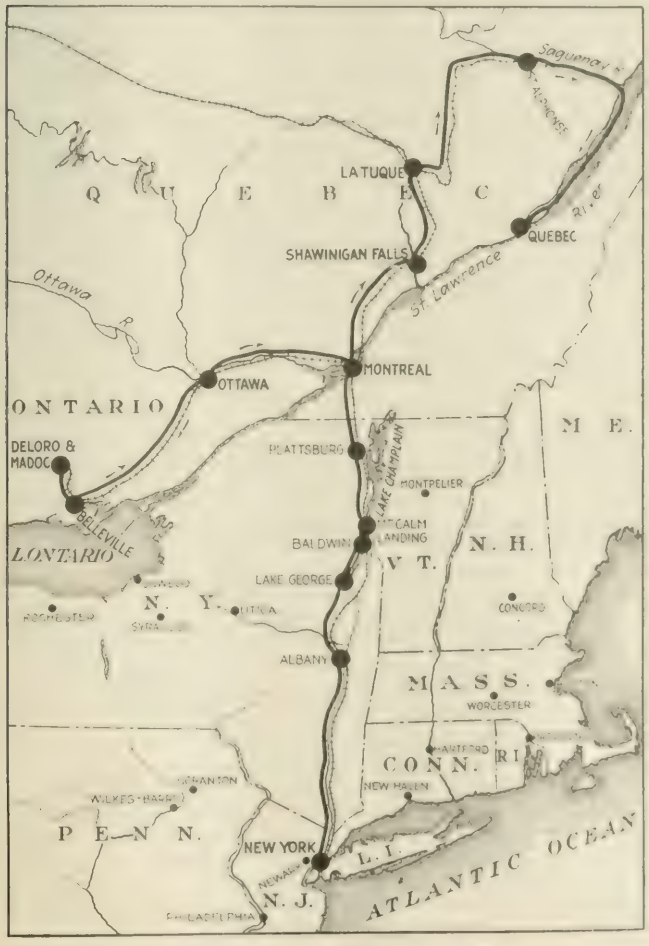
Monday, June 28

Meeting at Hotel Windsor, Montreal

9 A.M.—Business sessions, reports of Council, officers and committees.

10 A.M.—Reading of papers: address of welcome; "The Mann Report," A. W. Smith; "The Proposed National Department of Public Works," James R. Withrow; Symposium on Electrolytic Cells: "Early Commercial Electrolytic Cells," C. B. Barton; "The Fundamentals of Electrolytic Diaphragm Cells," H. K. Moore; "The Vertical Cylindrical Cell," L. D. Vorce; paper whose title has not yet been announced, A. H. Hooker.

2 P.M.—Reading of papers: "The Manufacture of Lime for Chemical and Metallurgical Purposes" (lantern slides), R. K. Meade; "The Evaporator Laboratory at the University of Michigan," W. L. Badger; "The Relation Between Temperature Drop and Heat Transmission in Vertical Tube Evaporators," W. L. Badger and P. W. Shepard; "The Relation Between the Boiling Point of Saturated Sodium Chloride Solution and Pressure," W. L. Badger and E. M. Baker; "The Relation Between Hydrostatic Head and Temperature Drop in Vertical Tube Evaporators," W. L. Badger and P. W. Shepard; "Experiments on the Corrosion of Iron and Steel," W. D. Richardson; "The Solution of Metals in Acids as Related to Corrosion," W. D. Richardson; "A Suggested Basis for an Index of Corrosion of Iron and Steel," W. D. Richardson.



ITINERARY OF THE A. I. C. E.

Tuesday, June 29

Meeting at Hotel Windsor

9 A.M.—Business sessions.

10 A.M.—Reading of papers: "Byproduct Coke Oven Industry," C. R. Bellamy; "American Progress in Dendro-Chemistry," H. O. Chute; "Industrial Application of Absorption" (illustrated by lantern slides), E. B. Müller; "The Sulphuric Acid Plant Fume Problem," J. R. Withrow and Frank C. Vilbrandt; "Chemistry of Rubber," Maximilian Toch.

2 P.M.—Visit to the glycerine refineries of Max & Rawolle, Ltd., by special street car.

8 P.M.—Meeting place to be announced. "Utilization of Peat," B. F. Haanel.

9 P.M.—Smoker at Windsor Hotel.

Wednesday, June 30

"Institute Special Train" will leave Ottawa for Belleville sufficiently early in the evening to pass through the scenic Rideau Lake District by daylight. Arrive at Belleville about 10:30 P.M. Train will be met on arrival by members of the Belleville Committee. Members who prefer to secure rooms at the Hotel Quinte should make reservations in advance to the Secretary, Dr. J. C. Olsen, or to Lucius E. Allen, Belleville, Ont.

Thursday, July 1

9:30 A.M.—Members will be taken for a motor drive about the city, visiting points of interest, and leave for Deloro, via Sterling and Marmora, viewing en route the Oak Hills and the Trent Valley.

11:30 A.M.—Arrive at Deloro. Inspection of the extensive works of the Deloro Smelting & Refining Co., Ltd., where the process of smelting and refining ores from the Cobalt region is carried out, producing cobalt, nickel and arsenic. Stellite metal is also produced by the electric furnace.

1 P.M.—A luncheon will be tendered all visiting members by the Deloro Smelting & Refining Co., Ltd., at its clubhouse.

2 P.M.—Leave for Belleville, via Madoc, at which point a short stop will be made at the plant of G. H. Gillespie & Co., miner and manufacturer of talc. There are also several fluorspar mines at Madoc.

4 P.M.—Inspection of the extensive plant of the Industrial Alcohol Co., Ltd., at Corbyville. This plant has been in operation since 1859 and in addition to manufacturing industrial alcohol, produces the famous "Corby Special Selected Rye Whiskey."

5.45 P.M.—Informal reception to members and their ladies at the Belleville Club. Light refreshments will be served.

7:30 P.M.—Complimentary dinner at the Hotel Quinte, tendered by the City of Belleville and the County of Hastings.

11:30 P.M.—Train for Shawinigan Falls.

Friday, July 2—At Shawinigan Falls

Visits to power house of the Shawinigan Water & Power Co.; plant of the Belgo Canadian Pulp & Paper Co., manufacturer of paper, ground wood, sulphite, etc.; plant of the Canada Carbide Co., manufacturing calcium carbide; plant of the Canadian Electro Products Co., manufacturer of acetaldehyde, paraldehyde and acetic acid. Entertainment for the ladies. Opportunity may be afforded for those who desire to stop at Grand Mere and visit the Laurentide Pulp & Paper Mill.

Saturday, July 3—At Latuque

Visit to sulphate pulp mill of the Brown Co. Fishing and boating at Wayagamac Club.

Sunday, July 4—At St. Alphonse

All-day steamer trip down the Saguenay River to Quebec. The Saguenay trip is one of the famous trips of the world and affords a view of the beautiful scenery on this river and also on the lower St. Lawrence.

Monday, July 5

Visiting the beautiful and historic City of Quebec.

Gas Men Convene to Consider Crisis of Their Industry

The emergency committee and members of the American Gas Association met Wednesday, May 26, in the Hotel Pennsylvania to consider ways and means to combat the shortage of basic raw material used in the manufacture of gas. With the great scarcity of coal, coke and gas oil the situation looks discouraging for the consumers as well as the manufacturers. Some of the plants have barely enough for present operations and all are wondering whether or not they will be able to operate during the coming winter.

Philip H. Gadsden, chairman of the emergency committee, said that the most important question was "how to keep the plants functioning to the consumer." With supplies of coal practically exhausted and supply of gas oil entirely inadequate for the purpose for which it is used, due largely to the increased demands for gasoline and kerosene, a most serious and critical situation confronts the gas manufacturers.

Résumé of Oil Situation

N. H. C. Smith, of the Bureau of Mines, gave a résumé of the oil situation in this country, and it certainly was not very encouraging. With the tremendous demand for gasoline by the automobile industry and the development of the Diesel type of oil engine, every possible means was being used to increase the supply. Higher fractions in the distillates for motor fuel robbed the gas oil, on the one hand, while the use of fuel oil for Diesel engines and oil-burning engines robbed it on the other, thereby increasing the cost and decreasing the supply of gas oil. It is estimated that Jan. 1, 1920, there were 7,500,000 automobiles and trucks in operation in the United States and that 1,500,000 would be added this year.

Oscar H. Fogg, secretary-manager of the association, said that although the growth of the various cities was increasing steadily, the limit of growth of gas companies has been hampered because the companies had no control over their income. Under regulated rates the average price of gas in 150 cities has advanced 15 per cent in the last five years, from $1.09 per 1,000 ft. in 1915 to $1.26 in 1919. During the same period all other commodities, necessities and luxuries have gone well above the 100 per cent mark.

After the addresses, the following resolutions were passed:

(1) To appoint a committee of seven to confer with representatives of the oil industry to obtain sufficient oil for the gas industry;

(2) To establish a differential in the selling price temporarily, to meet present emergency;

(3) To abolish the obsolete cp. standard.

Examination for Organic and Inorganic Chemist

The United States Civil Service Commission announces that an open competitive examination for organic and inorganic chemist, for men only, will be held July 6. Vacancies in the Philippine Service at $3,000 a year, and in positions requiring similar qualifications, at this or higher or lower salaries, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer or promotion.

For further particulars apply to United States Civil Service Commission, Washington, D. C.

German Dye Companies Pay Big Dividends

The balance sheets of the large aniline dye companies of Germany show that in spite of the chaotic condition of business in general they at least are making money. The report of the Farbenfabriken vorm. Fr. Bayer & Co., Leverkusen, shows a net profit (at normal rate of exchange) of $5,725,000 as against $3,270,000 last year.

The Farbwerke vorm. Meister Lucius & Bruning, Höchst-am-Main, has a net profit of $6,050,000, as against $3,750,000 last year, and a dividend of 14 per cent, as against 12 per cent last year, is being paid.

It is said that the German coal-tar ring controls 40 per cent of the capital raised last December, which carries a double voting power in order to prevent the control passing into foreign hands. The Berlin Aniline Color Works is paying 18 per cent dividends, compared with 12 per cent paid last year.

Book Reviews

METALLOGRAPHY. PART I—PRINCIPLES. By *Samuel L. Hoyt.* New York: McGraw-Hill Book Co.; 251 pages; 1920. Price, $3.

This is Part I of the first edition of a treatise in three parts on Metallography; namely, Part I—Principles; Part II—The Metals and Common Alloys (in press); and Part III—Technical Practice (in preparation). It is the outgrowth, says the author, of a course of lectures delivered at the University of Minnesota, and judging by its scope and treatment may best be classed as an advanced textbook on the subject. In this first general part the usual topics are covered, including chapters on constitution diagrams, preparation of metallic alloys, metallic microscopy, microstructure of metals and alloys, pyrometry and thermal analysis, physical properties and mechanical properties. Although there is nothing essentially novel in the presentation and discussion of the subject matter, the author's conventional treatment of it is due primarily to the well-established nature of its facts and hypotheses which necessarily does not permit of radical departures in this direction. The whole subject has, however, been brought quite up to date in this Part I, and the student in the field will not fail to find in it the latest authoritative information on the topics covered; he will also find the discussion more thorough and detailed than in most other textbooks of this sort.

One or two features of the book warrant special mention. The rather difficult topic of constitution diagrams has been handled in a clear and yet sufficiently comprehensive manner which should be very satisfying to the student who is not at home in the subject and would otherwise be obliged to consult other more abstract and perhaps more systematic but certainly less vivid and less easily understood treatments. Much to be commended is the author's generous use of footnote references to the best original literature; the reader will not likely get the erroneous impression that this small volume represents the confines of our knowledge on the subject, but will be stimulated to further reading and search. The illustrations are uniformly excellent and this is particularly true of the photomicrographs, which are unusually fine.

The impression is obtained that the author in the paragraphs dealing with metallographic apparatus has not always given apparatus of American manufacture the prominence which in view of its recent development it really deserves. This naturally detracts somewhat from the practical usefulness of these paragraphs.

Part I of this text certainly justifies us in awaiting the publication of the complete work with much interest and anticipation. Paul D. Merica

Personal

H. W. DAHLBERG, of the Great Western Sugar Co., Denver, Col., is now manager of the research department, which has been combined with the statistical department.

W. C. GRAHAM, formerly manager of the research department of the Great Western Sugar Co., Denver, Col., has resigned to take entire charge of the various plants of the American Potash Co. at Antioch, Neb.

ELLWOOD HENDRICK, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, delivered an address before the Delaware Section of the American Chemical Society, Delaware State College, Newark, Del., on "Chemistry and Civilization," on May 29. On June 12 he will deliver the address to graduates of the Rose Polytechnic Institute, Terre Haute, Ind., at the commencement exercises.

Dr. ARTHUR LACHMAN, of San Francisco, whose mysterious disappearance last December was the cause of grave concern on the part of his friends, was found May 19 on a train en route to San Francisco and is now at his home.

W. LEE LEWIS, professor of chemistry, Northwestern University, will succeed Dr. Willard as chairman of the Chicago Section of the American Chemical Society.

Dr. GEORGE A. PERLEY, of New Hampshire College, has been at Copper Hill, Tenn.

M. J. PROFFITT, formerly of the Great Western Sugar Co., Denver, Col., is now in charge of the sugar technology division at the Bureau of Standards, Washington, D. C.

Dr. F. H. RHODES has resigned the position of director of research for the chemical department of The Barrett Co., at Frankford, Pa., in order to accept the appointment as professor of industrial chemistry in Cornell University.

Provost EDGAR SMITH of the University of Pennsylvania tendered his resignation to the board of trustees, which has been accepted. Dr. Smith presented his resignation last February. In accepting it now the board makes him emeritus professor of chemistry and places at his disposal the Harrison laboratory, where Dr. Smith expects to devote the greater part of his time to research work.

L. I. SHAW, assistant chief chemist for the U. S. Bureau of Mines, Washington, D. C., and R. T. Stull, chief ceramist for the Bureau and in charge of the station at Columbus, Ohio, have been visiting Western stations at Golden, Col., Salt Lake City, San Francisco and Seattle.

E. T. STANNARD, vice-president of the Alaska Steamship Co., has been elected a vice-president of the Kennecott Copper Corp. Mr. Stannard will move his headquarters from the mines at Kennecott to Seattle, Wash.

F. W. WILLARD, of the Western Electric Co., has transferred his activities to the planning of a new transoceanic cable plant for his company at Norfolk, Va.

C. E. WILLIAMS, who was recently assigned to electrometallurgical work at the Seattle Station of the Bureau of Mines, has reached Seattle after making a tour of the electrometallurgical centers of the East.

Obituary

GEORGE GILBERT POND, dean of the School of Natural Science of Pennsylvania State College, died at Hartford. He was born in Holliston, in March, 1861. For five years he was instructor in chemistry at Amherst and then became a professor in the same department. He left Amherst to accept the appointment with the Pennsylvania State College.

EDMUND GYBBON SPILSBURY, mining and metallurgical engineer of note, president of the E. G. Spilsbury Engineering Co. and former president of the Engineers' Club of New York and of the American Institute of Mining and Metallurgical Engineers, died suddenly May 28 of heart failure in the New York Eye and Ear Infirmary following an operation for cataract a few days previously.

Current Market Reports

The Non-Ferrous Metal Market

New York, June 7, 1920.—There have been few important changes in the non-ferrous metal market. Copper declined ½c., while tin strengthened slightly. Lead, also, is firmer.

	Cents per Lb.
Copper, electrolytic	15 50
Aluminum, 98 to 99 per cent	12 [illegible]
Antimony, wholesale lots	[illegible]
Nickel, ordinary	4 [illegible]
Nickel, electrolytic	4 [illegible]
Tin, Straits, spot	[illegible]
Lead, New York, spot	[illegible] 7 25
Lead, E. St. Louis, spot	[illegible] 50
Zinc, spot, New York	7 85
Zinc, spot, E. St. Louis	7 50

OTHER METALS		
Silver	oz.	$0.9925
Cadmium	lb.	1 40@1 50
Bismuth, (500 lb. lots)	lb.	2 70@3 00
Cobalt	lb.	2 30@3 00
Magnesium (f.o.b. Niagara Falls)	lb.	1 60@1 85
Platinum	oz.	90@95
Iridium	oz.	300@400
Palladium	oz.	90@100
Mercury	75 lb.	87 50

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33 50
Copper bottoms	38 00
Copper rods	38 00@40 00
High brass wire and sheets	30 25
High brass rods	25 00
Low brass wire and sheets	27 25
Low brass rods	28 00
Brazed brass tubing	43 25
Brazed bronze tubing	41 75
Seamless copper tubing	34 00
Seamless high brass tubing	33 00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	24 00@25 50
Aluminum, sheet scrap	24 00@25 50
Copper, heavy machinery comp.	15 00@16 00
Copper, heavy and wire	15 50@16 00
Copper, light and bottoms	14 00@14 50
Copper, heavy cut and crucible	16 25@16 75
Brass, heavy	9 50@10 00
Brass, light	8 00@8 50
No. 1 clean brass turnings	9 25@9 75
No. 1 comp. turnings	13 50@14 00
Lead, tea	5 00@5 50
Lead, heavy	7 00@7 25
Zinc, scrap	5 00@5 25

The Iron and Steel Market

Pittsburgh, Pa., June 3, 1920.

The improvement in rail traffic conditions that began two or three weeks ago is now proceeding at a more rapid pace. It is not a case of strikers returning to work, as the strike itself was practically ended some time ago, but rather of new men becoming more accustomed to their work, of team work by the railroads, under the direction of the Interstate Commerce Commission, having an effect, and of the natural tendency of a rail congestion to diminish more and more rapidly. In previous cases of traffic congestion the railroads would labor for a long time without apparent results, but when improvement once began it would proceed more and more rapidly.

There are few points now that cannot be reached by rail shipments, if the shipment can once be started. With many steel consumers the point is not to receive fresh shipments from mills, but rather to get shipments that were put on the rails long ago and stalled somewhere en route. As to car supplies, they are still meager, but practically all plants report more or less improvement in placements. Of notable assistance in improving the position of the iron and steel industry has been the partial resumption of the Pittsburgh & Lake Erie, so important to the Youngstown district. The road is still not doing a great deal in handling carload freight, but solid through freight train movement is fairly heavy. As a result largely of improvement on the Pittsburgh & Lake Erie, operations in the Youngstown district at blast furnaces at steel mills, though hardly at finishing mills, are now at about 70 per cent.

The steel industry has hardly attained the point yet of making shipments equal to its current production, but such a point does not seem to be far distant now, and when that is attained the mills must address themselves to the movement of the large amount of steel that has accumulated. Except for a moderate tonnage of ingots and billets, all the steel accumulated has been on order. What effect upon the attitude of consumers the movement of so much steel will have remains to be seen. Ever since the beginning of the rail strike it has been notable that while consumers of steel in general were incommoded, they did not seem to be incommoded as much as one would expect from the great reduction in steel receipts.

Market Prospects

The pig iron, unfinished steel and finished steel markets are all very dull, the condition having become more pronounced week by week. The attitudes of buyers and sellers are just what they usually are in such a combination of circumstances. Buyers, having been very nervous earlier in the year for fear they would not secure all the steel they expected to need and having bid up prices with all the mills that were desirous of obtaining as high prices as possible, are now nervous in the other direction, and will buy nothing but what they are absolutely certain they will need. A few are even thinking about reselling stocks and material due them, in expectation that they may be able to replace the material later on, though they cannot now, at lower prices.

Producers Indisposed to Reduce Prices

As usual, the producers are indisposed to reduce prices merely because their sales are lighter than formerly. As long as the steel producer has unfilled tonnage on books he is disposed to stand firm, for to cut prices to effect forward sales starts a disturbance in the market and by the time the delivery period arrives the buyer may have still better offers. Roughly speaking, the steel mills are sold ahead in inverse ratio to the prices they have been charging, the Steel Corporation farthest ahead, say seven or eight months as an average for all products, the large independents for from two to five months, and the small independents for shorter periods. Thus it is the highest priced mill that first has occasion to make its prices more attractive, but the price cut is the highest price, and the prices asked for farther forward deliveries are not necessarily affected. Black sheets for prompt shipment, for illustration, brought as high as 10c. toward the close of February and about 9c. a month ago, while now they can be had for about 7.50c. Independents that are sold up for from two to three months ahead, however, have only been quoting between 5c. and 6c. and their position is not necessarily disturbed, while the Steel Corporation, with its Industrial Board price of 4.35c., is not concerned whatever in the matter.

Pig Iron

The market in pig iron continues to be confined to small lots for early or spot shipment, and thus the test of values for far forward deliveries, such as are ordinarily contracted for in a strong market, is entirely lacking. Prompt bessemer recently brought $43, valley, in small lots, as against $42.50 formerly quoted, making "the market," such as there is, quotable at $43, valley. Foundry continues quotable at $45, valley. Basic, which seemed to be established at $43.50, is reported to have sold at $43 in one or two instances. The furnaces are well sold up for a few months, on the basis of customers taking full deliveries according to contract.

Semi-Finished Steel

Billets are in no request and prices are simply nominal as last done in actual transactions, $60 to $65 for standard billets and $70 for small billets. Sheet bars are in light demand, makers quoting $70 to $75 on bessemer and $75 to $80 on open-hearth. There is a fair demand for slabs, with offerings light, except of blooming-mill slabs. Rods are in moderate demand, at $70 to $75, but not as active as two or three weeks ago.

Ferro-Alloys

The pressure for prompt ferromanganese has subsided and the market is not strong at the previous quotation of $250, delivered. Contract alloy remains at $200, delivered. Spiegeleisen is quiet at $72.50@$75, furnace, for prompt or forward. Electrolytic ferrosilicon is inactive, prices being largely nominal at about $78@$80 for 50 per cent and $150@$155 for 75 per cent, delivered. Bessemer ferrosilicon remains at $62.50 for 10 per cent, $65.80 for 11 per cent and $69.10 for 12 per cent, f.o.b. furnaces at New Straitsville and Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, June 4, 1920.

There has been very little activity in the chemical market during the period, with whatever buying that has been done confined to small orders. The general impression seems to be that the transportation situation is easier and points to recovery soon, although producers are still having difficulty in obtaining raw materials for the manufacturing of the finished product. The firmness noted throughout the *acid* list for some time back is well sustained, while *muriatic,* 20 deg., which is very scarce, has been sold as high as $3.50@$4.50 per cwt. during the week. There has been no actual change in *acetic,* 99½ per cent glacial, but the average price is now nearer $17 than it has been for the past few weeks. *Caustic potash* is on the decline and sales have been heard of around 27c. per lb., but business on this item has been very small and producers are gradually recovering from the recent difficulties with labor and transportation. *Soda ash* remains in the same nominal position, with very little material being offered on the spot market at prices ranging between $3.50 and $4 per cwt. There are some resale American goods being offered by Japan at figures below the present market. These offerings are for contracts at $3@$3.50 per cwt., but buyers are not disposed to take chances on future delivery. *Caustic soda* is in practically the same position, $6.25@$6.50 per cwt. being the prevailing nominal quotations, with offerings coming in from Japan at figures slightly under this price.

Coal-Tar Products

Although there have been some few declines during the period, the long expected break has not yet arrived. In general former quotations hold, with very little material changing hands, and that in a small way. Japan at present is a factor in this market and is offering material at prices below those quoted here, but consumers seem to be sitting tight watching for the long-promised upheaval in the domestic market. *Dimethylaniline* is now back on the market after a considerable absence and offerings range between $1.25 and $1.50 per lb., against a range of $1.50 to $1.60 of the previous week. *Aniline oil* dropped to a new level and is now to be had at 42@48c. per lb., compared with 45@50c., the recently prevailing figure.

Naval Stores

This market continues dull, with very small offerings being made in the *rosins.* Former prices still hold nominally, as shipping conditions from Savannah are still retarding the arrival of material in this port. *Turpentine* is now in fairly good supply and further arrivals are expected shortly. The current price in the New York market is around $1.95 per gal., which, compared with the top figure of $2.35 of last week's report, represents a considerable drop in this item.

Crude Rubber

The unsettled conditions of the money market, combined with a holding back on the part of the large rubber consumers, have brought about the listless condition of this market. *Rubber* has been on a steady decline for some time past and the absence of the usual fluctuating prices, added to the fact that present spot quotations are below future offerings, emphasizes the absolute lack of activity in the trade.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	$0 65 – $0 75	
Acetone	lb.	$0 15 – $0 20	21 – 22
Acid, acetic, 28 per cent	cwt.	3 50 – 3.75	4 00 – 4 25
Acetic, 56 per cent	cwt.	6 00 – 6 50	8 75 – 9 00
Acetic, glacial, 99½ per cent. carboy	cwt.	15 50 – 16 00	16 50 – 18 00
Boric, crystals	lb.	15 – 15½	15½ – 16½
Boric, powder	lb.	15 – 15½	15 – 16
Citric	lb.	1 05 – 1 12	1 17 – 1 18
Hydrochloric (nominal)	cwt.	2 00 – 2 50	3.50 – 4 00
Hydrofluoric, 52 per cent	lb.	12 – 12½	13 – 14
Lactic, 44 per cent tech	lb.	11 – 11½	12 – 16
Lactic, 22 per cent tech	lb.	04 – 05½	.06 – 07
Molybdic, C. P.	lb.	4.00 – 4 50	4 50 – 5 00
Muriatic, 20 deg. (see hydrochloric)			
Nitric, 40 deg.	lb.	06 – 07	07½ – 08½
Nitric, 42 deg.	lb.	07½ – 08	08½ – 09½
Oxalic, crystals	lb.	.55 – 57	.60 – 65
Phosphoric, Ortho, 50 per cent solution	lb.	.22 – 23	24 – 25
Picric	lb.	.28 – 35	.40 – .50
Pyrogallic, resublimed	lb.	2 50 – 2 55	2.60 – 2 65
Sulphuric, 60 deg., tank cars	ton	14 00 – 18 00	
Sulphuric, 60 deg., drums	ton		
Sulphuric, 66 deg., tank cars	ton	23 00 – 25 00	
Sulphuric, 66 deg., drums	ton	35 00 – 40.00	50 00 – 55 00
Sulphuric, 66 deg., carboys	ton	36 00 – 40 00	50.00 – 55 00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	37.00 – 42 00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28 00 – 30 00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32 00 – 35 00	40 00
Tannic, U. S. P.	lb.	1 50 – 1 60	1.65 – 1.70
Tannic (tech)	lb.	– –	.60 – .90
Tartaric, crystals	lb.	– –	.80 – .85
Tungstic, per lb. of WO	lb.	– –	1.20 – 1 40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6 00 – 7 00
Alcohol, Methyl, 95%	gal.	– –	2 50 – 2 70
Alcohol, Methyl, pure	gal.	–	3 50 – 3 55
Alcohol, denatured, 188 proof (nominal)	gal.	– –	1 10 – 1 15
Alcohol, denatured, 190 proof (nominal)	gal.	– –	1 05 – 1 10
Alum, ammonia lump	lb.	.04½ – .05	05½ – .06
Alum, potash lump	lb.	.07½ – .08½	.09 – .09½
Alum, chrome lump	lb.	15½ – 18	19 – .20
Aluminum sulphate, commercial (nominal)	lb.	01½ – .02	02½ – 03½
Aluminum sulphate, iron free	lb.	.02½ – 03	04 – 04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10¾	11 – 12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 – 35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – 16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – 16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – 13½	13 – .14½
Ammonium nitrate	lb.	.08¾ – .12	
Ammonium sulphate	lb.	.07 – 07¼	08½ –
Amylacetate	gal.	– –	5 00 –
Amylacetate tech	gal.		4.75 – 5 25
Arsenic, oxide, lumps (white arsenic)	lb.	– –	.13½ – 14
Arsenic, sulphide, powdered (red arsenic)	lb.	.23 – .24	
Barium chloride	ton	150.00 – 160 00	1.75 – 2 00
Barium dioxide (peroxide)	lb.	.21 – .23	24 – .25
Barium nitrate	lb.	.09½ – 11	.11 – 12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)		– –	
Blue vitriol (see copper sulphate)		– –	
Borax (see sodium borate)		– –	
Brimstone (see sulphur, roll)		– –	
Bromine	lb.	.70 – .90	1.00 – 1 05
Calcium acetate	cwt.	3.50 – 3.55	
Calcium carbide	lb.	04½ – 04½	04½ – 05½
Calcium chloride, fused, lump	ton	23.00 – 25.00	30 00 – 40 00
Calcium chloride, granulated	lb.	01½ – 01¾	02 – 02¼
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4 50 – 5 50
Calcium peroxide	lb.	– –	1 50 – 1 70
Calcium phosphate, monobasic	lb.	– –	75 – 80
Calcium sulphate, pure	lb.	– –	25 – 30
Carbon bisulphide	lb.	.08 – .09	10 – 11
Carbon tetrachloride, drums	lb.	.11 – .11½	12 – 15½
Carbonyl chloride (phosgene)	lb.	– –	80 – 1 05
Caustic potash (see potassium hydroxide)		– –	
Caustic soda (see sodium hydroxide)		– –	
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – 10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	– –	2.00 – 2.05
Copperas (see iron sulphate)		– –	
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	– –	.65 – .70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		– –	
Epsom salt (see magnesium sulphate)		– –	
Ethyl Acetate Com. 85%	gal.	1.35 –	1 40 –
Ethyl Acetate pure (acetate ether 98° to 100°)		– –	1 75
Formaldehyde, 40 per cent (nominal)	lb.	.36 – 40	57 – .65
Fusel oil, ref.	gal.	– –	5.25 – 6 00
Fusel oil, crude (nominal)	gal.	– –	
Glauber's salt (see sodium sulphate)		– –	
Glycerine	lb.		26½ – 28½
Iodine, resublimed	lb.	4 30 – 4 35	4.40 – 4 45
Iron oxide, red	lb.	– –	.03 – .20
Iron sulphate (copperas)	cwt.	1 50 – 1 75	1.80 – 2 00
Lead acetate, normal	lb.	– –	13½ – 15½
Lead arsenate (paste)	lb.	11 – 12	.13 – 17
Lead nitrate, crystals	lb.	– –	.90 – 1.00
Litharge	lb.	.14 – .15	15½ – .16
Lithium carbonate	lb.	– –	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – 16
Magnesium sulphate, U. S. P.	100 lb.	3.00 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	– –	3.25 – 3.60
Nickel salt, double	lb.	– –	.14 – .16
Nickel salt, single	lb.	– –	.16 – .18
Phosgene (see carbonyl chloride)		– –	
Phosphorus, red	lb.	.50 – .55	.60 – 65
Phosphorus, yellow	lb.	– –	.35 – .37
Potassium bichromate	lb.	.35 – .37	45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.52 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – 95
Potassium carbonate, U. S. P.	lb.	– –	.85 – .88
Potassium carbonate, crude	lb.	.21 – 28	.26 – .28

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities

		Carlots	Less Carlots
Alpha naphthol, crude	lb.		$1 25
Alpha naphthol, refined	lb.		1.45
Alpha naphthylamine	lb.	65 –	70
Aniline oil, drums extra	lb.	15 –	20
Aniline salts	lb.	42 –	50
Anthracene, 80% in drums (100 lb.)	lb.	80 –	1 00
Benzaldehyde (free)	lb.	2 00 –	2 10
Benzidine, base	lb.	1 35 –	1 40
Benzidine, sulphate	lb.	1 20 –	1 25
Benzoate of soda, U. S. P.	lb.	95 –	1 10
Benzoate of soda, U. S. P.	lb.	85 –	1 00
Benzol, pure, water-white, in drums (100 lb.)	gal.	27 –	30
Benzol, 90%, in drums (100 lb.)	gal.	25 –	31
Benzyl chloride, 95-97%, refined	lb.	35 –	40
Benzyl chlorides, tech.	lb.	25 –	35
Beta naphthol benzoate (nominal)	lb.	90 –	95
Beta naphthol, sublimed (nominal)	lb.	80 –	85
Beta naphthol, tech (nominal)	lb.	67 –	85
Beta naphthylamine, sublimed	lb.	2 35 –	2 40
Cresol, U. S. P., in drums (100 lb.)	lb.	18 –	40
Cresol, ortho, in drums (100 lb.)	lb.	25 –	35
Cresylic acid, 97-99%, straw color, in drums	gal.	1 10 –	1 20
Cresylic acid, 95-97%, dark, in drums	gal.	1 00 –	1 05
Cresylic acid, 50%, first quality, drums	gal.	65 –	75
Dichlorbenzol	lb.	08 –	10
Diethylaniline	lb.	–	1 80
Dimethylaniline	lb.	1 25 –	1 30
Dinitrobenzol	lb.	20 –	27
Dinitrochlorbenzol	lb.	10 –	15
Dinitronaphthaline	lb.	40 –	55
Dinitrophenol	lb.	90 –	95
Dinitrotoluol	lb.	40 –	45
Diphenylamine (nominal)	lb.	45 –	46
Dyphenylene oxide (nominal)	lb.	–	85
Hexalin (concrete)	lb.	2 25 –	2 30
Metadinitrobenzene	lb.	1 15 –	1 20
Monochlorbenzol	lb.	–	15
Monomethylaniline	lb.	1 –	1 85
Naphthalene, crude	lb.	–	05
Naphthalene, flakes (250 lb.)	lb.	05½ –	12
Naphthalene, salts	lb.	15 –	18
Naphthionate of soda, crude	lb.	75 –	80
Nitrobenzol	lb.	14 –	16
Nitronaphthaline	lb.	40 –	50
Nitrotoluol	lb.	30 –	35
Orthodichlorbenzol	lb.	8 –	4 00
Orthodinitrobenzol	lb.	–	1 25
Orthonitrophenol	lb.	–	2 50
Orthonitrotoluol	lb.	15 –	45
Orthotoluidine	lb.	55 –	65
Paradichlorbenzol, block	lb.	15 –	18
Paranitraniline, 100%	lb.	1 60 –	1 70
Paranitrophenol, 100%	lb.	1 –	1 10
Paranitrotoluol	lb.	08 –	12
Paraphenylenediamine	lb.	1 65 –	1 75
Paratoluidine	lb.	1 10 –	1 20
Paratoluolsulphonamide	lb.	1 60 –	3 00
Pentachlorphenol	lb.	1 00 –	1 10
Phthalic anhydride	lb.	70 –	75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	17 –	20
Pyridin	gal.	3 00 –	3 50
Resorcin, crude	lb.	4 15 –	4 30
Resorcin, pure	lb.	5 75 –	6 25

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0.50 —	$0.52
Salicylic acid, U. S. P.	lb.	.50 —	.60
Salol	lb.	.90 —	1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25 —	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19 —	.24
Sulphanilic acid, crude	lb.	.28 —	.32
Toluidine	lb.	1.70 —	2.50
Toluidine, mixed	lb.	.45 —	.55
Toluol, in tank cars	gal.	.28 —	.....
Toluol, in drums	gal.	.29 —	.32
Xylidine, drums, 100 gal.	lb.	.44 —	.50
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37 —	.45
Xylol, commercial, in tank cars	gal.	.23 —	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36 —	$0.39
Beeswax, refined, light	lb.	.39 —	.40
Beeswax, white pure	lb.	.63 —	.68
Carnauba, No. 1. (nominal)	lb.	1.00 —	1.05
Carnauba, No. 2, regular (nominal)	lb.	.85 —	.88
Carnauba, No. 3, North Country (nominal)	lb.	.44 —	.45
Japan	lb.	.21 —	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09½ —	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	..... —	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 128-130 m.p.	lb.	.13 —	.14
Paraffine waxes, refined, 133-135 m.p.	lb.	.15½ —	.16½
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½ —	.18½
Stearic acid, single pressed	lb.	.25 —	.26
Stearic acid, double pressed	lb.	.26 —	.27
Stearic acid, triple pressed	lb.	.28 —	.29

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.75
Pine oil, pure, dest. dist.	gal.	1.60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$19.00 —	$20.30
Rosin E-I	280 lb.	20.30 —	20.50
Rosin K-N	280 lb.	20.50 —	22.00
Rosin W. G.-W. W.	280 lb.	22.50 —	23.00
Wood rosin, bbl.	280 lb.	17.80 —	18.50
Spirits of turpentine	gal.	1.90 —	1.95
Wood turpentine, steam dist.	gal.	..... —	.....
Wood turpentine, dest. dist.	gal.	1.90 —	2.00
Pine tar pitch, bbl.	200 lb.	..... —	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50 —	15.00
Retort tar, bbl.	500 lb.	15.00 —	15.50
Rosin oil, first run	gal.	.87 —	.89
Rosin oil, second run	gal.	.89 —	.92
Rosin oil, third run	gal.	1.04 —	1.05
Rosin oil, fourth run	gal.	1.12 —	1.15

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.37½ —	$0.38
Upriver coarse	lb.	.28¾ —	.29½
Upriver caucho ball	lb.	.30 —	.30½
Plantation—First latex crepe	lb.	.38 —	.39
Ribbed smoked sheets	lb.	.38¾ —	.39
Brown crepe, thin, clean	lb.	.37 —	.38
Amber crepe No. 1	lb.	..... —	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½ —	$0.20
Castor oil, AA, in bbls.	lb.	.20 —	.22
China wood oil, in bbls.	lb.	.22½ —	.23½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½ —	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½ —	.19½
Corn oil, crude, in bbls.	lb.	.17½ —	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½ —	.16
Cottonseed oil, summer yellow	lb.	.19 —	.19½
Coteonseed oil, winter yellow	lb.	.21 —	.22
Linseed oil, raw, car lots (domestic)	gal.	1.65 —	.....
Linseed oil, raw, tank cars (domestic)	gal.	1.60 —	.....
Linseed oil, boiled, car lots (domestic)	gal.	1.67 —	.....
Olive oil, commercial	gal.	3.10 —	3.25
Palm, Lagos	lb.	.12½ —	.13½
Palm, bright red	lb.	.13 —	.13½
Palm, Niger	lb.	.11 —	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.16½ —	.17½
Peanut oil, refined, in bbls.	lb.	.22 —	.24
Rapeseed oil, refined in bbls.	gal.	1.70 —	1.72
Rapeseed oil, blown, in bbls.	gal.	1.80 —	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17 —	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.13 —	.13½

FISH

Winter pressed Menhaden	gal.	$1.17 —	$1.18
Yellow bleached Menhaden	gal.	1.20 —	1.22
White bleached Menhaden	gal.	1.23 —	1.24
Blown Menhaden	gal.	1.30 —	1.32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$20.00 —	$22.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	16.00 —	18.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	8.00 —	10.00
Blanc fixe, dry	lb.	.05½ —	.06
Blanc fixe, pulp	ton	60.00 —	80.00
Casein	lb.	.15 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.05 —	.06
Chalk, English, dense	lb.	.04½ —	.05
China clay (Kaolin) crude, f.o.b. Pkin, Va.	net ton	8.00 —	12.00
China clay (Kaolin), imported, lump	ton	25.00 —	35.00
China clay (Kaolin), imported, powdered	ton	30.00 —	60.00
Feldspar (nominal) f.o.b. N. Y. State	ton	13.50 —	18.00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7.50 —	8.00
Feldspar, ground, f.o.b. Baltimore	net ton	18.00 —	25.00
Fire clay, f.o.b. Baltimore	net ton	5.00 —	7.00
Fuller's earth, domestic, powdered	ton	25.00 —	30.00
Fuller's earth, imported, powdered	ton	35.00 —	40.00
Graphite (dust polish grade 30%) Ashland, Ala.	lb.	..... —	0.01
Graphite (dust facing grade 50%) Ashland, Ala.	lb.	..... —	0.01½
Graphite, crucible, 85% carbon Ashland, Ala.	lb.	..... —	.07
Graphite, crucible, 90% carbon Ashland, Ala.	lb.	..... —	.08½
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	.....
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	..... —	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	..... —	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	..... —	17.00
Shellac, orange, fine	nominal lb.	1.50 —	.....
Shellac, orange, superfine	lb.	1.60 —	1.65
Shellac, A. C. garnet	lb.	1.30 —	1.35
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	60.00 —	70.00

Refractories

Following prices are f.o.b. Works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-90 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.20 —	.21
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.21 —	.22
Ferro-manganese, 70-80% Mn.	gross ton	200.00 —	250.00
Spiegeleisen, 16-20% Mn.	gross ton	73.00 —	75.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25 —	2.75
Ferro-silicon, 50%	gross ton	80.00 —	90.00
Ferro-silicon, 75%	gross ton	150.00 —	200.00
Ferro-silicon, 10-15%	gross ton	60.00 —	65.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90 —	1.10
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50 —	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70 —	$0.85
Coke, foundry, f.o.b. ovens	net ton	15.50 —	16.50
Coke, furnace, f.o.b. ovens	net ton	14.50 —	15.50
Petroleum coke, refinery, Atlantic seaboard	net ton	..... —	24.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00 —	30.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, Mex.	net ton	30.00 —	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00 —	65.00
Manganese ore, 45% Mn and over	unit	.80 —	.95
Manganese ore, chemical (MnO_2)	gross ton	80.00 —	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	7.50
Uranium oxide, 96%	lb.	2.75 —	3.00
Vanadium pentoxide, 99%	lb.	12.00 —	14.00
Vanadium Ore	lb.	1.00 —	3.00
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.16 —	.17½
Ilmenite, 52% TiO_2	lb.	.01½ —	.02
Rutile, 95% TiO_2	lb.	.15 —	.25
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75 —	3.00
Zircon, washed, iron free	lb.	.10 —	.....
Monazite, per unit of ThO_2	unit	42.00 —	.....

*Nominal

Structural Steel

Mill, Pittsburgh

Beams and channels, 3 to 15-in	100 lb.	$2.45@ $4.00
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45@ 4.00
Tees, 3-in. and larger	100 lb.	2.45@ 4.00
Plates	100 lb.	2.65@ 4.00
Rivets, structural, ¾-in. and larger	100 lb.	4.50
Rivets, conehead for boilers, ¾-in. and larger	100 lb.	4.60
Sheets, No. 28 black	100 lb.	4.35@ 6.50
Sheets, No. 10 blue annealed	100 lb.	3.55@ 6.00
Sheets, No. 28 galvanized	100 lb.	5.70@ 8.50

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

PHOENIX—V. A. Thompson, city mgr., will receive bids until June 16 for the installation of a complete infiltration intake system.

California

BISHOP—The Bishop Union High School Dist. received bids for the construction of a 2-story high school from R. W. Moller, Call-Post Bldg., San Francisco, $150,846; Young & Nunamaker, Bishop, $151,800. Laboratory equipment will be installed in same.

BURBANK—The Burbank Development Co., 206 West San Fernando St., is having plans prepared for the construction of 2 soap factory buildings on Verdugo Ave. Soap-making machinery will be installed in same. Estimated cost, $200,000.

LONG BEACH—The city received bids for the construction of a sewage pumping plant with pumps, motors, flush tanks, etc., from John Cummings, 1200 Washington Bldg., Los Angeles, $44,650; John Radick, $46,999; Peter Tomick, $57,900. A. DeRuiz, engr.

LOS ANGELES—The Miller Rubber Co., South High St., Akron, O., plans to build a tire factory to have a daily output of 2,800 casings here. F. C. Millhoff, general sales mgr.

LOS ANGELES—The Oil Mining Equipment Co., 2026 Santa Fe Ave., will build a group of factory buildings including an 80x547-ft. main building with a 60x150-ft. shed, 20x200-ft. boiler house, etc. Work will be done by day labor.

NATIONAL CITY—The city received bids for the construction of a complete sewer system, including 8 flush tanks, 73 lamp holes and septic tank, from R. H. Downer, 668 Colusa Ave., Berkeley, $94,250; John Engbretsen, 205 McNeece Bldg., San Diego, $110,250; M. McGinnis, San Diego, $116,685.

SAN DIEGO—The Citrus Soap Co., 902 K St., has awarded the contract for the construction of a 4-story, 200x300-ft. soap factory at Union and Market Sts., to the Winter Constr. Co., 2141 Sacramento St., Los Angeles, at $200,000. Noted May 26.

Connecticut

WALLINGFORD—The Interstate Silver Co., 48 State St., Meriden, has awarded the contract for altering the factory and constructing an addition to the boiler house at Plant E, on Center St., to the Immick Co., State St., Meriden. Estimated cost, $250,000.

District of Columbia

WASHINGTON—The General Purchasing Officer of the Panama Canal will receive bids until June 18 for furnishing steel or pig iron, antimony, pig lead, phosphor-tin, silica sand and bituminous enamel, etc.

Illinois

ALTON—The Illinois Glass Co. is having plans prepared for the construction of a glass plant. R. S. Godard, constr. engr.

SANDWICH—The School Bd. will soon award the contract for the construction of a 3-story high school. A chemical laboratory will be installed in same. Estimated cost, $285,000. J. W. Royer, archt.

Indiana

EVANSVILLE—The Indiana Atomized Fuel Co is building a 1-story, 80x100-ft. plant to reduce coal to an atomized state by means of a chemical process. Estimated cost, from $125,000 to $150,000. B. U. Cain, secy.

Iowa

AURELIA—The Consolidated School Bd. has awarded the general contract for the construction of a 1-story, 80x150-ft. school, to W. J. Zitterell Co., Webster City. Laboratory equipment will be installed in same. Estimated cost, $207,000.

GEORGE—The School Bd. will soon award the contract for the construction of a 2-story, 80x127 ft. high school here. A chemical laboratory will be installed in same. Estimated cost, $90,000. Perkins & McWayne, Sioux Falls, S. D., archts. and engrs.

GREENE—F. L. Stober, Secy. of the School Bd., has awarded the contract for the construction of a 2-story, 66x127-ft. city high school, to the Miller Constr. Co., 502 Black Hawk Bank Bldg., Waterloo. A general chemical laboratory will be installed in same. Estimated cost, $150,000.

ORIENT—J. F. Kingerly, Secy of the Bd. Educ., is having preliminary plans prepared for the construction of a school building. A chemical laboratory will be installed in same. W. Gorden, 319 Hubbell Bldg., Des Moines, archt.

WINFIELD—The city has awarded the contract for the construction of a sewage disposal plant, to the Layton Constr. Co., Muscatine, at $135,000.

Maine

MADISON—The town is having plans prepared for the construction of a 2-story, 82x149-ft. high school here. A chemical laboratory will be installed in same. Harry S. Coombs, Masonic Temple, Lewiston, archt.

Massachusetts

HUDSON—H. M. Hope Engr. Co., archts. and engrs., 185 Devonshire St., Boston, will soon award the contract for the construction of a 5-story, 60x100-ft. factory for the manufacture of rubber goods, for the Apsley Rubber Co., Hudson. Estimated cost, $125,000.

Michigan

ASHLEY—The Bd. Educ. plans to build a 2-story high school. Chemical laboratory equipment will be installed in same. Estimated cost, $200,000. Mrs. M. E. Green, secy. E. M. Wood, 516 Oakland Bldg., Lansing, archt.

DETROIT—Smith, Hinchman & Grylls, archts., Washington Arcade, will soon award the contract for the construction of a 1-story, 79x532-ft. factory addition on Artillery Ave., for the International Metal Stamping Co., Artillery Ave.

PONTIAC—The city has awarded the contract for the water filtration plant, to the Dreher Constr. Co., Flint. Estimated cost, $315,399. Noted April 21.

Minnesota

COLERAINE—A. King, clk., will receive bids until July 15 for the construction of a 2-story, 200x200-ft. high school, for the Bd. Educ. A chemical laboratory will be installed in same. Estimated cost, $350,000. W. T. Bray, 616 Torrey Bldg., Duluth, archt. and engr.

LEWISTON—The Bd. Educ. is having plans prepared for the construction of a 3-story, 60x100-ft. addition to the high and grade school. A chemical laboratory will be installed in same. Estimated cost, $125,000. Croft & Boerner, Palace Bldg., Minneapolis, archts.

WAYZATA—The School Bd will soon award the contract for the construction of a 3-story, 140x150-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $325,000.

Missouri

PILOT GROVE—The School Bd. plans to build a 2-story, 58x70-ft. high school here. A chemical laboratory will be installed in same. Estimated cost, $15,000. H. R. Primmer, Nevada, Mo., archt.

ST. LOUIS—The St. Louis Mill Casting Co., 7701 North Conduit St. has awarded the contract for the construction of a 1-story, 100x484-ft. foundry, at 737-411 Thatcher St., to the Page-Gelmes Constr. Co., Merchants Laclede Bldg. Estimated cost $120,000.

New Jersey

JERSEY CITY—Colgate & Co., 107 Hudson St., has awarded the contract for the construction of a 3-story, 48x82-ft. factory on Morris St., to J. C. Boyce Co., 70 East 45th St., New York City. Estimated cost, $70,000.

KEYPORT—The Whitall Tatum Co., 19 Bartlett St., New York City, has awarded the contract for the construction of a 2-story, 100x200-ft. factory for the manufacture of glassware to H. H. Vaught, Grand Central Terminal, New York City. Estimated cost, $100,000.

NEWARK—Samuel Jones & Co., 21 McCollah St., has awarded the contract for the construction of a 1-story, 50x80-ft. factory addition, etc., to the C. K. Hedde Co., 765 Broad St., at $25,000.

TRENTON—The Perkasian Rubber Corp. has awarded the contract for the construction of three factory buildings on Whitehead Rd., to the Farrell Constr. Co., 55 West 39th St., New York City. Estimated cost, $250,000.

TRENTON—The Van Pottery Co., Parker Ave., has awarded the contract for the construction of a 1-story, 54x68-ft. pottery on Parker Ave., to J. P. Drugan, 184 West State St., at $18,000.

VINELAND—F. H. Bent, engr., 142 West State St., has awarded the contract for the construction of a sewerage system including a septic tank, etc., at the Home for the Feeble Minded, to the New York Sewage Co., 39 East 28th St., New York City, at $13,578. Noted May 19.

New York

NEW YORK—W. Zinsser, West 59th St., has awarded the contract for the construction of a 4-story, 50x50-ft. factory for the manufacture of paint, to Ruggles-Robinson, 331 Madison Ave. Estimated cost, $50,000. Noted May 26.

Ohio

CLEVELAND—The Willard Storage Battery Co., 246 East 131st St., had plans prepared for the construction of a 1-story, 25x260-ft. sheet metal factory.

PROSPECT—The Bd. Educ. plans to build a 2-story high school. A chemical laboratory will be installed in same. Estimated cost, $75,000. O. H. Howard, 8 East Broad St., Columbus, archt.

WHITTEMORE—St. Michael's Roman Catholic Church plans to build a school. A chemical laboratory will be installed in same. Estimated cost, $100,000. Address Parson & O'Meara, Mason Bldg., Ft. Dodge, Ia.

Pennsylvania

FRANKFORD JUNCTION (Philadelphia P. O.)—The Belmont Packing & Rubber Co., 133 North 2nd St., Philadelphia, has awarded the contract for the construction of a 2-story, 120x120-ft. factory to the Hogg Constr. Co., Denchla Bldg., Philadelphia.

South Dakota

ARLINGTON—The Bd. Educ. is having plans prepared for the construction of a 2-story L-shaped grade and high school. A chemical laboratory will be installed in same. Estimated cost, $100,000. Howard Parsons, 600 Builders Exch., Minneapolis, Minn., archt.

Tennessee

MEMPHIS—The Blount Pipe Works, 149 South Front St., plans to construct a 2-story, 50x90-ft. building at 146 Front St. O. E. Hamilton, local engr.

MEMPHIS—The Plough Chemical Co., 122 South 2nd St., is in the market for additional manufacturing equipment. Estimated cost, $50,000.

Virginia

NORFOLK—The Western Electric Co., 302 McKevitt Bldg., plans to build a reinforcement cable plant on a 17-acre site opposite the Navy Yard. F. W. Willard, Western Electric Company's Hawthorne station, Chicago, engr.

Wisconsin

KAUKAUNA—The Thilmany Pulp & Paper Co. will build a [illegible] addition to its plant. C. C. Hoskins, chief engr. Work will be done by day labor.

MILWAUKEE—The Modine Manufacturing & Mfg. Co., 912 So. Lake Bldg., has awarded the contract for the erection of a factory, 80x140-ft. facades on Prospect Pl., to J. M. Cook, 5148 Vel Rose Ave. Estimated cost, $75,000.

RACINE—S. C. Johnson & Son, 1012 16th St., will soon award the contract for the construction of a 4-story, 60x160-ft. warehouse and varnish plant on 16th St. A Guilbert, Robinson Block, archt. Kalbperry Corp., 31 Union Sq., W., New York City, engr.

WEST ALLIS—The Interstate Steel & Mfg. Co., 705 South Pierce St., Milwaukee, will build a 1-story, 80x200-ft. fabricating shop at 47th and Rogers Sts. Work will be done by day labor.

Manitoba

WINNIPEG—The Canadian Government plans to install equipment to sterilize the water supply by ultra violet rays at all the public institutions here. G. Griexson, minister of Pub. Wks.

Ontario

FORT WILLIAM—The Canada Iron Foundries Ltd., has awarded the contract for the construction of a 1-story, 46x80-ft. foundry, to M. H. Bradan, Francis Block. Estimated cost, $20,000.

WINDSOR—The Essex Co. Tuberculosis Sanitarium, c/o Mrs. H. R. Casgrain, pres., plans to build a 2-story sanitarium. Medical equipment for tubercular treatment will be installed in same. Estimated cost. $100,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN CHEMICAL SOCIETY, N. Y. Section, will hold a regular meeting June 11, at the Chemists' Club.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its midsummer meeting at Boston, July 15 and 16.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

Manufacturers' Catalogs

THE NATIONAL COMPRESSED AIR MACHINERY Co., Los Angeles, Cal., calls attention to Bulletin No. 20, devoted to National class "D" vertical air compressors. Described, together with some illustrations, are compressors as follows: Duplex, vertical balanced construction, permitting of high speeds, high capacity per unit of weight and floor space, and freedom from vibration; three main bearings, carried on the main frame, and fitted with laminated shim brass of 0.002-in. thickness; single acting type, eliminating stuffing boxes, but embodying the National combined piston-cross-head feature, with its attendant pump automatically controlled cylinder lubrication—not an oiler or grease cup on the machine. The valves are a happy medium between the old, heavy, self-destructive poppet type and many of the later delicate, so-called plate types. Inlet and outlet valves are interchangeable. One extra is furnished with each machine, and any broken valve replaced free for two years from shipment of compressor. The dimensions of the extra heavy shaft are published in the bulletin that all may see. Shaft is keyseated on both ends, making it a truly right and left hand machine as shipped. May run in either direction at will. Water jackets completely surround the cylinders and heads, including the discharge valve caps.

New Publications

REFRACTORY MATERIALS AS A FIELD FOR RESEARCH. By Edward W. Washburn. Reprinted from the *Journal* of the American Ceramic Society of January, 1919, vol. 2, No. 1, by the National Research Council, reprint No. 3, price 30c.

NITROGEN: ITS FIXATION, ITS USES IN PEACE AND WAR. By Grinnell Jones. Reprinted from the *Quarterly Journal of Economics*, vol. 34, May, 1920, Harvard University, Cambridge, Mass.

LIST OF REFERENCES ON DYESTUFFS, CHEMISTRY, MANUFACTURE, TRADE. Compiled under the direction of Herman H. B. Meyer. From the Library of Congress, Government Printing Office. Price 15c.

The Inco is the title of the publication of the International Nickel Co., vol. 1, No. 1 of which appeared in February, 1920.

TNT AS A BLASTING EXPLOSIVE. By Charles E. Munroe and Spencer P. Howell. Dept. Circular 94, U. S. Department of Agriculture, Washington, D. C., issued, May, 1920.

THE ELECTRIC FURNACE AS APPLIED TO METALLURGY. Reprinted from the *Transactions* of the American Electrochemical Society, vol. 37, 1920, by Arthur D. Little, Inc., Cambridge, Mass., and known as Bibliographic Series No. 4.

A CHEMICAL SURVEY OF THE NATURAL GASES OF KANSAS AND OKLAHOMA. By H. C. Allen and E. E. Lyder. Engineering Bull. No. 11, published by the University of Kansas, Lawrence, Kan.

ELECTROMETALLURGICAL AND ELECTROCHEMICAL INDUSTRY IN THE STATE OF WASHINGTON. By Charles D. Grier. Engineering Experiment Station Series Bull. No. 5, University of Washington, Seattle, Wash.

AN INVESTIGATION OF THE PROTECTIVE VALUES OF STRUCTURAL STEEL PAINTS. By J. S. Coye. Bull. 54, Good Roads Section, Engineering Experiment Station, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa.

THE RELATION BETWEEN THE ELASTIC STRENGTHS OF STEEL IN TENSION, COMPRESSION, AND SHEAR. By Fred B. Seely and William J. Putnam. Bull. No. 115, Engineering Experiment Station, University of Illinois, Urbana, Ill. Price 20c.

THE FOREST PRODUCTS LABORATORY, Madison, Wis., has published the following: "The Use of Fluorides in Wood Preservation"; 14 pages, with tables and bibliography; discusses in detail the results of experiments in Europe and America, and shows that sodium fluoride has considerable preservative value. "Automatic Regulation of Humidity in Factories," 4 pages, illustrated; reprint from *Scientific American Monthly*, January, 1920; describes apparatus developed at the Forest Products Laboratory for automatic control of moisture content in wood products during manufacture. "Wood Ashes and Production of Potash," 5 pages, illustrated; reprint from CHEM. & MET., Nov. 12-19, 1919.

THE BUREAU OF FOREIGN AND DOMESTIC COMMERCE has published the Commercial Handbook of China, by Julean Arnold, in two volumes, with a total of 1,100 pages.

STATE AMERICANIZATION. By Fred Clayton Butler. Bull. 1919, No. 77, published by the Bureau of Education, Department of the Interior, Washington, D. C.

COMMUNITY AMERICANIZATION, a handbook for workers. By Fred Clayton Butler. Bull. 1919, No. 76, published by the Bureau of Education, Department of the Interior, Washington, D. C.

U. S. TARIFF COMMISSION PUBLICATION: Tariff Information Series No. 14, The Incandescent Gas-Mantle Industry.

NEW FEDERAL BOARD OF VOCATIONAL EDUCATION PUBLICATIONS: Bull. 45, Job Specifications; Bull. 46, The Turnover of Labor; Bull. 47, Industrial Accidents and Their Prevention.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONSS I: A, The Work on Mineral Resources Done by the U. S. Geological Survey, by Edson S. Bastin and H. D. McCaskey (Mineral Resources of the U. S., 1918, Part I), published March 31, 1920; I: 15, Gold, Silver, Copper, Lead and Zinc in Arizona in 1918, by V. C. Heikes (Mineral Resources of the U. S., 1918, Part I), published Feb. 20, 1920; I: 16, Gold, Silver, Copper, Lead and Zinc in Utah in 1918, by V. C. Heikes (Mineral Resources of the U. S., 1918, Part I), published March 4, 1920; I: 17, Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1918, by Charles G. Yale (Mineral Resources of the U. S., 1918, Part I), published Feb. 24, 1920; I: 18, Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1918, by C. N. Gerry (Mineral Resources of the U. S., 1918, Part I), published Feb. 27, 1920; I: 21, Secondary Metals, by J. P. Dunlop (Mineral Resources of the U. S., 1918, Part I), published April 9, 1920; I: 25, Copper in 1917, by B. S. Butler (Mineral Resources of the U. S., 1917, Part I), published March 13, 1920; I: 26, Gold, Silver, Copper, Lead and Zinc in Colorado in 1917, by Charles W. Henderson (Mineral Resources of the U. S., 1917, Part I), published March 1, 1920; II: 18, Potash in 1918, by W. B. Hicks (Mineral Resources of the U. S., 1918, Part II), published March 31, 1920; II: 19, Asphalt and Allied Substances in 1918, by C. C. Osbon (Mineral Resources of the U. S., 1918, Part II), published March 31, 1920; II: 20, Mineral Waters in 1918, by Arthur J. Ellis (Mineral Resources of the U. S., 1918, Part II), published March 19, 1920; II: 21, Architectural Concrete Stone and Concrete Blocks in 1917 and 1918, by G. F. Loughlin (Mineral Resources of the U. S., 1918, Part II), published March 16, 1920; II: 22, Strontium in 1918, by George W. Stose (Mineral Resources of the U. S., 1918, Part II), published March 30, 1920; II: 23, Asbestos in 1918, by J. S. Diller (Mineral Resources of the U. S., 1918, Part II), published March 20, 1920; II: 24, Talc and Soapstone in 1918, by J. S. Diller (Mineral Resources of the U. S., 1918, Part II), published March 29, 1920.

NEW BUREAU OF STANDARDS PUBLICATIONS: Scientific Paper No. 356, Microstructure of Iron and Mild Steel at High Temperatures, by Henry S. Rawdon and Howard Scott, issued March 15, 1920; Scientific Paper No. 367, Turbidity Standard of Water Analysis, by P. V. Wells, issued March 17, 1920; Scientific Paper No. 371, A New Cadmium-Vapor Arc Lamp, by Frederick Bates, issued April 10, 1920; Scientific Paper No. 372, Wave Lengths Longer Than 5,500 A in the Arc Spectra of Seven Elements, by C. C. Kiess and W. F. Meggers, issued May 7, 1920; Scientific Paper No. 375, The Double-Polarization Method for Estimation of Sucrose and the Evaluation of the Clerget Divisor, by Richard F. Jackson and Clara L. Gillis, issued March 30, 1920; Scientific Paper No. 376, Critical Ranges of Some Commercial Nickel Steels, by Howard Scott, issued April 6, 1920; Scientific Paper No. 377, Intercrystalline Brittlesness of Lead, by Henry S. Rawdon, issued April 6, 1920; Tech. Paper No. 155, Cements for Spark-Plug Electrodes, by Homer F. Staley, issued Feb. 21, 1920; Tech. Paper No. 156, Metallographic Features Revealed by the Deep Etching of Steel, by H. S. Rawdon and Samuel Epstein, issued March 19, 1920; Tech. Paper No. 158, A Peculiar Type of Intercrystalline Brittleness of Copper, by Henry S. Rawdon and S. C. Langdon, issued April 10, 1920; Tech. Paper No. 159, Porosity and Volume Changes of Clay Firebricks at Furnace Temperatures, by George A. Loomis, issued April 26, 1920; Tech. Paper No. 161, by W. B. Newkirk, issued April 6, 1920.

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

Volume 22 — New York, June 16, 1920 — *Number* 24

And the Mountain Labored And Brought Forth—Harding

HERBERT HOOVER was not nominated for President by the Republicans at Chicago last week. Instead the country was treated to an anticlimax in political affairs the like of which has not been witnessed in a generation. We claim no astuteness as political observers or prophets, but it requires no seventh son of a seventh son or veiled seer to detect the machinations of the Old Guard in determining for the members of a great political party their nominee for the Presidency. It would be to laugh were it not so pitifully tragic. And had better material been lacking, the mediocrity of the successful candidate would not have been so painfully evident as it now is by contrast with the superiority of some of his opponents.

The *dénouement* is the best argument yet produced for some device that will enable the American people to select a President with some consideration for his fitness for the job. HERBERT HOOVER'S candidacy was in effect a protest against the old régime, and the popular support which unquestionably was his throughout the country was a rally to that protest. We need waste no words of denunciation over what was done at Chicago, but we cannot be blind to the need, more insistent than before, of a new type of thinking in national affairs.

No group of engineers or technically trained men would be guilty of such a monstrous farce as was perpetrated at Chicago last week. They do not select an artist to design and build a bridge nor a dispensing druggist to operate a great chemical works; nor would they pick a second-class politician to direct the complex affairs of a great nation. Their training and experience naturally protest against the selection of anyone unfit for his duties.

It is indeed time that the voice of the engineer be heard in public affairs. We know that his methods and policies will not please the orthodox political leader, but we are quite cetain that the results of his labors will be to the advantage of the country. Unless there be something in political life which leads men to forsake the dictates of their best judgment, we believe that engineers would select men with something of the same care and particularity that they now apply to materials of contruction. The same powers of logic and analysis that they now bring to bear on the solution of a scientific problem would be applied in diplomacy and statesmanship; and their previous success in professional work would be a recommendation worth considering.

Somehow the longer we contemplate the Republican national convention, the prouder we are of the conference of engineers in Washington when the Federated American Engineering Societies was formed.

Congressional Acts of Omission

WHATEVER may be one's personal opinion and preference on the Treaty of Peace and the League of Nations, and the merits of the controversy between the President and the Senate, it is impossible to escape the conviction that commerce and industry have suffered because Congress was so embroiled in a political fight that it failed to give attention to the industrial needs of the nation. Legislation of the utmost importance was sidetracked while eloquent Senators paid their respects to members of opposing political parties, with the result that Congress adjourned *sine die* without enacting vital legislation on which a vast amount of time and energy had been spent. The so-called dye bill designed to foster and protect the domestic coal-tar industry was filibustered to death by Senator THOMAS, who apparently is a blind opponent of protection to American industry. It may be that the proponents of the bill were too anxious and too confident, and that their own testimony gave basis for the belief that a monstrous monopoly would be established. And we know how odious an industrial monopoly has been in recent years. It is further evident that the conflict of interest between the makers and users of dyes prevented harmonious support of a tariff program.

All other tariff bills relating to minerals, glass, porcelain, apparatus, etc., died without action.

The water-power bill was passed by both houses of Congress, and those who had worked so insistently for twelve years to secure legislation on this subject hoped that their labors would be rewarded. It was unfortunate, therefore, that the President, for whatever reason, failed to sign the bill before Congress adjourned. Possibly this was due to the fact that the Departments of War, Agriculture and the Interior were concerned with the bill and were unable to approve it for signature in due time. The Attorney-General is reported to have stated informally that the President has ten days following the adjournment of Congress in which to sign bills, but no official pronouncement has yet been made. Water-power development in the United States is therefore delayed for another year or two—a period during which we may expect high prices for coal and labor, and one in which the development of economical power will be most urgent.

The bill to establish the United States Fixed Nitrogen Corporation was, at the last moment, favorably reported to the Senate. This gives it the advantage of a position on the calendar, but the long delay which must ensue in its further consideration, during which time the Government nitrate plants must remain idle, is greatly to be regretted.

The bill to increase the force and salaries in the

Patent Office also died without action. This is greatly to be regretted, because salaries in the Patent Office are woefully inadequate and the service is suffering by the resignation of men who can no longer enjoy the luxury of working for the Government. We are less sympathetic, however, with the other patent bill, authorizing the Federal Trade Commission to accept and administer, for the benefit of the public, inventions, patents and patent rights. Such a bill passed the Senate March 22, and was on the House calendar for consideration. In modified form it was saddled as a rider onto the salaries bill. Whatever may be the merits of this proposal, they seem at first glance to be outweighed by obvious objections.

Practically the only act of Congress in which chemists can take any satisfaction was the passage of the Army reorganization bill, in which provision was made for the retention of the Chemical Warfare Service as a separate unit. This was accomplished after all hope seemed to be lost, and in spite of the unsympathetic attitude of the Secretary of War and the Chief of Staff. That Congress was able to see the light as presented by proponents of the measure is greatly to its credit.

The Relation of Botany to Chemistry

IN A late number of the *Journal* of the Society of Chemical Industry J. B. FARMER called attention to the rather neglected relations between economic botany and chemical industry. He urged a more intense consideration of the subject, and we second the motion.

In a popular article lately published in the *Saturday Evening Post* Dr. HERBERT C. HOOVER called attention to the fact that our leading economic requirement today is to make agriculture produce and thrive. The situation is that unless we grow our own food and clothing we must buy material for these needs abroad, and the obligation to do this will put us in the position in which England and Germany were before the war. We shall be competitive buyers of food and clothing in foreign countries and as one of the earth's industrial nations we shall need to maintain a great navy to keep the best markets open to us, we shall be in constant strife with our neighbors for advantage in this respect and the outlook for living on terms of amity with them will become cloudy. On the other hand, if we produce our own food and raiment, we can manufacture as much as we can find a market for and there will be nothing to hinder us from living in peace and good will toward all and from all. He emphasized, as the greatest hazard to this desired condition, the invasion of agriculture, which has been in process for some time, by industry. If industry draws labor away from the farms, the farms cannot produce.

There are also other sides to the relation of agriculture with industry, and one of these is the needed introduction of engineering into farming. Our land does not produce what it should produce, and if good results are to be obtained this must be at least doubled. It can be done, provided we go about it intelligently; but it will require competent engineers to turn the trick. An example of such development is shown by the great area of former swamp land in western New York which was reclaimed under the brilliant leadership of THEODORE ELY KNOWLTON, of Rochester, a well-known engineer. The results showed increased values, agricultural wealth and more particularly increased production that were materially greater than was anticipated. Given the same wages, most men prefer to work in industry in cities to working on farms in the country. Why is this? Men tend to huddle together rather than to disperse like molecules in a gas. If we apply BOYLE'S law we shall recognize that this decrease in volume is due to increased pressure from without, and it is easy to learn that this pressure is due to a desire for freedom during hours of leisure, to a wish for fixed hours, to a desire for gossip, and to see lights at night, and because women are even more urgent than men in this respect. All these things may be had in industrial farming, and industrial farming is a problem of engineering, in its lay-out. But industrial farming is impossible without better yields, and better yields demand research in botany and biological chemistry and in the physiology of plants. Given a large industrial establishment with enough produce to look out beforehand for markets and distribution, with contented workmen, with control laboratories and research constantly in process, and it can succeed where the single farmer with a hundred and sixty acres of diversified products will fail. It will require thought and education and intelligence and imagination and administrative ability; but what are engineers for if not to supply these very requirements? With botany and chemistry wedded to engineering, industrial farming and abundant yields will become possible. In our number of June 2 we published an article by Dr. MILTON WHITNEY that told clearly how, under proper control, the economical use of fertilizers may be improved. What is needed is the very quality of intelligence that industrial farming can and probably will call to its aid.

Another side to the co-ordination of botany with chemistry is in the furnishing of raw materials for chemical industries. These come only in part from mines. There is a report of certain hybrid trees similar to spruce that grow with great rapidity, maturing within less than half the time of ordinary wild spruce. The meaning of such an achievement to the paper industry is of immense importance—but we have yet to learn of a confirmation of the report or of any excitement in the paper industry over the possibility of such a botanical masterstroke.

The best quality of book and magazine papers may be made economically from bamboo, and bamboo grows in the United States on the mainland and in great abundance in its possessions, but we don't seem to be bothering much about the nature and varieties of the shrub, despite the paper famine.

Occasionally we learn of organic chemical products that heretofore have been synthesized only with the greatest difficulty and at high cost, which are available in large quantities in certain kinds of plants. We don't even know why these substances are found there and we are greatly surprised when we learn it. As soon as we do we repair straightway to the earth-and-sun product for our intermediate material, instead of beginning with benzene or naphthalene, working an interminable time, and then getting only restricted yields. If we knew more about plants we should know where to get many products that are now hard to obtain.

The soil offers us raw materials in perpetuity. Isn't it worth while to see what it has to offer and to look into its capacity to supply us with many things we need? Sometimes botanists bring great gifts. There was CHARLES DARWIN, for instance. He was a botanist.

Minerals Separation Forestalled In Contempt Proceedings

JUDGE BOURQUIN'S decision dismissing the contempt proceedings brought by Minerals Separation, Ltd., against the Butte & Superior Co. appears upon another page. The complainants charged that Butte & Superior was using less than 1 per cent of oil in violation of the Court's injunction.

This decision—in which the complainant, Minerals Separation, Ltd., is "remitted to some one of the familiar methods to secure determination upon the merits of these alleged infringements" and is told that it "cannot be permitted to transfer the controversy from merits to contempt"—is of general interest because it is a check upon the tendency which Minerals Separation, Ltd., has developed to assume proprietorship of all flotation, because of the *result*. This assumption is contrary to the Supreme Court's decision in the Butte & Superior case, in which the court distinctly states that Minerals Separation, Ltd., is entitled to protection on a *process* and not on a *result*.

The decision is of particular interest, coming, as it does, just as an exactly similar attempt is being made to have the Miami Copper Co. declared in contempt.

Elimination Examinations Suit the Mirror Minds

REPORTS from the colleges throughout the country indicate that during the past year students in unprecedented numbers took up the study of chemistry. Everywhere both laboratory facilities and teaching staffs were strained. To meet the situation some institutions immediately enlarged both laboratories and staffs, some gave examinations to eliminate the excess of students, some did both and some did nothing with the result that their educating effectiveness was considerably reduced. Of these four measures, only the first can be approved, the second should not be tolerated, the third may be excused with certain reservations, while the fourth should not be awarded the dignity even of consideration.

The passing of both rigid entrance qualifications and examinations should be required and no larger classes formed than can be efficiently taught. It is altogether a too common practice to allow an excess initial registration and then after a month or so flunking all but the number for whom apparatus can be provided, leaving a lot of men stranded at a critical time. Some institutions are reported to have made as high as 40 per cent reductions this year in chemical courses apparently without a thought of their true obligations.

The reason why the elimination of excess students by means of examination grades alone should not be approved will readily be seen from the following:

A few years ago the dean of a well-known university in looking over the grades found that the examination marks of four Chinese students were suspiciously alike. He immediately sent for their examination papers and upon comparing them found they were so nearly identical that three must be copies of an original. In order to find which ones were the rogues, the Chinese were told that their examination papers had been lost and it would be necessary for them to write them over again. Every precaution was taken to catch any signs of communication among them, but not a trace of cheating was observed. When the second examination had been finished the dean was astonished to find that he had not solved the question, for he had four more identical papers. The perplexity was eventually solved by finding that all four Chinese were honorable copiers, each having memorized the language of their texts.

From their complicated language the Chinese have received an exceptional amount of memory drill, which soon becomes a phenomenal quantity if further exercised in stowing away an American college education. Such a development of memory produces a mirror mind, which reflects all that enters it with ease. In some professions, such as acting, the mirror mind is at a premium, but in the practice of the sciences it may be quite mediocre. Yet the grades received from most any examination possible to devise are to an important extent a function of mirror mindedness. Therefore they should not be a prime factor in determining whether or not a student can profitably use his time studying a science, chemistry at any rate.

In reporting the final grades of Chemistry Y to the professor in charge, a young assistant felt very enthusiastic because every student had received a mark above that required for passing. He was very much upset when his superior not only did not reciprocate, but began scanning the list with a view of getting at least a man or two. Muttering to himself, "This will never do. What will the dean think of this course if I pass everybody?" the professor finally picked out SMITH, who had only a snug margin over the flunking line. Knowing SMITH'S case well, the assistant took up his defense, stating that while SMITH was not as brilliant in expressing himself in an examination as the others, he had worked harder than most of the men in the course and merited passing. In after years SMITH was numbered within the few of that class who made successful use of their chemical training.

It is obvious that if SMITH'S class had been too large to suit stinted college facilities, he would have been one of the first to fall before the elimination examination. Some other standard of sizing up students is needed, and if any are to be eliminated from continuing the chemical courses, it should be the ones who are not putting all their efforts into their work and just get by with the aid of a mirror mind. The young stuttering Demostheneses should not be sacrificed because they lack a nimble tongue at examination time.

Cleaning Up Mexico—With Soap

STATISTICS are proverbially dry and uninteresting, and even the curious would scarcely look for anything startling in figures showing domestic exports of soap from the United States. But we submit that there is food for thought in the fact that in April of this year of grace we sent 2,352,313 pounds of soap to Mexico. This was one-fourth of our total exports of soap. Visions of the great unwashed should fade before such evidence of cleanliness, for it may safely be assumed that the commodity is used in processes of ablution. And if it be true that cleanliness holds among the virtues the exalted position usually ascribed to it, our southern neighbors are perhaps more godly than we thought. Here are possibilities, maybe, undreamed of by statesmen, soldiers and missionaries. What a simple process of regeneration and conversion—moral and spiritual! How delightful the transformation through unction applied to body and soul; superior to bullets and less distressing than gas. The chemist may yet be called upon to clean up Mexico.

Western Chemical & Metallurgical Field

Liberty Potash Co. in Receiver's Hands

The Liberty Potash Co., which was organized by Salt Lake City interests for the extraction of potash from leucite in Wyoming, is in the hands of the Bankers Trust Co. as receiver. Efforts are now being made to re-finance the company with the intention of putting the plant in operation again. It is reported that about $800,000 was raised originally for the construction of the plant at Green River, Wyo., and that subsequently an indebtedness of about $300,000 was contracted in its operation, making a total of $1,100,000 represented in the venture.

The lack of adequate technical direction in the design and operation of the plant is assigned as one of the reasons for the failure of the company. Potash in the form of chloride equivalent to 35 per cent K_2O was produced to the extent of about twenty-one carloads, and proved to be an excellent material for fertilizer, and it is still believed that the process can be operated with sufficient skill and economy to make this product at a profit under present market conditions. In brief the process consists in volatilizing KCl by calcining leucite with lime rock and sodium chloride in the ratio 60: 30: 10, and catching the volatilized chloride in bags.

Photographic Chemicals Being Produced on the Pacific Coast

The production of the so-called "modern" photographic developers in this country is a recent achievement and marks a step in the advance toward our chemical independence. Previous to 1915, for instance, all of the "metol" used by American photographers was imported, being produced almost entirely in Germany, a relatively small portion being made in France. When the importation of this largely used developer was cut off, "serchol," which was manufactured in England, was offered and used extensively as a substitute.

It seems to be the consensus of opinion that "metol" of the highest purity has advantages not possessed by other developers, and the production of this chemical was undertaken by many chemists and chemical manufacturers during the last four years, but until recently without great success. A very satisfactory grade of metol is now being made by the American Chemical Co., of San Francisco, and is largely used by the motion-picture studios near Los Angeles as well as being supplied to the general trade. The process by which it is made was developed by W. J. Van Sicklen, and he has also been successful in the production of hydroquinone and other photographic chemicals, together with a few allied pharmaceuticals.

Until recently practically all of the heavier photographic chemicals used in the West have been made in the East. The Arthur R. Maas Chemical Co., of Los Angeles, has developed a process for the manufacture of and is now producing considerable quantities of "hypo" and sodium sulphite.

The "metol" and "hypo" are being produced from raw materials obtained locally or else imported directly from the Orient to Pacific Coast ports. This indicates that the chemical industry in this section of the country has advanced to an extent sufficient to supply materials needed in the manufacture of the more refined chemical products.

Fuel Oil Becoming Scarce and Expensive

Failure of existing and prospective oil fields to maintain equality of production to the consumption of petroleum products has been predicted by reliable authorities. The truth of this is already becoming apparent and the situation is acute in certain parts of the country. In March of this year the Standard Oil Co. (California) increased the price of fuel oil 25c. per bbl. and of gasoline 2c. per gal., at the same time paying an additional 25c. per bbl. for crude oil at the wells. In announcing this advance the company stated that an increase in prices was the only known and tried means at its disposal that would bring about an increased production of crude oil, prevent the shipment of fuel oil and gasoline to competitive markets and at the same time restrain demand. In January, 1920, the output of California's refineries amounted to about one-tenth of the gasoline and one-quarter of the fuel-oil production of the United States. It is but a question of time until conditions such as now exist in California will be reflected throughout the country and ultimately result in becoming a question of national importance, since there is now lacking an adequate means of effectively combating the situation.

Power derived from fuel is becoming increasingly expensive and the consumer of power so obtained must face an uncertainty in the supply, this being particularly true of that from fuel oil. Recent experiences, the result of strikes affecting transportation and the production of fuels, have brought this forcibly to attention. In establishing new industries, the source of power and the effect of increased consumption on the future costs are factors which must be given consideration; more particularly will increased power costs adversely affect electrochemical industries.

The Resources of Colorado

In a recent address before the Denver Commercial Club, Charles C. Gates showed that the state possesses 1,000,000 undeveloped hydro-electric hp. according to the U. S. Geological Survey, 383,000,000,000 tons of unmined coal and vast oil shale deposits which have been shown to hold seventeen times as much oil as taken out in the wells of the United States since 1857.

With charts prepared by the Denver Gas & Electric Co., he demonstrated that Denver's power is supplied at cheaper cost than that prevailing in the Atlantic States, Eastern Central States, and Western cities except Los Angeles, which has the lowest power costs in the country. Aside from the production of the metals, Colorado offers many possibilities to the chemically-controlled industry.

Copper and Magnetite in Copper Smelter Slags—I

Chemical and Microscopic Examination of a Series of Representative Slags, Showing How Copper Losses Occur, the Relation of Magnetite to Copper Loss, the Behavior of Converter Slags in Reverberatory Furnaces and Suggestions for Reducing Copper Slag Losses

BY CHARLES G. MAIER AND G. D. VAN ARSDALE

TODAY'S urgent necessity for the maximum economy of operation of all basic industries should renew the interest of metallurgists in smelter losses. Maximum production being no longer an immediate *sine qua non*, a critical examination of even those losses which ordinarily are deemed at a minimum is entirely justified.

In considering the problem of metal loss in copper smelter slags, two aspects are pre-eminent: How far is satisfaction with a conventional average 0.3 or 0.4 per cent copper loss in reverberatory or blast-furnace slags justifiable? and, What should be done with secondaries? In attempting an answer to these or similar questions, one may search technical files in vain for such fundamental information as the actual condition in which copper exists in slags, or even as to just what happens when converter slags are poured into reverberatories.

Such information as is available is usually the result of personal experience in the operation of furnaces. Thus one person may postulate that, because he has had trouble with unsettled prills of matte in slag, such constitute the serious source of loss, if not its totality, while another who has had matte-clean slags suspects only the presence of oxides in the silicate portion of the melt, and still others suspect, but do not explain, some relationship between magnetite in slags and copper loss. All are correct in degree, but a comprehensive theory to account for empirical facts, and based on close examination of the actual materials themselves, is lacking and would seem to be highly desired.

In a previous article[1] the authors have attempted to show that while chemical methods of attack, when used alone, are inadequate for the development of any comprehensive theory, a combination of chemical and microscopic methods seems capable of furnishing much new and interesting information. After a brief discussion of previously published material, the article mentioned points out the manner in which the copper constituents and the magnetite in reverberatory, blast-furnace and converter slags may be classified, and presents experimental evidence for distinguishing the various forms of inclusions, etc.

While this previous work was entirely confined to samples representative of the practice at that time in various Phelps Dodge Corporation branches, opportunity has since been had to extend the examination to various other slags produced at copper matte-smelting works, and moreover work has been done on samples from reverberatories taken during the admixture of converter slag. This latter work in particular throws much light on previously obscure relationships between copper loss and magnetite or ferric iron, and has led to the attainment of a mental picture of various phases of matte smelting which should be of general interest.

[1] ENG. AND MIN. J., May 10, 1919, vol. 107, p. 815; abstracted in CHEM. & MET. ENG., vol. 21, pp. 46 and 61.

RESUMÉ OF PREVIOUS WORK BY THE AUTHORS

Inasmuch as the discussion of the work described in the present article is very closely related to previous results, the following brief summary of the latter is given.

It was found that in the reverberatory and blast-furnace slags examined there was present but one microscopically visible form of copper—namely, a matte *residue*. Matte on solidification seems to be primarily a two-constituent material, containing an iron sulphide constituent saturated with copper sulphide, and a copper sulphide constituent saturated with iron sulphide or metallic copper. The latter phase is equivalent to white metal and it is this part of the original matte which is visibly distinguishable as pellet-like inclusions in the slag. Quantitative chemical methods, devised to determine the amount of these pellets, accounted for only a part of the total copper, the difference being copper dissolved in the silicate portion of the slag. The amount dissolved was found to be approximately constant and between 0.15 and 0.20 per cent. Further chemical and microscopic evidence indicated the dissolved content to be present as sulphide. The facts that the visible pellets of copper sulphide were only rarely matte and usually white metal, the disappearance of the iron sulphide constituent being accompanied by the presence of gas bubbles, tending to keep the pellet afloat, were taken to indicate chemical reactivity with the formation of sulphur dioxide. The reaction was concluded to involve the oxidation of iron sulphide, or possibly copper sulphide by ferric iron.

In converter slag a larger portion of the copper content was found to be the pellet form of white metal, although the dissolved content was in these slags varied, averaging from 0.1 to 0.5 per cent copper.

Of great importance in relation to our present work was the classification of slags according to the magnetite crystals occurring therein, as follows:

1. Slags without visible magnetite crystals typical of blast-furnace or extremely rapidly chilled reverberatory slags.

2. Slags showing magnetite crystals formed during solidification, typical of usual reverberatory slags.

3. Slags with well-formed, clean-cut and large magnetite crystals, formed during the molten condition, typical of converter slags.

EFFECT OF ADDING CONVERTER SLAGS TO REVERBERATORIES

In March and April, 1919, a series of reverberatory slag samples was taken at the Copper Queen smelter, representing the condition of slag at time intervals, before and after the addition of molten converter slag. The microscopic and chemical examination of these samples in the light of previous work on the classifica-

tion of copper losses and magnetite crystal forms has led to some interesting results.

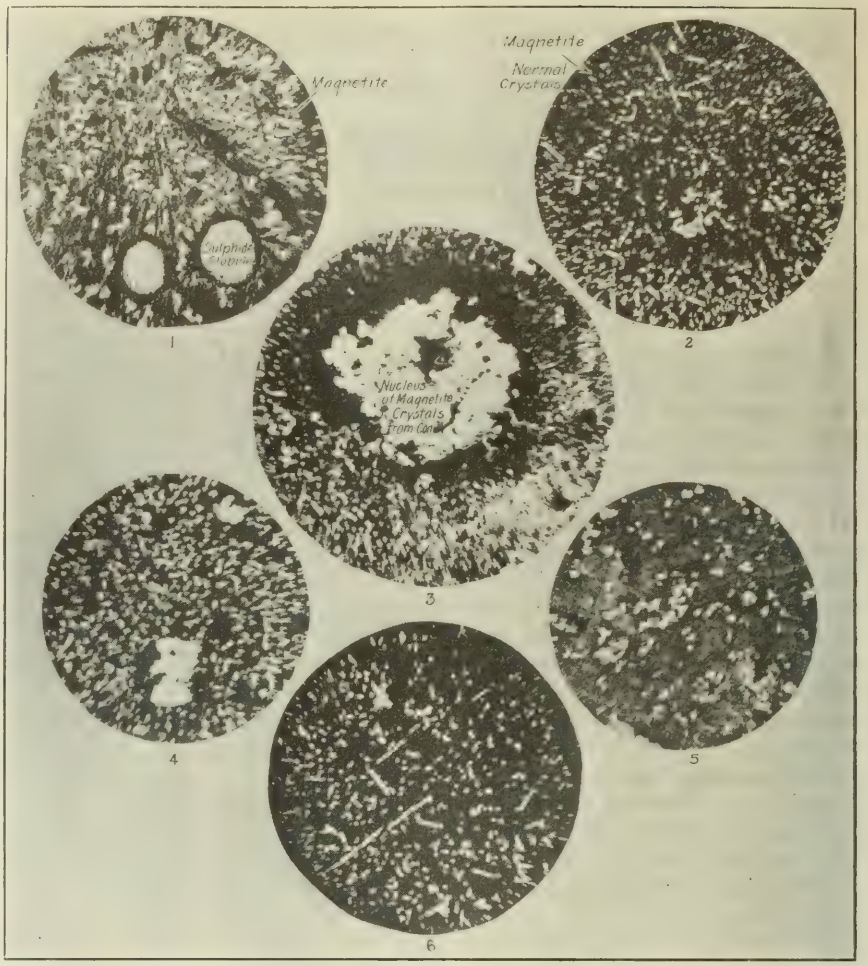
A cursory microscopic examination of these samples, which were taken at the time of converter-slag pour, and at lapses of ten, twenty, thirty and forty minutes, shows no unusual condition as far as copper content is concerned, except for the presence of some metallic inclusions (which will be discussed below). Consequently the chemical method for distinguishing between the total dissolved and pellet copper (silver nitrate method described in previous article) was considered a satisfactory criterion for the chemical determination of the effect of the addition of converter slag to reverberatories. Table I shows the results obtained.

The effect of the admixture on the copper content of the *mixed* slag is clearly indicated by the first row of figures, showing that the total copper content increases unmistakably. The increase is completely due, however, to an increase in the sulphide copper globule content. The third row of figures, giving the dissolved copper, shows practical constancy for the entire period of the test and even samples taken a month later, shown in the second part of the table, have an average dissolved copper content extremely close to the original.

If one assumes 0.06 per cent copper, as shown in the table, to be the normal globule content before the addition of converter slag, the last row shows an excess amount of globules, due to the addition, and of about the same order of magnitude as the normal, and even though the total amount of copper represented be small, the results seem to warrant the conclusion that the addition of converter slag was the cause of a definite increase in suspension not to be accounted for by the small percentage of secondary slag added.

There is no *a priori* reason discernible why the dissolved copper content of reverberatory slags should be changed by the addition of moderate amounts of converter slag, which affect only to small degree the composition and temperature of the melt. Theory and observation are in accord here. For the suspended globules, however, if previous theories of the reaction of sulphides of iron with ferric iron are correct, there should be found in the iron content of the slag the explanation of the increase of suspended copper noted in Table I.

The flotation effect due to the reaction of ferric iron with sulphides to form sulphur dioxide gas should be related to the ferric iron content of the slag. Microscopically it is possible that only a part of the ferric iron is visible as magnetite. Moreover, the magnetite, as revealed, is so variable as to render quantitative results from microscopic examination impractical, so that a chemical method of correlation was sought. The method finally chosen for the chemical determination of ferric iron in these slags was that of disintegration with hydrofluoric acid in the presence of an atmosphere of carbon dioxide. There are objections to this method, but details of procedure and the justification of the method for the present purpose will be found in the appendix.



FIGS. 1 TO 6. MICROSECTIONS OF SLAGS FROM COPPER QUEEN SMELTER
Fig. 1. Converter slag. Fig. 2. Reverberatory slag before addition. Fig. 3. Reverberatory slag, 10 min. later. Fig. 4. Reverberatory slag, 20 min. later. Fig. 5. Reverberatory slag, 30 min. later. Fig. 6. Reverberatory slag, 40 min. later. All microphotographs originally at 75 ×, reproduced at 40 ×. HF etching.

The results obtained are of first interest, as will be evident from the examination of Table II. As expected, there is a definite increase in the ferric iron content of the reverberatory slag after the addition of converter. Whether or not the total ferric iron content should be considered as magnetite is scarcely pertinent for the present discussion, for since magnetite is re-

TABLE I. COPPER IN REVERBERATORY SLAGS BEFORE AND AFTER ADDING CONVERTER

Sample and Time After Pour	Part I — Original Set of Samples						Part II — Same Furnace 1 Month Later		
	Reverb. at Pour 0	After Reverb. 10 Min.	After Reverb. 20 Min.	After Reverb. 30 Min.	After Reverb. 40 Min.	Convtr. at Pour 0	After Reverb. 25 Min.	After Reverb. 35 Min.	After Reverb. 45 Min.
Total Cu	0.28	0.36	0.31	0.33	0.32	3.77	0.35	0.27	0.32
Suspended Cu	0 06	0 13	0 09	0 10	0.11	3.27	0.11	0 07	0.08
Dissolved Cu	0 22	0 23	0 22	0 23	0 21	0 50	0.24	0 20	0.24
		Average 0.223					Average 0.23		
Abnormal* globule content	0 06 (normal)	0 07	0 03	0.04	0 05	....	0 05	0.01	0 02

*Suspended Cu globules after addition, minus normal suspended content.

TABLE II. IRON AND SUSPENDED COPPER IN REVERBERATORY SLAG BEFORE AND AFTER ADDITION OF CONVERTER SLAG

Sample Taken	Part I Original Test: Reverb. Slag at Pouring of Converter	Part I Original Test: After 10 Min. Pour	Part I Original Test: After 20 Min. Pour	Part I Original Test: After 30 Min. Pour	Part I Original Test: After 40 Min. Pour	Part I Original Test: Converter Slag Used	Part II Duplicate Test: After 20 Min. Pour
Total iron	29 26	29 64	29 69	30 26	27 78		34 26
Ferrous iron	27.79	27.28	27 13	28 09	25 85		31 89
Ferric iron	1 47	2 36	2.56	2 17	1.93	11 4*	2 37
Magnetite†	3.0	4.9	5.3	4.5	4.0	23 7*	4 9
Copper as suspended globules	0.06	0 13	0 09	0 10	0 11	3 27	0 11
Ratio Cu as susp. glob. / Ferric iron × 100	4.1	5 5	3.5	4.6	5.7		4.6
		Average 4.8± 0.8 A.D.‡					
		Total average 4.7± 0.7 A.D.‡					

*From photograph, not a chemical determination.
†Based on assumption of complete crystallization of ferric iron as such, probably unwarranted, but given for comparison with photograph.
‡A.D. = average deviation from mean.

active with sulphides, as proved by the appended photomicrographs, the total ferric iron is the real deciding factor in the suspension of sulphide globules.

Qualitatively there can be no doubt that an increase of ferric iron in slag is closely related to increased suspension, the third and fifth rows of figures in Table II indicating conclusively the coincidence of an increase of suspension with an increase of ferric iron.

That this relationship is quantitative as far as the accuracy of chemical determination enables one to judge is indicated by the figures of the last row. If the suspension of sulphide globules were strictly proportional to the ferric iron content

$$\text{Suspended Cu} \propto \text{Fe}'''$$

then

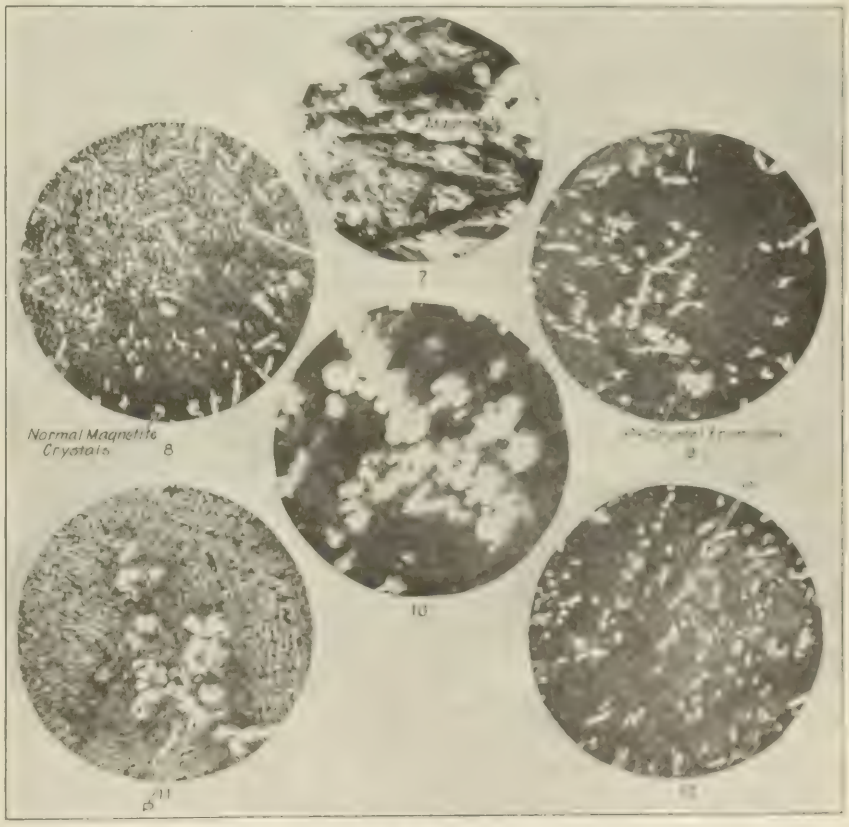
$$\frac{\text{Suspended Cu}}{\text{Fe}'''} = K$$

where K is a constant numerical ratio. This figure is the one given in the last row, and while these numbers do not show absolute constancy, the variation observed, indicated by the average deviation from the mean value, is approximately 15 per cent. Since the figures involve the determination of an amount of copper of the order of magnitude of 0.1 per cent, this deviation corresponds to an original error of 0.015 per cent copper, which is just about the limit of accuracy of the determination made, and consequently one is warranted in concluding that numerical proportionality exists between suspended copper and ferric iron in these tests.

From the microscopic point of view the above conclusions regarding the relationship of sulphide inclusions in slags to ferric iron is confirmed by the behavior with magnetite which may be actually observed upon examination of polished sec-

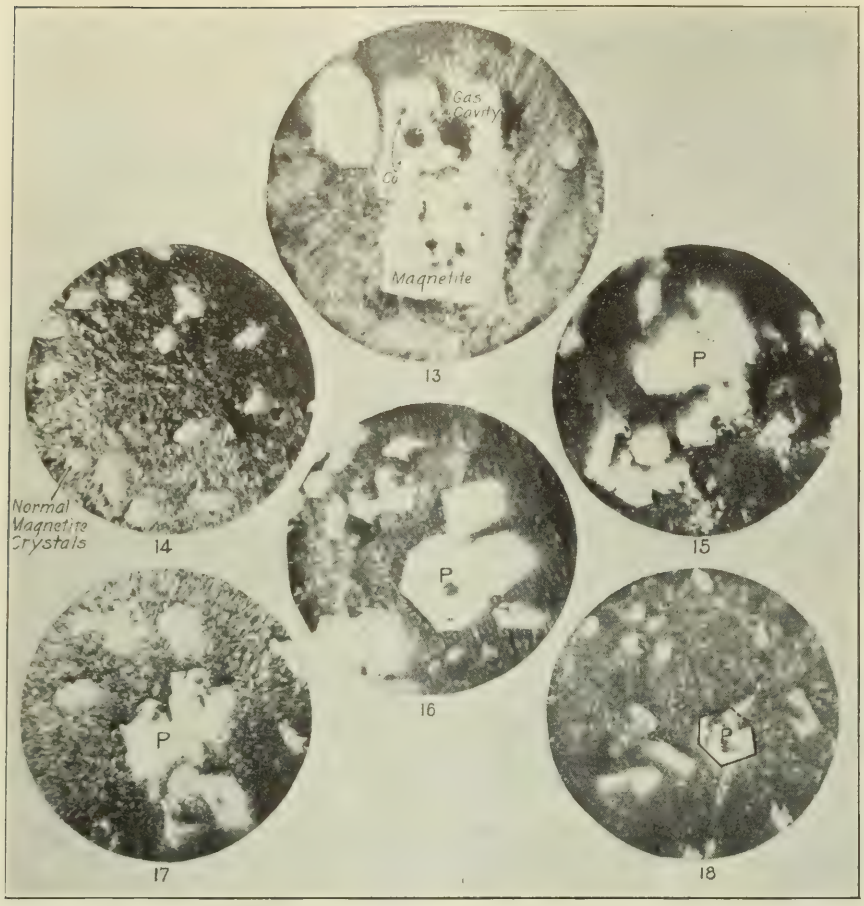
tions. Figs. 1 to 6 show pictures of the series of samples taken from 0 to 40 minutes after the addition of converter slag, which were taken at low magnification, and which serve more as an indication of the distribution of magnetite than as a true basis of comparison of its amount. The distribution is sufficiently uniform to serve as a quantitative guide without the use of an excessive number of observations. There are some points, however, of considerable interest. Compare, for example, the normal size of magnetite crystals (converter slag) in Fig. 1 with the normal size in Fig. 2 (reverberatory slag without the addition of converter), and it is apparent that the normal magnetite in reverberatory slag due to crystallization on solidification is considerably smaller in size than that occurring in the normal converter slag where crystallization takes place in a liquid medium. The fact that large crystals of magnetite, exactly similar in appearance to those which previous work has shown to exist in the fluid condition of converter slag, are found in the reverberatory after admixture can be taken to indicate that these particular crystals are the identical ones which existed in the liquid converter slag upon addition to the reverberatory. Furthermore, when after ten minutes' time from the addition large nuclei of highly magnetitiferous slag are seen in the reverberatory sample (Fig. 3), it is an obvious step to conclude that this condition represents the primary step in the assimilation of the converter slag by the reverberatory.

These agglomerates of magnetite crystals disappear with time, confirming the idea of some mode of disintegration of the magnetite other than silicate fluxing.



FIGS. 1 TO 12. MICROSECTIONS OF SLAGS FROM CUPELLATION ASSAYS AT HIGHER MAGNIFICATIONS

Figs. 1, Converter slag. Figs. 2, Reverberatory slag before addition. Figs. 3, Reverberatory slag 10 min. later. Figs. 12, Reverberatory slag at same time. All photomicrographs enlarged 50 diameters. Figs. 1 to 6 inclusive show magnetite crystals from converter slag.



FIGS. 13 TO 18. MICROSECTIONS OF SLAGS FROM COPPER QUEEN SMELTER AT VERY HIGH MAGNIFICATION

Fig. 13. Converter slag. Fig. 14. Reverberatory slag before addition. Fig. 15. Reverberatory slag, 10 min. later. Fig. 16. Reverberatory slag, 20 min. later. Fig. 17. Reverberatory slag, 30 min. later. Fig. 18. Reverberatory slag, 40 min. later. All microphotographs originally at 1000 ×, reproduced at 550 ×. HF etching. "P" marks magnetite crystals from converter slag.

as this would require gradual diminution in size of individual crystals. There is evidence, discussed below, that there is considerable tendency for magnetite crystals, when present in fused slag, to settle rather rapidly to the bottom, and the fact of these nuclei remaining suspended indicates the manner in which converter slag is taken up by the reverberatory. There would seem to be no reason for the coherence of these magnetite crystals except through the medium of some surface tension effect in the fused slag. It is a well-known fact that any magnetic phenomena which these crystals might show disappear at a relatively low temperature. The action taking place is, then, first of all, upon addition of fused converter slag containing magnetite crystals to the fused reverberatory slag, the silicate portion of the converter slag is dissolved away into the silicates of the reverberatory, leaving magnetite crystals and numerous sulphide copper globules which were originally present to the extent of several per cent. It will be shown later that copper sulphide in the molten state wets the surface of magnetite crystals, and consequently each original sulphide globule attaches to itself any magnetite crystals with which it may come in contact. There is exact analogy here with the manner in which sulphide minerals attach themselves to oil drops in an aqueous pulp, magnetite taking the place of mineral and fused sulphides that of the oil. According to previous work, sulphur dioxide should be the result of chemical reactions involved in such contact, and accordingly there is to be seen a central gas cavity in Fig. 3. This gas has buoyed up the nucleus and the reactivity is obviously the reason for its continuous suspension in the liquid slag.

Figs. 7 to 12, of specimens similar to Figs. 1 to 6, but at twice the magnification, show somewhat more clearly the difference in the size of the magnetite crys-

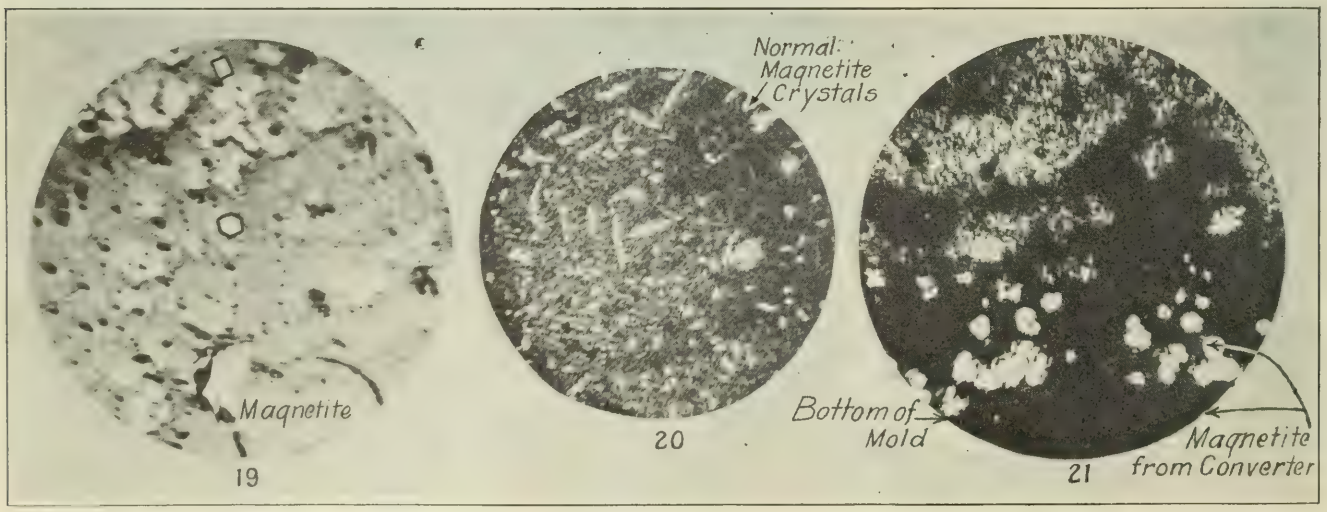
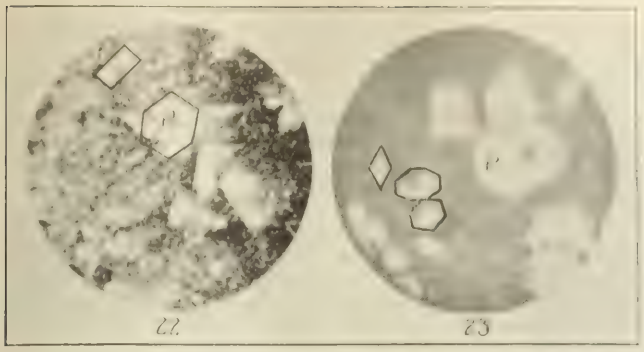


FIG. 19
Outlined crystals show average size of magnetite in converter slag. 150 ×, reproduced at 115 ×. Unetched.

FIG. 20
Reverberatory slag, 10 min. after addition. Center of slag sample showing no large crystals of magnetite. 150 ×, reproduced at 115 ×. HF etching.

FIG. 21
Same slag sample as Fig. 20 but at bottom of mold. Showing large magnetite crystals settled to bottom. 150 ×, reproduced at 115 ×. HF etching.



FIGS. 22 AND 23. SURFACE DISINTEGRATION OF MAGNETITE CRYSTALS

Fig. 22. Reverberatory slag, 40 min. after addition. Fig. 23. Reverberatory slag, 20 min. after additions. Both 1000 ×, reproduced at 525 ×. HF etching. P and outlined crystals are magnetite from converter slag.

tals from the two sources originating either in the converter slag or in the normal crystallization of the reverberatory slag on cooling. Again, the crystals in Fig. 7 (converter slag) as compared to those in the unmixed reverberatory (Fig. 8) are seen to be several times as large. In Fig. 9, ten minutes after admixture, not having accidentally struck a position on the slag showing a nucleus, there are visible only occasional large magnetite crystals which had their origin in the converter. These have been designated by the letter *P*. A necessary consequence of the reactivity between magnetite and sulphide inclusions would be the disintegration of the former crystals, and in Figs. 10 and 11 there is apparent a beginning of such action, even though the total outline has not appreciably changed. It is interesting to note, in confirmation of the previous statements, that in Fig. 11 the difference in structure in the silicate phase is visible in the vicinity of the nucleus. As usual, after forty minutes the greater part of the large magnetite crystals have disappeared, and there remains only the normal magnetite crystallization characteristic of unmixed reverberatory slag.

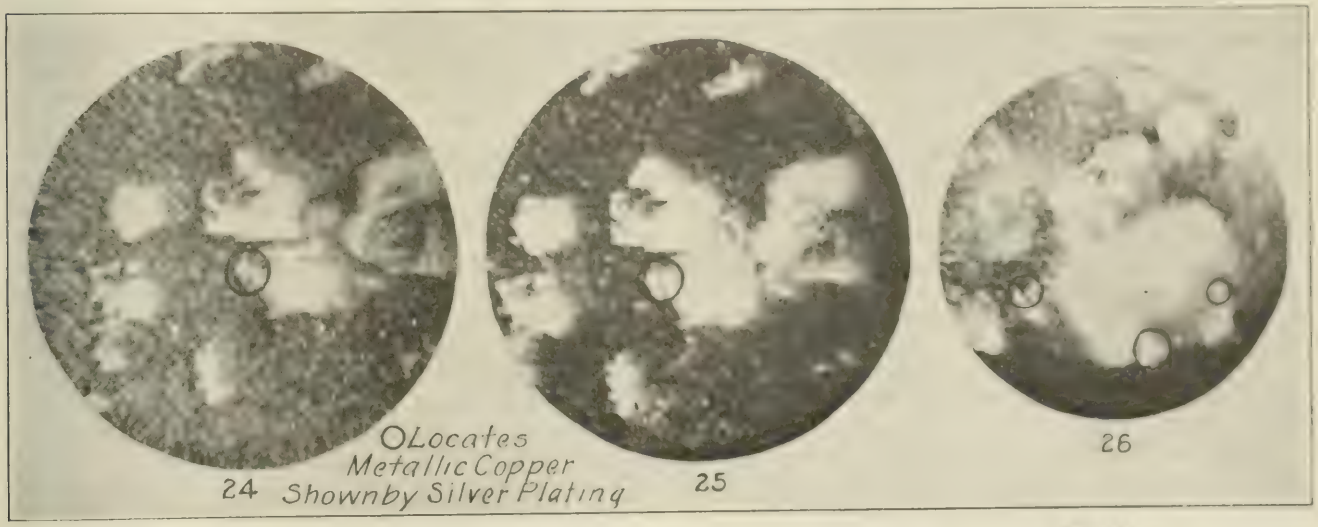


FIG. 24

Reverberatory slag 30 min. after addition, HF etching. Many copper inclusions visible to eye, but not distinguishable in photograph. 1000 ×, reproduced at 750 ×. HF etching.

FIG. 25

Same specimen as Fig. 24 after $AgNO_3$ etching. Silvery spots locate copper inclusions. 1000 ×, reproduced at 750 ×. Double etching.

FIG. 26

Reverberatory slag 10 min. after addition. Same appearances as in Fig. 25. 1000 ×, reproduced at 750 ×. Double etching.

Copper Inclusions in Magnetite

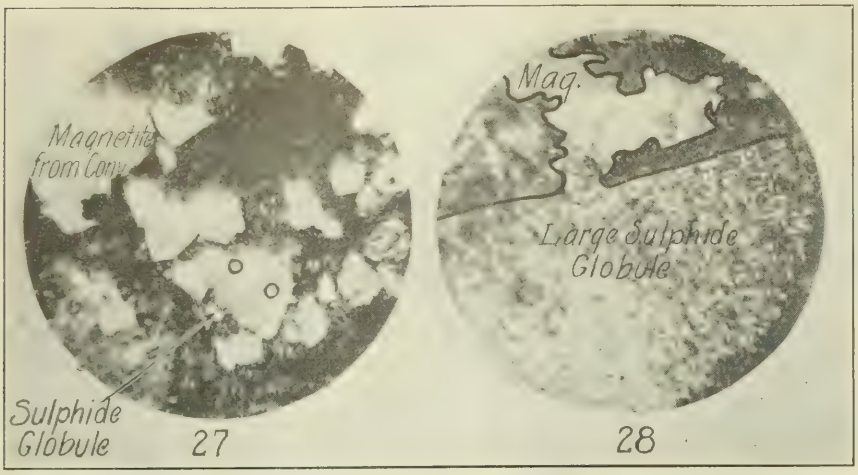
The inclusion of metallic copper in magnetite crystals, heretofore never observed, so far as is known, is a matter of considerable significance and is plainly shown in Figs. 12 to 18. These pictures were taken at a very high magnification (originally 1,000 diameters) and emphasize anew the marked difference in size and structure between the crytals from the two sources. Their especial interest, however, lies in the fact that not only do they show the above-mentioned inclusions in large magnetite crystals, but also show crystal skeletons of originally large crystals whose sides or interiors have been disintegrated because of chemical fluxing action (effect of sulphides!).

Fig. 13 shows a very large and well formed magnetite crystal present in converter slag, and enables us to distinguish two types of inclusion. The large dark spots are gas cavities or at least unfilled holes in the magnetite crystal and their perfectly spherical form would seem to indicate the action of chemical disintegration after the formation of a large perfect crystal had taken place rather than an original cavity due to imperfect crystallization.

The lighter poorly defined inclusions are metallic copper, recognizable as such by the color on visual observation and by the deposition of silver crystals on etching with dilute silver nitrate solution. This phenomenon of copper inclusion may account for the variation on dissolved copper content observed with converter slags when tested by the silver nitrate method, inasmuch as these inclusions are extremely minute and would certainly not be freed by grinding through 100-mesh screens.

The magnetite crystals of Fig. 14, unmixed reverberatory slag, are much smaller and seem not to contain inclusions. If inclusions do occur they must be of little relative significance as far as the copper content of the slag is concerned, inasmuch as no such inclusions are apparent at 1,000 diameters magnification.

Figs. 15 and 16, photographs taken on samples ten and twenty minutes after admixture, show, in contrast to the above, characteristically large magnetite crystals and, of especial interest, also show metallic inclusions. Since the amount of copper in the original converter slag represented by such inclusions in crystals can certainly not be greater than the total dissolved copper—that is to say, approximately 0.5 per cent—it must be



FIGS. 27 AND 28. DIRECT REACTIVITY OF SULPHIDE UPON MAGNETITE
Fig. 27. Reverberatory slag, 20 min. after addition. Fig. 28. Converter slag. Both 1000 ×, reproduced at 500 ×. HF etching.

true that in mixed slags containing 10 per cent or less of converter slag, the effect of such inclusions does not involve significant quantities. At least some portion of metallic inclusions would be shown up as globule content by the silver nitrate method. It is important that these inclusions not observed in normal reverberatory slag are apparently characteristic of the converter and their presence in this mixed slag seems to furnish still further conviction as to the source of the crystals in which they occur.

Of even greater importance in regard to a possible rational explanation of the relationship between copper and magnetite in these slags is the second significant fact that magnetite crystals in the later pictures (see also Figs. 22 and 23) and particularly in Fig. 18 show ragged edges and fragments of originally rather large magnetite inclusions. Inasmuch as such fragmentary crystals are not usual in the converter slag itself where the predominant sulphide constituent is high grade, characteristic of white metal, it seems warrantable to assume that the corrosive action is chiefly due to the iron sulphide portions of these reverberatory slags. This is further confirmation of our previous theory concerning the primary disappearance of the iron sulphide constituent in suspended globules.

Gravitational Settling

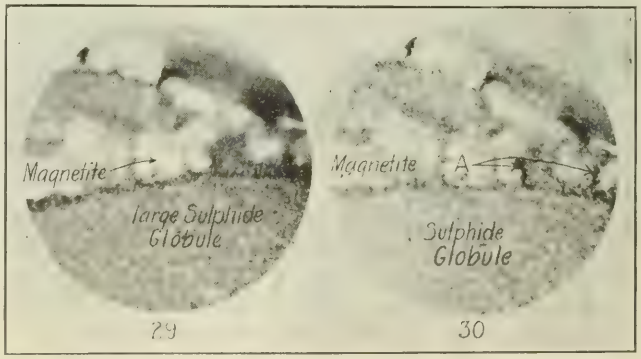
The separation of magnetite from fused slag by gravitational settling is a matter of considerable importance with respect to previous conclusions. It is true that as microscopically apparent on the usual specimen the number of large magnetite crystals characteristic of the converter is less than might be expected from the percentage admixture, but Figs. 19 to 21 show the explanation for this fact and furnish contributory evidence toward the theoretical relationships of sulphur elimination during and after matte smelting. Fig. 19 of converter slag has had two crystals outlined in ink to indicate the average size. Fig. 20, taken near the center of the mold as cast for sampling, shows only minute crystals characteristic of those normally found on solidification and lying in straight rows which indicate definitely their formation during this period. The last picture, Fig. 21, taken near the bottom of the mold, as indicated by the curved line in the margin, shows the number of magnetite crystals of the same size as those in the top section of converter slag. These crystals have settled to the bottom of the mold previous to the act of solidification.

Having shown in previous work the possibility of the reactivity of magnetite and sulphides, the mechanism for the disappearance of the larger magnetite crystals present because of the addition of converter slag can be easily imagined. Any crystal growing to considerable size during some molten condition, because of local oxidizing conditions in the melt, or when added as a large originally well-formed crystal through the medium of converter slag, becomes of a size to insure practically unhindered settling (compare Stokes' law, velocity varies as the square of the radius), rapidly comes in contact with the matte at the bottom of the melt and since it is wet by this phase is subject to rapid disintegration, quite in conformity to the action observed in many micrographs.

The reaction producing metallic copper by contact between magnetite and sulphides may be classified as to whether these sulphides be dissolved or present as suspended inclusions in the slag. In substantiation of the theory to be developed later regarding the correlation of magnetite and copper loss, it is desirable to show that the disintegration of the magnetite crystals is primarily due to reaction with sulphides rather than silicate fluxing. Figs. 24 to 26 show photographs taken to illustrate this point. Owing to the limitations of monochromatic reproduction the points of interest have been emphasized by artificial means. The first picture (Fig. 24) contains a typical group of corroded magnetite crystals. On the original, metallic copper inclusions were easily recognizable, located about the corroded crystal in such a manner as to leave no doubt that they were reaction products. In the absence of excess iron sulphide, the copper sulphide has continued to react with the magnetite, and since no pellets are visible it is probable that this copper sulphide was in the dissolved form.

Fig. 25 is from a photograph taken after treatment of the polished slide shown in Fig. 24, by an etching solution of silver nitrate, thus showing up copper inclusions by means of the bright spots of silver formed thereon.

While Figs. 24 to 26 were taken to show the reaction



FIGS. 29 AND 30. SURFACE TENSION EFFECTS IN SLAG
Fig. 29. Converter slag photographed under yellow monochromatic light. Fig. 30. Converter slag photographed under blue monochromatic light, showing copper in black spots. Both 1000 ×, reproduced at 500 ×. HF etching.

of dissolved copper sulphide with magnetite, the direct reactivity with globules of sulphide is a matter of some importance and is well illustrated by Figs. 27 and 28. Fig. 27 is a particularly good illustration of the reaction. The chief point of interest is the central magnetite crystal with the treelike growth in it. The small semicircular globule at the bottom of the large central magnetite crystal is the remains of a sulphide pellet, and the treelike growth is the path of the lines of penetration of the reaction. The minute globules at the end of the growth are appropriately enough the fruit of the reaction—that is to say, metallic copper.

Fig. 28 shows a much larger sulphide inclusion and the manner in which upon contact with magnetite the sulphide phase pours out of its spherical form to engulf and disintegrate the crystal. The ink lines indicate the extent of the engulfing action and serve to separate the silicate portion of the slag from the sulphide globule and its burden of attached reacting magnetite.

The matter of surface tension relationships between magnetite crystals and sulphide pellets has been mentioned above and Figs. 29 and 30 show photographs taken with the purpose of exhibiting this action. Metallic copper resulting therefrom is also apparent. The photographs have been made more clear by ink lines showing the outline of the constituents as well as by the use of color screens for contrast purposes in photography.

If magnetite were not wet by sulphide globules the reaction which is the source of the flotation of copper-bearing pellets could not take place so readily, and consequently it seems not impossible that some suitable addition agent might be found which when added to the fused slag would alter the surface tension effects in a manner similar to certain flotation poisons which have been noted by various observers in aqueous flotation pulps. If such agents could be found to prevent the wetting of the magnetite, there is no doubt that a considerable portion of the sulphide globule copper loss might be eliminated, since the elimination of the gas due to reaction would permit much improved settling.

(Part II will be published in a subsequent issue.)

Papers on Enameling Before the Chicago Section, American Ceramic Society

The Chicago Section of the American Ceramic Society met at a dinner at the City Club, Chicago, on Friday evening, May 21. In addition to the business program two papers were presented in connection with the enameling industry, the first of which, by L. H. Menne, was entitled "Enameling of Cast Iron."

Enameling of Cast Iron

The first thing to consider in the enameling of a cast-iron piece is its shape. This must be uniform and free from heavy spots and sharp edges. The metal must be a soft open-grain iron with a 2½ to 3 per cent silicon content and about 0.5 per cent manganese. Sulphur must be low.

Care must be taken in molding that the sand is neither too fine nor too coarse in order to obtain an open-grain surface. No facing must be used on the mold. In pouring the iron the metal must not be too hot, as then a film of scale and sand on the cold casting will make it impossible to produce a smooth enameled surface. It is better to cool the metal slowly in the mold in order to give an annealing effect and to prevent cracking of the casting during enameling.

Castings should not be milled before enameling, as this usually produces a too close-grained surface for best results. When necessary to do any finishing the castings must be pickled and sand blasted afterward. The enameling operation should be undertaken shortly after the sand blasting, but if castings have been stored a considerable time all traces of rust must be carefully removed.

Enameling is usually done in a gas-fired open-muffle furnace, the sides of the furnace being high enough to protect the ware from direct flame. The temperature should be from 1,500 to 1,600 deg. F. The slush coat is usually prepared in pans in the muffle furnace, but in large plants a special melter is used for this purpose. The enamel itself consists of quartz, feldspar, borax and sometimes lead, manganese dioxide and cobalt oxide. The mixture is sintered in the muffle furnace for about 2 hr., dropped in water, broken up or allowed to cool in the pan, as the case may be, crushed and then milled.

The cover coat consists of silica, alumina, fluxes and opacifying materials which are smelted, run into water, dried and ground in porcelain-lined mills with porcelain balls. No flint pebbles should be used for dry grinding.

Crazing of the cover coat can be regulated in the mill by adding clay, tin oxide or zinc oxide. It can also be avoided by adding from 3 to 5 per cent of silica in the form of quartz without disturbing any of the other ingredients.

Preparation of Steel for Enameling

L. G. Whitford, of the Benjamin Electric & Manufacturing Co., made a short talk on the preparation of steel for enameling, a brief summary of which follows.

Many enameling shops receive the forms for enameling from outside shops. In such cases the enamel shop should always be sure that an order is made up from one and only one gage of steel, or much annoyance and loss will be experienced when the burning operation is performed.

As a preliminary, grease and oil are first removed by burning them off in a furnace or immersing the form in a chemical bath. If the piece is to be burned it is first usually sprinkled with hydrochloric acid and held in the furnace until the piece is red hot. When a chemical bath is used, the material passes from the acid tank to a water tank, where it is rinsed and sponged by hand to remove the carbon film which remains on the surface after pickling. It is then passed into a neutralizing tank for a few minutes. Soda ash and caustic solutions are most commonly employed for this operation, one-tenth normal solution giving very good results. It then passes from the neutralizer tank to a drying room which is heated to 250 deg. F.

The most efficient cleaning solutions on the market consist of mixtures of caustic soda, soda ash, borax, trisodium phosphate, sodium chloride, rosin and soap. The action of these cleaning solutions is purely physical except in the saponification of the small amounts of animal or vegetable oils that might be present in some cases, cutting the oil away from the surface and emulsifying it. The bath is maintained at boiling or just below.

Selenium and Tellurium

By Victor Lenher*

A RECENT survey made by the Committee of the National Research Council on the uses of selenium and tellurium has shown that the electrolytic copper refining plants in this country, without making any material addition to their plants, can furnish approximately 300,000 lb. of selenium and about 125,000 lb. of tellurium per year. The uses of these elements in quantity are nil. They have a few minor uses. During the war selenium was used in considerable quantity for the decolorization of glass during the shortage of manganese. When the commercial ocean traffic was resumed and manganese was again brought to this country, the demand for selenium by glass companies dropped to practically nothing.

Small amounts of selenium are used in the manufacture of the selenium cell, which is unique in its action toward light. The conductivity of selenium varies so greatly in light and in darkness that this property of its conductivity varying directly proportional to the intensity of the source of light has found several industrial applications in the development of the selenium cell. This selenium cell has been used at various times for automatically turning off city gas lights at daybreak. It has been used to light and to extinguish the lights in light buoys, in army signaling of various kinds based on the heliograph principle, in the wireless telephone, and it has been used by the French as a control in such chemical processes as the contact sulphuric acid.

Metallic tellurium has not yet been found to have any practical applications of even minor importance.

Possible Uses for Selenium and Tellurium

Various possible uses for these elements have been suggested, but a considerable amount of research is desirable. For example: The use of either of the elements in the iron or steel industry. The field of organic medicinals with these elements has barely been touched. The physiological action in the derivatives similar to sulphur and selenium might well be studied. No experiments are recorded on the use of the chlorides or bromides of these elements as acclerators in the rubber industry, nor has the field of synthetic dyestuffs been studied carefully.

An address wes recently given by the writer at the St. Louis meeting of the American Chemical Society, suggesting a number of possibilities for the use of selenium oxychloride as a laboratory and research reagent. If this kind of chemistry can be developed by one new derivative of selenium, it is interesting to contemplate future possibilities in further researches with these elements.

The Engineering Division of the National Research Council has created a sub-committee on the uses of selenium and tellurium, consisting of Arthur E. Hall, chairman; H. G. Greenwood, Victor Lenher, O. C. Ralston, E. W. Rouse, S. Skowronski and A. W. Smith. This committee has been working in close contact with the Raritan Copper Works, Perth Amboy, N. J.; the United States Metals Refining Co., Chrome, N. J.; the American Smelting & Refining Co., Omaha, Neb., and the Baltimore Copper Smelting & Rolling Co., Baltimore, Md., which includes all of the producers of these elements in this country. These companies will furnish workable quantities of selenium and tellurium for research purposes at cost price.

E. W. Rouse, of the Baltimore Copper Smelting & Rolling Co., Baltimore, Md., will ship at any time reasonable quantities of selenium gratis to investigators upon the recommendation of the committee on the uses of selenium and tellurium of the National Research Council. Arthur E. Hall, of the Omaha plant of the American Smelting & Refining Co., will forward reasonable quantities of tellurium gratis under the same conditions.

In times past various prizes have been offered in Europe for work on the utilization of such elements as bromine and boron. These elements at one time had a very restricted use. Selenium and tellurium, though practically useless at present, will unquestionably find their place as a useful necessity to man, but a large amount of research work is, of course, necessary.

Madison, Wis.

*Professor of Chemistry, University of Wisconsin.

The French Iron and Steel Industry

The iron-ore resources of France before the war were estimated at 3,300,000,000 metric tons (metric ton = 2,204.6 lb.), or 300,000,000 tons less than those of Germany and 2,000,000,000 tons greater than England's. New basins have been discovered since 1910, and the French deposits, exclusive of those of Lorraine, are now estimated to be about 4,000,000,000 tons.

Aside from the new basins discovered, the relative resources of Germany and France (due to the recovery of the Lorraine basins) are at the present time: Germany about 1,270,000,000 tons and France 5,630,000,000. The exploitable iron-ore deposits of French North Africa (Algeria and Tunis) are estimated at from 100,000,000 to 150,000,000 tons.

The basins in the Departments of Meurthe-et-Moselle, Lorraine, Normandy, Anjou, Brittany and Pyrenees comprise the principal iron-ore deposits of France with an estimated tonnage of: Meurthe-et-Moselle, 3,000,000,000 tons; Normandy, Anjou, and Brittany, 200,000,000 tons; Pyrenees, 100,000,000 tons; Lorraine, 2,330,000,000 tons.

The production of iron ore in Germany, excluding Luxemburg but including Alsace-Lorraine, during 1913 was 28,608,000 metric tons, and in France, 21,918,000 tons. The estimates of possible production are: For Germany about 7,000,000 tons; and for France 43,000,000 tons and over, due to the recovery of Lorraine.

The principal iron- and steel-producing regions of France are:

The east, producing in 1912, 69 per cent of the pig iron, 55 per cent of the steel, and 43 per cent of the finished products.

The north, 17 per cent of the pig iron, 23 per cent of the steel, and 32 per cent of the finished products.

The center, 4 per cent of the pig iron, 12 per cent of the steel, and 14 per cent of the finished products.

The southwest, 5 per cent of the pig iron, 4 per cent of the steel, and 4 per cent of the finished products.

The west, 2 per cent of the pig iron, 3 per cent of the steel, and 4 per cent of the finished products.

The southeast, 3 per cent of the pig iron, 3 per cent of the steel, and 3 per cent of the finished products.

Alsace-Lorraine produced, in the first six months of 1919, 446 per cent of the iron, 32.1 per cent of the steel, and 28.4 per cent of the finished products manufactured in all France.

The Saybolt Viscosity of Oil Blends

A System of Charts for Determining Oil Blends of Components of Known Viscosity — Logarithmic Rule and Correction Factors to Be Applied in Calculations—Tables of Viscosities of Blends Containing 25, 50 and 75 Per Cent of Heavier Oil

By WINSLOW H. HERSCHEL

AS IS well known, the viscosity of a blend of two oils is less than the arithmetical mean of the viscosities of the component oils, but "there appears to be no simple law connecting the viscosity of a mixture with that of its constituents."[1] A convenient diagram for determining the viscosity of blends has been given by Espy[2] for viscosities between 300 and 55 seconds, Saybolt, but no equation is given by which the diagram may be extended beyond the range of his experiments.

This investigation has shown that the formula of Arrhenius, as given by Dunstan and Thole,[3] is of considerable help when used with suitable corrections. This formula shows that the viscosity of a blend is the weighted geometrical mean between the viscosities of the component oils, and may be written

$$\log \mu = v_1 \log \mu_1 + v_2 \log \mu_2 \qquad (1)$$

where v_1 and v_2 are the percentage volume concentrations, and μ_1 and μ_2 are the viscosities of the component oils, expressed in the absolute unit of viscosity, the poise.

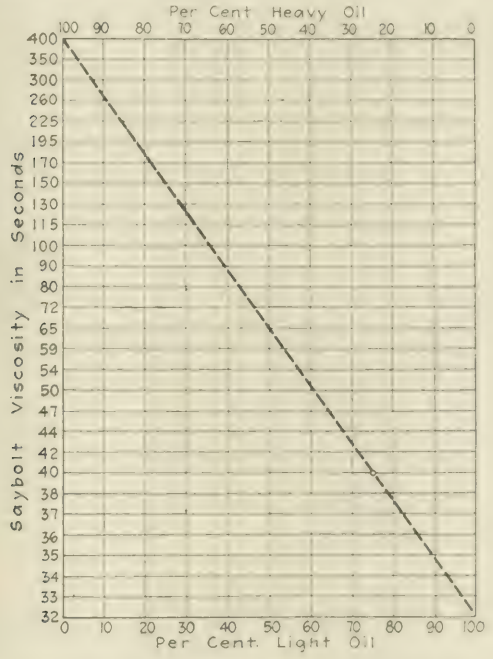


FIG. 1. CALCULATED VARIATION IN VISCOSITY OF A BLEND WITH THE VISCOSITY AND PER CENT OF OILS

Example: A blend of 40 viscosity, as shown by the point on the dotted line, may be made from 25 per cent of oil of 400 viscosity and 75 per cent of oil of 32 viscosity, both oils and blend being at the same temperature.

When the Saybolt Universal viscosimeter is used, the viscosity in poises may be calculated by the equation

$$\mu = \gamma (0.00220t - 1.80/t) \qquad (2)$$

where t is the time of flow, or Saybolt viscosity, in seconds, and γ is the density at the temperature of test, in grams per cubic centimeters.[4]

Since there is no definite relation between the viscosity and the density of oils (except when they are all from the same crude), and since it is generally assumed in the petroleum industry that two oils have the same viscosity if they show the same time of flow when tested in a viscosimeter, the effect of changes of density may be disregarded in approximate calculations.

Table I was calculated from equations (1) and (2) disregarding γ. It shows the Saybolt viscosities of blends containing 25, 50 and 75 per cent of either of the component oils. Each line of the table shows values of Saybolt viscosity for blends with a given viscosity of the lighter oil, the headings of the columns showing the viscosity of the heavier oil. Each rectangle formed by the intersection of a line and a column contains three values which are viscosities of blends of the two oils in question. Beginning at the top of a rectangle, these values are for blends containing 25, 50 and 75 per cent respectively of the heavier oil.

Blending Chart

On account of the large number of variables it is difficult to present Table I graphically. Fig. 1 is perhaps the most satisfactory form of diagram for a blending chart. Its form was due to Espy, but it was plotted from data of Table I.

According to Espy the data from a series of tests of two component oils mixed in all proportions are sufficient to enable a chart to be prepared which will be applicable to oils of all crudes. Higgins, however, made mixtures of Mexican with Scotch shale and Borneo oils, and found that the addition of 10 per cent of these latter oils caused the viscosity of the Mexican oil to be decreased 79 and 74 per cent in the two instances.

Tests at the Bureau of Standards

The first series of tests was made with two oils of approximately the same viscosities as those used by Espy and gave a fairly good check on his results. In order to get a large difference of viscosity between the two component oils, blends were made with gasoline and kerosene in Series 2. Equation (2) is not valid for viscosities less than 32 seconds, and for tests with gasoline it was necessary to use the Ubbelohde viscosimeter,[5] although the times of flow, as given in Table II,

[1] W. F. Higgins, Collected Researches National Physical Laboratory, vol. 13, p. 291; 1916.

[2] W. E. Espy, *Petroleum*, vol. 8, p. 27; 1919.

[3] A. E. Dunstan and F. B. Thole, The Viscosity of Liquids, p. 41; 1914.

[4] Winslow H. Herschel, Proc. A. S. T. M., vol. 15, pt. II, p. 331; 1915. Technologic Paper No. 111, Bureau of Standards, p. 19; 1919.

[5] Winslow H. Herschel, Technologic Paper No. 155, Bureau of Standards, 1919. Proc. A. S. T. M., vol. 15, pt. II, p. 334; 1915.

TABLE I. SAYBOLT VISCOSITIES OF BLENDS CONTAINING 25, 50 AND 75 PER CENT OF HEAVIER OIL, BOTH CONSTITUENTS BEING AT THE SAME TEMPERATURE AS THE BLEND

Viscosity Heavier Oil / Lighter Oil over 160 vis.	35	40	45	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	400	Lighter oil less than 160 vis.
	33	33	34	34	35	35	35	36	36	36	36	37	37	37	37	37	37	38	38	38	38	38	38	38	39	39	39	39	39	40	
	33	35	36	37	39	40	41	43	44	45	46	47	47	48	49	50	51	52	53	53	54	55	56	57	57	58	59	60	61	65	32
	34	37	40	42	46	50	54	58	62	65	68	72	75	78	81	84	88	91	93	96	99	103	106	109	112	114	117	120	123	150	
322		36	37	37	38	39	39	40	40	40	41	41	41	42	42	42	43	43	43	43	43	43	43	44	44	44	44	44	45	46	
300 347		37	39	40	42	44	46	48	49	51	52	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	79	35
372		38	42	44	49	54	58	63	67	71	75	79	83	87	91	94	98	101	105	108	111	115	118	122	125	128	131	135	138	170	
314	293		41	42	42	44	45	45	46	47	47	48	48	48	49	50	50	50	51	51	51	51	52	52	52	53	53	53	54	55	
290 341	295		42	44	47	49	52	55	57	59	60	62	63	65	67	69	70	72	73	74	75	77	78	79	80	81	83	84	85	96	40
369	297		43	47	52	58	63	68	73	78	82	87	91	95	100	105	109	113	117	121	125	129	133	137	140	144	148	152	155	191	
305	285	282		46	48	49	50	52	52	53	54	55	56	57	57	58	58	59	59	60	60	60	61	61	62	62	63	63	64	66	
280 334	290	285		47	52	55	58	61	63	65	67	69	71	73	75	77	79	81	83	85	86	88	90	91	93	94	96	97	99	112	45
366	294	287		49	56	61	67	73	78	83	88	93	98	102	107	112	118	122	126	130	135	139	143	148	152	156	160	165	169	208	
297	277	274	272		52	54	56	57	58	59	60	61	62	63	64	64	65	65	66	66	67	67	68	68	69	69	70	70	71	74	
270 328	283	279	275		55	59	62	65	68	71	73	76	78	80	82	85	87	89	91	93	95	97	99	100	102	104	105	107	108	124	50
362	290	284	277		57	64	70	76	82	87	92	98	103	108	113	118	124	128	132	137	142	147	151	155	160	164	168	173	177	220	
289	272	269	266	263		62	63	65	66	68	69	70	71	72	73	74	75	75	76	77	77	78	79	80	80	81	81	82	82	87	
260 322	279	274	270	265		64	68	72	76	79	81	84	87	90	93	96	98	100	102	104	106	108	110	113	115	117	119	121	123	141	60
359	289	282	275	267		67	74	80	87	93	99	105	110	115	120	126	131	136	142	147	152	157	162	166	171	176	181	186	191	235	
280	261	259	257	255	252		72	74	75	77	78	80	81	82	83	84	85	86	88	89	90	91	92	92	93	94	94	95	96	102	
250 316	273	269	264	260	255		74	79	83	86	89	93	96	99	102	105	108	111	113	116	119	121	124	126	129	131	133	135	138	157	70
355	285	278	271	264	257		77	84	91	98	102	109	115	121	127	133	139	144	150	155	160	165	170	176	182	187	192	198	202	249	
272	253	251	249	247	244	242		82	84	86	87	89	91	92	94	95	97	98	99	100	101	102	102	103	104	105	106	106	107	115	
240 309	268	263	259	254	250	245		85	89	93	96	101	104	108	111	114	118	121	124	126	129	132	135	138	140	143	145	148	150	171	80
352	283	276	269	262	255	247		87	95	101	106	115	120	126	133	139	144	150	156	162	168	173	179	185	190	196	201	206	212	260	
264	245	243	241	239	237	235	233		93	95	96	98	100	101	103	105	106	108	109	110	111	112	113	114	115	116	117	118	119	128	
230 302	263	259	254	250	245	240	235		95	100	103	107	111	115	119	122	126	129	132	135	139	141	144	147	149	152	155	157	160	184	90
348	280	273	266	259	252	245	238		97	105	111	118	124	132	139	145	150	156	162	168	174	180	186	192	197	202	208	213	219	271	
255	237	236	234	232	229	227	225	222		103	105	107	109	110	112	114	115	117	118	120	121	122	123	125	126	127	128	129	131	139	
220 296	257	252	248	244	239	235	230	225		104	109	114	118	122	126	130	133	137	140	143	146	150	153	156	159	162	165	168	171	196	100
344	276	270	262	256	249	242	235	227		108	115	122	129	135	142	148	155	161	168	174	180	186	192	198	204	209	215	220	226	279	
246	229	227	225	224	221	219	217	215	212		112	114	116	118	120	122	124	125	127	129	130	131	133	134	135	137	138	139	140	149	
210 289	251	247	243	239	234	229	225	220	215		114	119	124	128	132	136	140	143	147	150	153	157	160	164	167	170	173	177	180	206	110
340	274	267	260	253	246	239	232	225	217		117	124	131	138	145	151	158	165	171	178	184	190	196	202	208	214	220	226	232	287	
237	221	219	218	216	214	211	209	207	205	202		121	124	126	129	131	133	135	136	138	140	141	142	144	145	146	147	148	149	160	
200 282	245	241	237	233	228	224	219	215	210	205		124	129	134	138	142	146	150	153	157	160	164	168	171	175	178	182	185	188	215	120
335	270	263	257	250	243	236	229	222	215	207		128	135	142	149	156	162	169	176	182	188	195	201	207	213	219	225	231	237	293	
228	213	211	209	208	206	204	201	199	197	195	192		132	134	136	138	140	142	144	145	147	148	150	151	153	154	156	157	158	170	
190 274	238	234	230	226	222	218	213	208	204	199	195		135	139	143	147	152	156	160	164	168	172	176	179	183	186	190	193	196	225	130
331	266	260	253	246	240	233	226	219	212	205	197		138	145	152	159	165	172	179	185	192	199	205	211	218	224	230	236	242	300	
219	204	202	200	199	197	195	193	191	189	187	185	182		142	145	147	149	150	152	154	155	157	158	160	161	163	164	166	167	180	
180 267	231	228	224	220	216	212	208	203	199	194	190	185		144	149	154	158	162	167	171	175	179	182	186	190	194	197	200	204	234	140
326	263	257	250	244	237	230	223	216	208	201	194	187		147	154	161	168	175	182	189	195	202	209	215	222	228	234	241	247	306	
210	195	194	192	190	189	187	185	183	181	179	177	175	172		152	155	157	159	161	163	165	167	168	170	172	173	175	176	178	190	
170 259	225	222	218	214	210	206	202	198	193	189	184	180	175		155	159	164	169	173	178	182	186	190	193	197	200	204	207	211	244	150
321	260	254	247	241	234	227	220	213	206	199	192	185	177		157	165	172	179	186	193	200	207	213	220	226	232	239	245	252	311	
200	187	186	184	183	181	179	177	175	174	172	170	167	165	163		163	165	167	170	172	174	175	177	179	181	183	184	186	187	200	
160 252	218	215	211	208	204	200	196	192	188	183	179	174	170	165		165	170	174	179	183	188	192	196	200	204	208	211	215	218	252	160
316	256	250	244	237	231	224	217	210	204	197	190	183	175	168		168	175	183	190	197	204	210	217	224	231	237	244	250	256	316	
400	300	290	280	270	260	250	240	230	220	210	200	190	180	170		170	180	190	200	210	220	230	240	250	260	270	280	290	300	400	

Viscosities of heavier oil, for lighter oils *over* 160 vis. ← → Viscosities of heavier oil, for lighter oils *less than* 160 vis.

NOTE.—The three values in each rectangle are viscosities of blends of the three percentage compositions given above.

have been computed for the Saybolt viscosimeter. If μ is the viscosity of a blend as calculated from equation (2) and μ' is the viscosity, in poises, as estimated from the viscosities of the two components, then $\frac{\mu}{\mu'}$ is a correction factor by which the viscosities, estimated by equation (1), must be multiplied to obtain the values as given by test. $\frac{t}{t'}$ is a corresponding correction factor for Saybolt viscosities. It will be noted from Table II that there is considerable difference between the correction factors for viscosities in poises and in Saybolt seconds for a given test at low viscosities, but that the difference becomes negligible at high viscosities. Table II also shows that the logarithmic rule does not indicate as low a viscosity of blend as found by test, and that the error is very great when there is a large difference in viscosity between the component oils.

Tests of Series 3 and 4 were made to determine the effect upon the correction factors of varying the crudes. In Series 3 two heavy oils, N and P, one of naphthene and the other of paraffine crude, were selected of approximately the same viscosity at the temperature of test, and blended with two lighter oils, M and Q of the same crudes. It was found that the maximum correction factor was obtained for a blend of N and Q and the minimum factor for P and M, and it is noteworthy that these are both blends of unlike crudes. Results of tests on these oils mixed in various proportions are given in Table III, and it is seen that the correction factors are lower when the heavy oil is of naphthene than of paraffine base.

Results Obtained When Using Kerosenes as Diluents

In order to see whether this rule was still valid when kerosenes of the two crudes were used as diluents, the tests of Series 4 were run with the results shown in Table IV. The letters showing the source of the oils have the same significance as in Table III, but the viscosities of the oils are different.

It is seen that the naphthene base oil, in Table IV, is

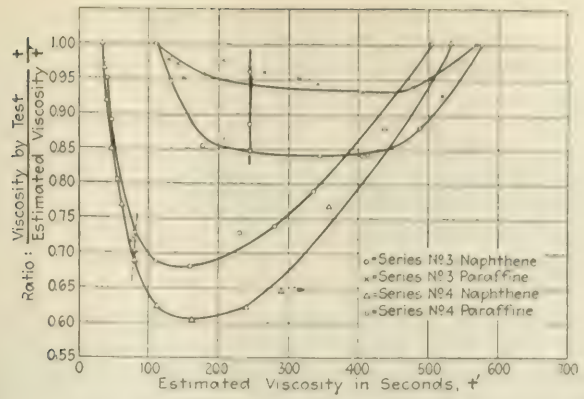

Ratio: Viscosity by Test / Estimated Viscosity
Estimated Viscosity in Seconds, t'
o-Series No 3 Naphthene
×-Series No 3 Paraffine
Δ-Series No 4 Naphthene
u-Series No 4 Paraffine

FIG. 2. THE RELATION BETWEEN THE VISCOSITY AS DETERMINED BY TEST AND AS ESTIMATED BY THE LOGARITHMIC RULE

"cut" (thinned out) to a greater extent than the paraffine base oil, but the difference is not so great as in Table III.

In both tables the blends containing component oils of the same crudes show values of the correction factors which are intermediate between the extreme values for blends of unlike crudes.

TABLE II. SERIES 2. TESTS OF 50 PER CENT BLENDS OF OILS FROM VARIOUS CRUDES WITH GASOLINE AND OTHER DILUENTS, AT 20 DEG. C. (68 DEG. F.)

Oils	Sp.Gr. 15.6° C. / 15.6	t	μ	$\frac{t}{t'}$	$\frac{\mu}{\mu'}$
1. Pennsylvania	0.864	259.7	0.485		
2. Midcontinent	0.901	668.6	1.315		
3. Texas	0.932	673.9	1.361		
4. California	0.942	390.4	0.788		
5. Mineral seal	0.832	54.0	0.0708		
6. Kerosene	0.782	33.9	0.0172		
7. Commercial gas	0.743	30.0*	0.0059		
8. Aviation g-s	0.700	28.8*	0.0036		
50 per cent blends					
1 + 5		95.4	0.1613	0.888	0.871
1 + 6		53.3	0.0694	0.849	0.761
1 + 7		38.8	0.0313	0.816	0.584
1 + 8		36.0	0.0229	0.840	0.546
2 + 5		130.8	0.2360	0.790	0.774
2 + 6		59.6	0.0859	0.667	0.572
2 + 7		41.2	0.0386	0.665	0.437
2 + 8		39.4	0.0328	0.727	0.475
3 + 5		117.9	0.2131	0.708	0.687
3 + 6		56.1	0.0788	0.626	0.516
3 + 7		39.8	0.0353	0.641	0.393
3 + 8		35.4	0.0219	0.648	0.312
4 + 5		104.6	0.1861	0.839	0.788
4 + 6		53.1	0.0716	0.734	0.616
4 + 7		38.2	0.0308	0.726	0.450
4 + 8		34.7	0.0200	0.736	0.374

TABLE III. SERIES 3. TESTS OF BLENDS OF UNLIKE CRUDES AT 55 DEG. C. (131 DEG. F.)

Oils	Per Cent of Lighter Oil in Blend	Sp.gr. 15.6° C. / 15.6	t	μ	$\frac{t}{t'}$	$\frac{\mu}{\mu'}$
N + Q	100	0.885	111.5	0.1965		
	90		122.7	0.2202	0.945	0.940
	80		134.0	0.2441	0.883	0.874
	70		152.1	0.2817	0.853	0.845
	60		181.1	0.3410	0.863	0.857
	50		209.7	0.3990	0.846	0.842
	30		290.2	0.565	0.839	0.837
	20		343.6	0.674	0.847	0.837
	10		424.0	0.838	0.873	0.877
	0	0.934	577.4	1.147		
P + M	100	0.925	111.7	0.2060		
	90		126.6	0.2363	0.977	0.975
	85		136.3	0.2557	0.972	0.971
	80		144.2	0.2710	0.952	0.949
	70		170.2	0.3220	0.958	0.957
	60		203.8	0.3861	0.977	0.974
	50		238.5	0.4520	0.971	0.968
	40		278.9	0.530	0.960	0.962
	35		299.7	0.568	0.950	0.951
	30		323.2	0.612	0.943	0.945
	20		377.1	0.710	0.930	0.931
	10		445.6	0.836	0.936	0.936
	5		481.1	0.901	0.925	0.923
	0	0.878	567.7	1.060		
N + M	50		219.5	0.4282	0.885	0.882
P + Q	50		236.2	0.4376	0.962	0.959

TABLE IV. SERIES 4. TESTS OF BLENDS CONTAINING KEROSENE OF DIFFERENT CRUDES AT 20 DEG. C. (68 DEG. F.)

Oils	Per Cent of Lighter Oil in Blend	Sp. gr. 15.6° C. / 15.6	t	μ	$\frac{t}{t'}$	$\frac{\mu}{\mu'}$
N + Q	100	0.800	33.7	0.0167		
	90		35.2	0.0213	0.865	0.847
	80		37.6	0.0286	0.918	0.790
	70		41.1	0.0389	0.845	0.773
	60		46.5	0.0537	0.767	0.713
	50		55.6	0.0768	0.685	0.674
	40		70.3	0.1115	0.623	0.694
	30		98.7	0.1750	0.604	0.666
	20		149.2	0.2803	0.621	0.666
	15		189.0	0.3620	0.644	0.656
	10		273.3	0.534	0.764	0.761
	5		384.8	0.758	0.880	0.877
	0	0.911	534.8	1.064		
P + M	100	0.808	33.8	0.0171		
	90		35.8	0.0231	0.976	0.904
	80		39.0	0.0325	0.950	0.848
	70		43.1	0.0438	0.891	0.765
	60		48.6	0.0582	0.805	0.678
	50		58.1	0.0815	0.728	0.634
	40		75.8	0.1215	0.687	0.632
	30		107.6	0.1866	0.679	0.654
	20		168.4	0.3116	0.731	0.722
	15		206.8	0.3872	0.738	0.733
	10		267.5	0.506	0.789	0.783
	5		346.2	0.662	0.839	0.836
	0	0.882	503.6	0.969		
N + M	50		57.4	0.0812	0.704	0.602
P + Q	50		56.5	0.0776	0.716	0.612

Diagrams Used for Estimating the Correction Factors

Fig. 2 shows the results of tests of Series 3 and 4. It will be noted that the time ratio, or correction factor, is not a minimum for the 50 per cent blends, which are indicated by vertical dotted lines. While this form of diagram is convenient for interpolation in a given series of tests, it is not convenient for interpolation between one series and another.

In order to reduce the number of variables, it was decided to concentrate attention upon 50 per cent blends. If the correction factor for this blend is known, the factors for other proportions may be estimated by sketching curves similar in shape to those of Fig. 2.

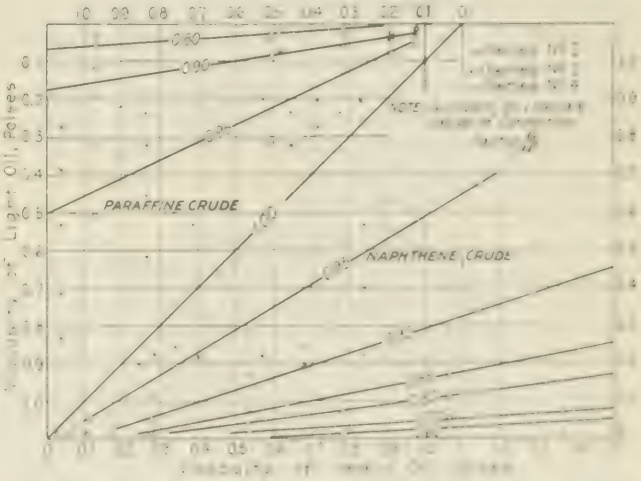


FIG. 3. DIAGRAM FOR ESTIMATING THE CORRECTION FACTOR FOR VISCOSITIES CALCULATED BY THE LOGARITHMIC RULE

The use of the correction factor $\frac{\mu}{\mu'}$ eliminates density and makes results more concordant than when $\frac{t}{t'}$ is used.

A blend of any proportion may be considered as a 50 per cent blend of two other blends, as for example, a 20 per cent blend is a blend of two others, one con-

taining 10 and the other 30 per cent of the component in question.

By estimating the viscosity of the 20 per cent blend from the experimentally determined viscosities of the 10 and 30 per cent blends, a new correction factor may be determined. Fig. 3 was plotted from correction factors obtained in this way.

The figure is divided into two sections by the diagonal line marked 1.00, the upper portion being for the blends P + M and the lower for N + Q. In plotting the diagram each point was marked with the corresponding value of $\frac{\mu}{\mu'}$ (not shown) and the lines drawn to conform as well as possible with these values, as in making a contour map.

Excluding steam-engine cylinder oils, and oils that are of too low a viscosity to be used in actual blending operations, the range is from about 1.5 to 0.12 poise. In the extreme case, therefore, the correction factor from Fig. 3 would be 0.75 for naphthene and 0.80 for paraffine crudes, corresponding to errors in viscosity of 33 and 25 per cent respectively. The errors in Saybolt viscosity would be somewhat less.

The estimation of the viscosity of blends containing cylinder stock presents an additional difficulty on account of the error in measurement of viscosities due to the change of volume of the oil after leaving the outlet tube. There is thus a possibility of serious disagreement between viscosities estimated by the use of Fig. 3 and experimental results, when cylinder stock is used at temperatures approaching the boiling point of water, unless precautions are taken to avoid the error above mentioned.

Conclusion

A table of viscosities of blends has been calculated from the logarithmic rule which is inaccurate but is the best available. The larger the difference in viscosity of the component oils the greater will be the error in the rule. For equal differences of viscosity the error increases as the viscosity of the lighter component decreases.

Diagrams are given for finding the correction factor for 50 per cent blends, and for then estimating the correction factors for blends of other proportions.

U. S. Bureau of Standards.

A Bankrupt Philosophy

"My emphatic conclusion is that Socialism as a philosophy of possible human application is bankrupt. The whole of the various sorts of Socialism are based on one primary conception, and that is that the productivity of the human being can be maintained under the impulse of altruism, and that the selection of the particular human for this most productive performance can be made by some superimposed bureaucracy. Their weakness is the disregard of the normal day-to-day primary impulse of the human animal—that is, self-interest for himself or for his family and home, with a certain addition of altruism varying with his racial instinct and his degree of intelligence. They fail to take into account, also, that there is but one sufficiently selective agent for human abilities in that infinite specialization of mind and body necessary to maintain the output of the intricate machinery of production, and that is the primary school of conception."—Herbert Hoover, in *The Nation's Business*.

Peat Fiber and the Textile Industry

Swedish efforts to introduce peat fiber as a substitute article in the textile industry have come to naught for the moment. It is the consensus that the prices for extracting the fiber from peat moss must be economical before it will ever come into general use. Two factories, one in Denmark and the other at Partille, near Goteborg, both established during the war for the purpose of utilizing peat fiber, have had to close their doors in recognition of this fact.

One of the leading exponents of the uses of peat fiber was Prof. Gustaf Sellergren, of Stockholm. It was upon his application that the Swedish Government recently caused an investigation regarding the possibilities of utilizing the vast deposits of peat moss in Sweden in the textile industry of the country. The experts appointed to make the investigation have completed their labors, and, among other things, found:

(1) Good textiles of peat fiber and "shoddy" can be manufactured and samples were demonstrated, but

(2) The Swedish peat mosses can produce only 100 kilos of fibers and moss per day, which is not sufficient for commercial purposes.

(3) The methods so far used in obtaining the fibers are too expensive.

The experts concluded by proposing that no further action be taken in the matter until the peat mosses could be examined carefully with regard to the amount of fiber contained, which work is within the province of the Swedish Committee on Geological Examinations and the government's peat engineers serving in the Swedish Department of Agriculture.

Prof. Sellergren states, however, that his methods have not been tried, and that his patent rights for Sweden already have been sold. He claims to have some very fine samples of textiles made of peat fiber, and says that while his interest in this fiber has been cooled by the findings some day he may return to the subject. He claims that Swedish peat mosses contain on an average 15 to 20 per cent peat fibers and that they should be utilized in connection with the fabrication of peat litter.

Treatise on Pyrometric Practice

The Bureau of Standards has completed the manuscript of a comprehensive treatise on modern pyrometry under the title "Pyrometric Practice." The object of this treatise is to provide investigators, manufacturers and others who may be concerned with the measurement of high temperatures with complete information as to the present state of the art of pyrometry, the instruments and methods used, the precautions that must be observed to obtain correct results, and to illustrate some of the industrial applications of pyrometry. The scope of the paper is indicated from the following subheads: Temperature scale; high temperature thermometry; thermal electrical pyrometry; optical pyrometry; radiation pyrometry; resistance thermometry; recording pyrometry; high temperature control; melting point methods at high temperatures; standardization of pyrometers and industrial applications of pyrometry. This paper will be ready in six to nine months. The completed volume will consist of 300 pages and will contain a large number of illustrations. The number for free distribution will probably be small, but provision will be made by which it can be obtained at cost from the Superintendent of Documents.

Elastic Properties of Bronze Castings

A Series of Tests Showing That a Definite Proportional Limit Can Easily Be Found for Bronzes, and the Suggestion Made That This Test Should Replace the More Usual but Illogical "Yield Point" Determinations

BY GEORGE F. COMSTOCK
Metallurgist, Titanium Bronze Co.

IN COMMERCIAL practice it has become customary to determine the so-called "elastic limit" or yield point of non-ferrous alloys as the tensile stress producing a deformation of 0.01 in. on a gage length of 2 in. The chief advantages of this method are its ease of application and the facility with which concordant results can be obtained by different operators on the same material. It is generally conceded that the "drop-of-the-beam" method, which is used for rolled soft steel, cannot be applied to non-ferrous alloys; and if the smallest appreciable deformation is taken as the criterion of the yield point, difficulties are at once encountered in agreeing as to what constitutes an appreciable deformation. Thus the figure of 0.01 in. has been recommended and apparently agreed upon as representing the smallest practical deformation that can readily be measured with dividers in determining the so-called "elastic limit" of non-ferrous alloys.

It is a question, however, whether this determination really gives us any information of value. It is intended, of course, to show the stiffness of the material, and what stress it would safely bear in service without bending or stretching. Yet it is obvious that the yield-point stress as so defined is appreciably more than enough to start deformation in the metal, and there is no way of telling from this determination at what stress the deformation really began. For trustworthy information on this point it is necessary to determine the true elastic limit or proportional limit of the material, and the accustomed use of the yield point in this connection is not correct, as there is no direct relation between it and the proportional limit. As has been stated by J. A. Capp in his paper on "The Elastic Limit of Manganese and Other Bronzes," before the American Society of Mechanical Engineers in 1910, "The real object of testing is to determine the characteristics of a material so that one may decide what shall be safe stresses in any structure, taking into account the elastic properties of the material, etc. Usually such safe loads are a certain proportion of the elastic limit. If, however, the elastic limit is determined by erroneous tests to be double its true value, any calculation based on such data is utterly unsafe."

This same idea applied to steel was enlarged upon by A. N. Mitinsky in "Some Suggestions Regarding the Determination of the Properties of Steel," published in the *Bulletin* of the American Institute of Mining Engineers for August, 1915, p. 1,697, but the author probably carried it a little too far in claiming that fatigue resistance is determined solely by the proportional limit, and that the wear of rails is also dependent on it.

The best definitions of elastic limit, proportional limit and yield point are undoubtedly those given by the American Society for Testing Materials in its "Standard Methods of Testing," and it is assumed that they are sufficiently well known not to require repetition here. Reference should also be made to the discussion on elastic limit, etc., in the *Proceedings* of this Society, vol. 16, part 2, p. 404. Some writers, as Howard, Upton in "Materials of Construction," and Thurston in "Materials of Engineering," do not make any distinction between elastic limit and proportional limit. Others, such as Lynch, Olshausen and Moore, hold that there is a difference between these limits, the true elastic or "set" limit being higher. Moore feels that the difference may be due to initial stresses in the material, or the limits of precision of the apparatus, or other similar causes. He has also stated that the determination of the proportional limit depends in no small degree on the sensitiveness of the apparatus used; while Morse, on the other hand, claims that in determining the proportional limit an extensometer of low precision gives the same result as one of high, though the latter is necessary for the elastic limit.

Elastic Behavior of Non-Ferrous Metals

The idea that ductile non-ferrous metals, especially in the cast condition, do not have any definite elastic limit, proportional limit or yield point is quite prevalent in the literature. For instance, in Upton's "Materials of Construction" the statement occurs (p. 23) that "there is no very definite elastic limit" in castings of ductile materials tested parallel to their surfaces or lengths, but in this case "the loading line is slightly curved from the beginning." Also he says (p. 29) that "the ductile materials other than steels usually have either non-isotropic crystals or very large initial internal stresses. These conditions prevent the fairly simultaneous yielding of all parts of the structure. The beginnings of yielding of the individual crystals are distributed over a considerable range of the loading. So in brasses and bronzes, for instance, we miss the decided yield-point action of the steels." Thurston, in his "Materials of Engineering" (part 3, p. 245), even goes so far as to say that non-ferrous metals "have usually, as purchased, no true elastic limit, but yield to small stresses without recovery of form, and their permanent set equals their maximum distortion." C. A. M. Smith, in a paper before the Institute of Metals on "The Elastic Breakdown of Non-Ferrous Metals" (*Journal*, vol. 2, p. 151), reported variable results obtained with his very delicate "sphingometer" for the measurement of minute strains, but in the discussion Parker stated that while lack of homogeneity in cast non-ferrous alloys probably accounted for 75 per cent of the cases of inequality of stress distribution in testing, yet in spite of this the elastic limit was not greatly affected.

This belief that cast non-ferrous metals do not have any real elastic limit, or any definite limit of proportionality of strain to stress, is one reason for the adop-

tion of the arbitrary criterion of 0.5 per cent elongation as marking the so-called "elastic limit" or yield point to be used in ordinary commercial work. Another reason is the assumption that the determination of the real elastic limit or proportional limit is too difficult for this class of work, and involves the use of expensive and delicate apparatus and considerable time. Corse and Skillman evidently took this attitude in their paper on "Manganese Bronze Tests" before the Eighth International Congress of Applied Chemistry (vol. 3, p. 25), for although urging that the usual yield-point determinations on this material are useless, they do not suggest taking the proportional limit instead, but would rely entirely on the tensile strength and elongation. Capp, in his paper on Manganese Bronze quoted above, considered not only that a delicate extensometer was necessary for proper determinations of the proportional limit, but that the gage lengths of the test bars should be 8 in. Nearly all authorities agree that this test must be made with spherical-seated holders for the specimen, and with an accurate extensometer averaging the deformations on two or three sides of the bar, and even then it is claimed by some that non-homogeneity of the specimen and inequality of stress distribution may obscure the real effects of inelastic action in the results. Therefore it has come about that proportional limit determinations have been considered as too refined and expensive for the ordinary commercial tests of bronzes, and the easier but almost worthless yield-point method has been retained instead.

Elastic Tests on Bronzes

During the past few years quite a large number of tests have been made in this laboratory on several types of cast bronze alloys with a view of determining fairly closely their true elastic properties. The measurements of elastic limit and proportional limit have been made in different ways, and although the instruments used have been of the simplest type, the results have been so consistent as to be of interest in showing what can be done along this line with almost crude equipment. It has also been brought out how truly deceptive the commercial yield-point determination is, and the results are probably worth emphasizing merely to prevent undue reliance being placed upon that determination. Another point which it is believed has been demonstrated is that ductile non-ferrous alloys, even when cast, do have a definite limit of proportionality of strain to stress.

A variety of alloys was used in this work, but the most complete results were obtained from manganese bronze, aluminum bronze with 10 per cent aluminum and 1 or 4 per cent iron, and the common gun-metal or zinc bronze of about 88-10-2 composition, including both the G and Pc2 specifications of the Navy Department, the latter allowing a much wider range of tin and an appreciable lead content. The manganese-bronze test specimens were cast in the form of keel-blocks, the aluminum-bronze as plain round bars, and the zinc-bronze specimens were cast in nearly the final size and shape, and fed through a lengthwise fin. The test specimens were all machined to approximately $\frac{1}{2}$-in. diameter between shoulders, and the gage length was in all cases 2 in. A few tests were made with specimens having plain ends, and pulled in ordinary wedge grips, but the results obtained in this way were too irregular, and it was soon recognized that the specimens must be pulled in grips having spherical seats through which the tension would be applied without any bending. The grips used here were fitted to receive a specimen with threaded ends, but similar grips intended to engage with extra shoulders on the ends of the specimens would probably be equally satisfactory.

The testing was all done with an Olsen Universal three-screw machine of 100,000-lb. capacity, but the lighter poise reducing the capacity to 10,000-lb. was used for nearly all the work below the yield point in order to increase the delicacy of the load measurements. The autographic mechanism supplied with this machine for drawing load-deformation diagrams was rejected as not being sufficiently sensitive with gage lengths of only 2 in., and a Berry strain gage was used in its place. Several methods of applying this instrument were tried. At first it was clamped to the test specimen and used as an extensometer, as shown in Fig. 1, the deformations in this case being read on only one side of the specimen. Although this method is not favored by most writers on this subject, it has been defended by J. J. Shuman in discussing Lynch's paper on "Elastic Limit" (*Proc.* A. S. T. M., vol. 15, part 2, p. 417).

Results With Strain Gage in One Position

In the first series of tests of cast specimens (not heat treated) the loads were applied in increments of 200 lb., the strain gage reading for the load was taken, and the load was removed to get the permanent set. This procedure was repeated for each load until the permanent set became about 0.0003 in.; after that the loads were not removed between increments, and the deformation only under load was measured each time. When this became greater than 0.01 in. the strain gage was removed, and the test specimen was broken in the usual way. The strain gage was graduated to 0.0002 in., and

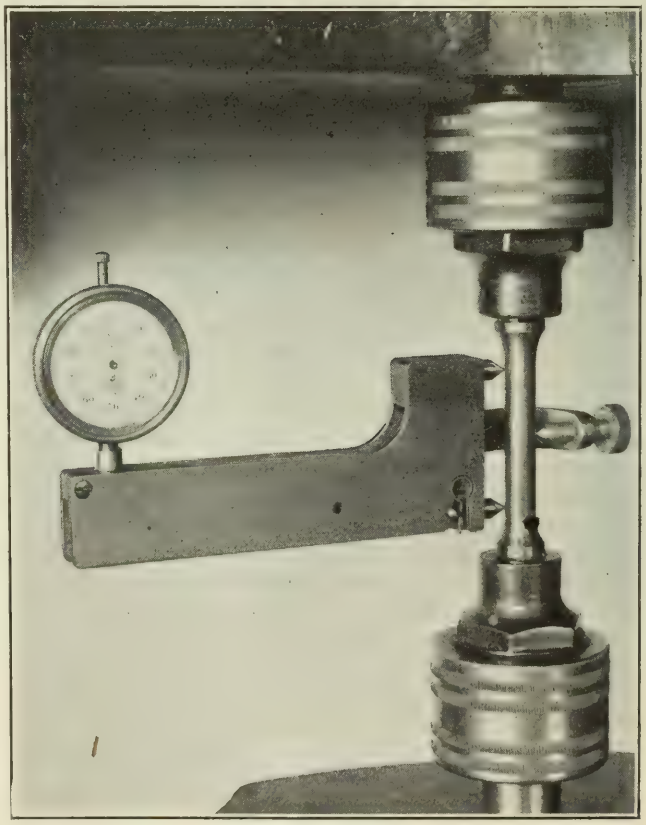


FIG. 1. BERRY STRAIN GAGE, AS USED IN THE FIRST SERIES OF TESTS

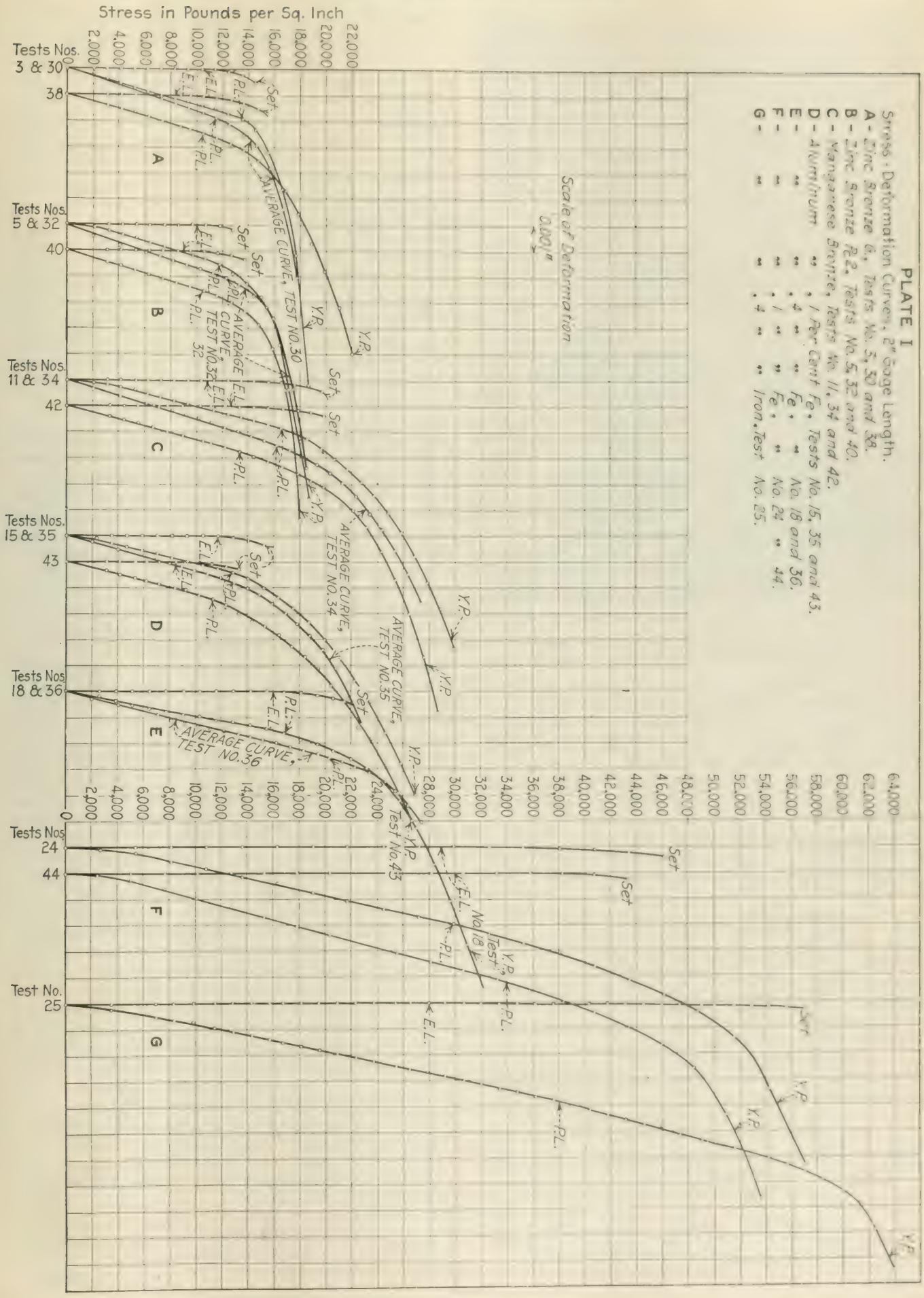


PLATE I
Stress - Deformation Curves, 2" Gage Length.
A - Zinc Bronze G., Tests No. 3, 30 and 38.
B - Zinc Bronze R.2, Tests No. 5, 32 and 40.
C - Manganese Bronze, Tests No. 11, 34 and 42.
D - Aluminum " .1 Per Cent Fe, Tests No. 15, 35 and 43.
E - " " .4 " " Fe, " No. 18 and 36.
F - " " .1 " " Fe, " No. 24 " 44.
G - " " .4 " " Iron, Test No. 25.
Stress in Pounds per Sq. Inch
Scale of Deformation 0.001"
Tests Nos. 3 & 30
38
Tests Nos. 5 & 32
40
Tests Nos. 11 & 34
42
Tests Nos. 15 & 35
43
Tests Nos. 18 & 36
Tests Nos. 24
44
Test No. 25
A
B
C
D
E
F
G
P.L.
E.L.
Y.P.
Set
AVERAGE CURVE, TEST NO. 30
AVERAGE CURVE, TEST NO. 32
AVERAGE CURVE, TEST NO. 34
AVERAGE CURVE, TEST NO. 35
AVERAGE CURVE, TEST NO. 36
Test No. 43
E.L. No. 18 Test
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
32,000
34,000
36,000
38,000
40,000
42,000
44,000
46,000
48,000
50,000
52,000
54,000
56,000
58,000
60,000
62,000
64,000

the readings taken were estimated to a tenth of this value, or 0.00002 in. The stress-set and stress-deformation curves were plotted on cross-section paper to a scale such that 1 in. vertically represented 5,000 lb. per sq.in., and 1 in. horizontally represented 0.002-in. extension on the gage length of 2 in., or 0.1 per cent deformation.

Tests on the heat-treated aluminum-bronze test specimens were made in the same way, except that a heavier poise was used on the machine, the increments were 500 lb. instead of 200, and the stress scale used in plotting was such that 1 in. represented 10,000 lb. per sq.in.

The results were obtained from the curves in the following way: The yield point was the stress at which the deformation curve crossed the line representing 0.01-in. extension, and the proportional limit was the stress at which this curve ceased to coincide with a straight line drawn through most of the points at the lower part of the curve. The elastic limit was the stress at which the set curve departed from an approximately vertical direction, sets of 0.00002 in. being generally neglected unless the next set recorded was considerably greater. The tensile strength, elongation and reduction of area were determined in the usual way after removing the strain gage and breaking the specimen. The moduli of elasticity were also read from the curves, but were not considered reliable, as will be explained below.

The results obtained in this way are listed in Table I, and some of the curves noted by a star and typical of each alloy are also illustrated in Plate I. The figures given represent pounds per square inch, or, in the case of the elongation and reduction of area, per cent.

Results Using Strain Gage in Three Positions

In all these tests it was found that the elastic limit was lower than the proportional limit, except in a few cases where both appeared about equal. According to most authorities, however, the elastic limit, if not equal to the proportional limit, should be slightly higher. Consequently the possibility of serious error in the above results was feared, and it was felt that this might have arisen from the manner of using the strain gage, that is, along one line only of the test specimen. Furthermore, many of the deformation curves were not as regular as might be desired, although the proportional limit was quite distinctly marked in all of them. To check the accuracy of the proportional limits tabulated above, it was therefore decided to test other specimens of these alloys, with the strain gage applied successively to each of three gage lines, equal distances apart around the surface of the specimen, for every load used. The test specimens were prepared, and held in the testing machine, in the same way as was previously described, but the loads used were 400, 800, 1,200, and every 200 lb. above that until the proportional limit had surely been passed. The gage was placed in each of three pairs of punch marks by hand three or four times at each load, and the average reading for each pair of marks was recorded. Considerable care was necessary in holding and reading the gage in this way, for the reading could be varied appreciably by changing the manner of applying the gage. It was not thought practical to drill holes into the specimens for the reception of the gage points, for with a small specimen such as was used in this work, premature failure would be almost certain to occur through the drilled holes. The loads were not released in these tests to determine the permanent sets, because it was not thought possible to apply the gage to the specimens accurately enough by hand to measure the very minute differences in length that these sets represent; also because attempts to get these measurements would have consumed very much more time. Therefore elastic limits are not reported for this series, and these tests were not carried far enough with the strain gage to get the yield points.

Three stress-deformation curves were obtained by this method for each specimen, and they were plotted to the same scale as has been described above. An average curve was also plotted by using the average deformation at each load, and it was always more regular in form than the three curves of actual measurements.

TABLE I. RESULTS USING STRAIN GAGE IN ONE POSITION

Test	Elastic Limit	Proportional Limit	Yield Point	Tensile Strength	Elongation, Per Cent	Reduction of Area, Per Cent
			Zinc-Bronze, Alloy G			
1	12,000	14,000	19,000	44,000	38.5	28.6
2	12,500	14,500	19,800	35,800	17.5	20.2
3*	10,500	13,500	18,100	42,000	31.5	31.0
4	9,000	15,000	20,600	38,700	18.5	16.4
Average,	11,000	14,200	19,400	40,100	26.5	24.1
			Zinc-Bronze, Alloy Pc2			
5*	10,000	11,500	18,400	37,200	26.0	24.8
6	8,500	10,000	21,000	46,200	34.0	26.8
7	10,000	14,000	19,500	46,200	31.0	27.9
8	9,000	13,000	19,800	36,000	15.0	14.9
Average,	9,400	12,100	19,700	41,400	26.5	23.6
			Manganese-Bronze			
9	13,500	17,000	26,900	74,900	32.0	28.7
10	14,000	17,500	29,800	82,300	22.0	20.9
11*	11,000	16,500	29,700	78,500	17.5	15.4
12	10,000	15,500	26,500	73,400	31.0	28.6
Average,	12,100	16,600	28,200	77,300	25.6	23.4
			Aluminum-Bronze, 1 Per Cent Fe			
13	12,000	13,000	27,100	67,500	20.0	20.9
14	10,500	12,500	27,500	77,600	21.0	20.6
15*	11,500	13,000	26,900	72,100	20.5	22.2
16	11,000	12,000	25,200	74,300	26.5	27.0
Average,	11,200	12,600	26,700	72,900	22.0	22.7
			Aluminum-Bronze, 4 Per Cent Fe			
17	17,000	17,500	33,100	84,600	18.5	18.2
18*	16,000	17,000	31,200	68,000	10.0	15.1
19	17,500	19,500	33,000	(Spoiled by flaw)		
20	13,500	16,500	31,300	89,600	25.5	22.6
Average,	16,000	17,600	32,100	80,700	18.0	18.6
			Aluminum-Bronze, 1 Per Cent Fe, Heat Treated			
21	23,000	28,000	53,500	85,600	12.5	15.4
22	23,000	27,000	55,800	97,400	15.0	19.6
23	29,000	39,000	65,500	92,700	7.5	10.3
24*	29,000	30,000	55,000	95,700	15.5	13.9
Average,	26,000	31,000	57,400	92,800	12.6	14.8
			Aluminum-Bronze, 4 Per Cent Fe, Heat Treated			
25*	28,000	38,000	63,600	107,400	19.0	21.0
26	36,000	39,000	56,000	90,300	12.0	12.9
27	25,000	39,000	61,300	99,500	11.0	12.9
28	28,000	29,000	57,000	102,900	22.0	22.0
Average,	29,200	36,200	59,500	100,000	16.0	17.2

*Illustrated in Plate I.

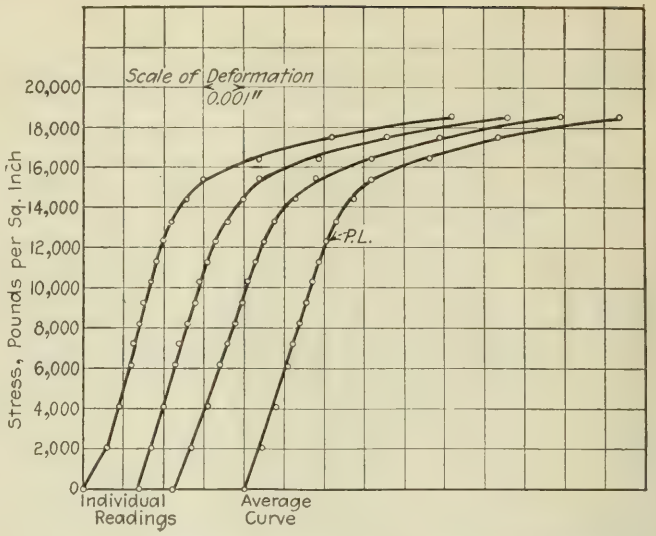


FIG. 2. STRESS-DEFORMATION CURVES FOR ZINC-BRONZE Pc2, TEST 32. GAGE LENGTH, 2 IN.

The true proportional limit and modulus of elasticity were determined from it, the latter being the stress divided by the extension per inch, for any point on a straight line drawn through most of the points of the lower part of the average stress-deformation curve. The results are presented in Table II in the same form as before, and typical average curves noted by a star for each alloy are also illustrated in Plate I.

TABLE II RESULTS WITH STRAIN GAGE IN THREE LOCATIONS

Test No.	Proportional Limit	Modulus of Elasticity	Tensile Strength	Elongation, Per Cent	Reduction of Area, Per Cent
		Zinc-Bronze, Alloy G			
29	8,000	11,000,000	33,800	21 5	22 9
30*	11,500	12,500,000	33,600	15 5	13 9
		Zinc-Bronze, Alloy Pc2			
31	11,000	13,500,000	35,400	22 0	23 9
32*	12,500	12,000,000	39,200	27 0	26.8
		Manganese-Bronze			
33	18,500	13,000,000	83,200	24 0	22 4
34*	16,500	13,000,000	85,700	25 0	21.8
		Aluminum-Bronze, 1 Per Cent Fe			
35*	13,000	14,500,000	72,700	29.0	26.1
		Aluminum-Bronze, 4 Per Cent Fe			
36*	20,500	16,000,000	71,000	9 0	10.4

* Average curves for these samples listed in Plate I.

In explanation of Table II it should be noted that both of the Alloy G specimens (tests 29 and 30) turned out to be unsound, so that their lower proportional limits

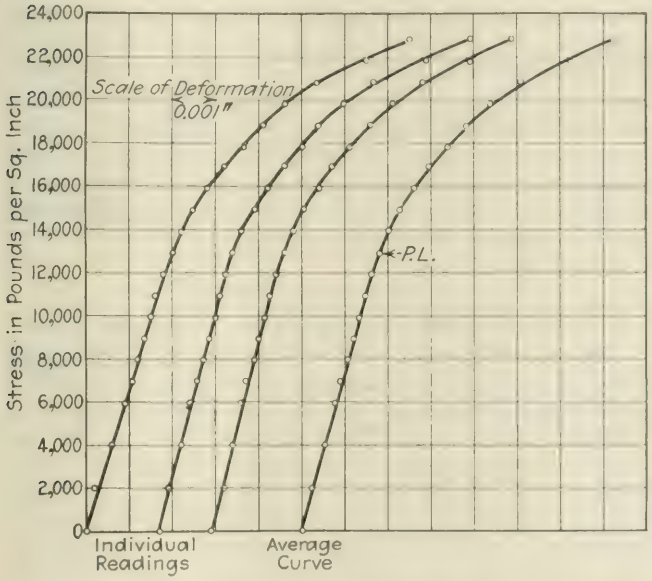


FIG. 3. STRESS-DEFORMATION CURVES FOR ALUMINUM-BRONZE, WITH 1 PER CENT Fe, TEST 35. GAGE LENGTH, 2 IN.

as compared with the previous tests (Nos. 1 to 4) might be expected. Also the specimen of aluminum-bronze with 4 per cent iron had been cast in sand 1¼ in. in diameter, and had been allowed to cool too slowly, so that it was somewhat annealed. This lowered the strength and ductility but raised the proportional limit. With these explanations the proportional limits check in a satisfactory manner those determined by using the strain-gage as an extensometer. It may be noted, moreover, from all the curves, such as those for zinc-bronze, alloy Pc2 (illustrated in Fig. 2) and for the aluminum-bronze containing 1 per cent iron (Fig. 3), that in the case of every specimen a proportional limit determined from one of the individual strain-gage curves would be just the same as the result found from the average

FIG. 4. HOME-MADE EXTENSOMETER, WITH AMES DIAL FROM BERRY STRAIN GAGE, SHOWING METHOD OF USE IN THE THIRD SERIES OF TESTS

curve for that specimen. This shows that no serious errors occurred in the proportional limit determinations of the first series of tests because of the use of the gage along only one line on the surface of each specimen. This is seen not to hold true for the modulus of elasticity, however, as the slopes of the individual curves vary considerably (Figs. 2 and 3), which shows that no true idea of this modulus can be obtained from the first series of tests. The curves from the heat-treated aluminum-bronzes were so regular and uniform that it was not thought necessary to check them in the second series.

Results Using Special Extensometer

Some of the individual curves of the second series were very irregular in their lower portions, on account of the great difficulty of placing the strain gage on exactly the same marks on the specimen accurately for each measurement. To eliminate this trouble, and to check the elastic limit and modulus of elasticity figures already obtained, an extensometer was constructed that could be kept attached to the specimen till after the yield point was passed, and that would measure the average deformation along two sides of the specimen. The same dial was used in the extensometer as in the strain gage, and the frame of the extensometer was constructed somewhat on the pattern of the instrument described before the Society for Testing Materials in 1915 by S. H. Graf (*Proc.* A. S. T. M., vol. 15, part 2, p. 376). In our instrument shown in Fig. 4, however, the motion transmitted from the test specimen to the dial is magnified five times by levers, as is done in the strain gage

itself, so that a unit on the dial represents the same deformation of the specimen, whether it is on the strain gage or on the extensometer.

Tests were made with this extensometer in exactly the same way as was described above for the first series of tests, the only difference being that the deformations measured in this third series were average deformations from two sides of the specimen, instead of being from only one side. The curves obtained in this way were more regular, and determinations were made of the elastic limit and modulus of elasticity as well as the proportional limit, yield point, etc. The results are listed in Table III and some typical curves noted by a star are also shown in Plate I.

TABLE III. RESULTS USING SPECIAL EXTENSOMETER

Test No.	Elastic Limit	Proportional Limit	Modulus of Elasticity	Yield Point	Tensile Strength	Elongation, Per Cent	Red. of Area, Per Cent
			Zinc-Bronze, Alloy G				
37	10,500	10,500	11,500,000	17,000	37,300	30.0	26.2
38*	8,500	10,500	13,800,000	22,000	32,900	15.0	20.0
			Zinc-Bronze, Alloy Pc2				
39	7,500	10,000	11,500,000	17,600	35,700	27.0	33.2
40*	9,000	10,500	13,500,000	17,900	35,800	24.0	30.2
			Manganese-Bronze				
41	13,500	13,500	16,000,000	29,600	77,600	20.5	21.8
42*	12,500	13,500	15,400,000	27,800	73,000	25.5	23.8
			Aluminum-Bronze, 1 Per Cent Fe				
43*	8,500	11,000	15,500,000	26,600	73,400	20.5	21.6
			Aluminum-Bronze, 1 Per Cent Fe, Heat Treated				
44*	30,000	34,000	15,000,000	51,600	81,800	9.0	16.5

* These curves shown in Plate I.

Discussion of Results

Allowing for individual variations in the test specimens, these results are in fairly good agreement with those given before. The proportional limits are nearly all lower than in the other series, but most of these specimens were of somewhat softer material as shown by the tensile strengths. The elastic limits check those in the first series, and the moduli of elasticity agree with those in the second series, except in the case of the manganese-bronze, where there is a considerable difference probably due to a different quality of metal.

It seems quite evident from this work that the elastic limits of these cast bronzes are nearly always found lower than the proportional limits, and never higher. The writer does not attempt to explain or defend this statement on theoretical grounds, but the curves certainly seem to demonstrate its truth.

Another point brought out clearly by the curves and tables is that there is no uniform relation between the proportional limit and the yield point or tensile strength in these alloys. Comparing tests 37 and 38, for instance, the latter showed a decidedly higher yield point (and modulus of elasticity) due to separation of the copper-tin eutectoid in greater amount, but its real proportional limit was as low as in the other specimen. Also the zinc-bronzes have distinctly lower yield points and much lower tensile strengths than aluminum-bronze with 1 per cent iron, yet the proportional limits of these two alloys are practically the same. When heat treated, however, the aluminum-bronzes are far superior to any of the other non-ferrous alloys in elastic properties, and the method of treatment leaves them free from internal stresses so that their proportional limits are very distinct and easily recognized.

No claim can be made for exceptional accuracy in these tests, but it has been demonstrated that a definite proportional limit can be found for non-ferrous castings without any great refinements of testing such as would be impractical in commercial work. When it is not desired to determine the elastic limit or modulus of elasticity, the proportional limit can be found with little trouble by means of a Berry strain gage attached to the test specimen and used as an extensometer. It is necessary, however, to pull the specimen with spherical-seated holders.

Of course any of the good extensometers on the market can be used with at least equally good results, and any of the methods for proportional limit determinations that have been described before the Society for Testing Materials may be followed.

It is suggested that for acceptance tests of non-ferrous castings the rough determination of the yield point as the stress giving a deformation of 0.5 per cent should be discarded as of no real significance, and that the importance of tensile strength measurements for this class of material should also not be emphasized, but that proportional limit determinations should be made and used for acceptance or rejection of bronzes that are intended to resist stresses in service. Ductility as expressed by a good percentage of elongation is probably a necessary quality to guard against brittleness; but as a measure of stiffness and useful strength without distortion, the proportional limit and not the yield point should be employed. That this can be done as readily in non-ferrous work as with steel is the chief conclusion to be drawn from the tests that have been described.

Acknowledgment should be made of the assistance of Austin B. Wilson in making many of these tests; and the author is also indebted to the Titanium Bronze Co. for the test specimens on which the work was done and the extensometer used, and to the Titanium Alloy Manufacturing Co. for the use of the testing machine and other laboratory facilities.

Niagara Falls, N. Y.

Exports of Crude Rubber From Brazil and Peru

The total shipments of crude rubber from the ports of Para, Manaos, and Itacoatiara, Brazil, and Iquitos, Peru, during the month of January, 1920, amounted to 6,273,039 lb., as compared with 6,624,915 lb. in the corresponding month of last year. Shipments from these ports during February totaled 8,162,264 lb. in 1920, as against 9,242,309 lb. in 1919; and the March shipments were 6,916,352 lb. in 1920 and 9,512,787 lb. in 1919. The price of this commodity still continues low and the effect of the low price is seen in the refusal of merchants to place large orders for forward delivery.

New Uses for Stainless Steel

Stainless steel is being employed very largely in the manufacture of pump rods, valve spindles, valves and other parts which are exposed to contact with water, steam and other corrosives. The scientific-instrument trade is using it for drawing instruments and other precision tools and for surgical instruments. It is being manufactured into stair rods, saucepans and pans of varying shapes, fenders for the hearth, and even into pokers and garden implements; and butchers' rails, spikes, skewers, saws and other butcher-shop requirements are being made from it. Sport is also taking an interest in stainless steel and is promoting a demand for golf-club heads, spurs, etc.

Scientific Control of the Filter Station—III

A Discussion on Washing and Drying Filter Cakes—Blowing With Air or Steam to Displace Filtrate, Wash Liquor and Water — Operations Fundamentally Dependent on Cake Formation*

By ARTHUR WRIGHT, M.E.

UNDOUBTEDLY present-day filtration is marked more by the advance in labor-saving devices than by any other feature of modern type filters. More economies, however, have been made in the better washing of the cakes in the new type filters, for whereas residual soluble in the cakes was formerly counted in whole per cents, today it is in fractions of 1 per cent. Materials that needed exacting washes were not handled in filter presses, the wash water in which almost always left some parts of the cake incompletely washed, yet these materials are today handled most efficiently in the modern filters.

The reason for the better results obtained is found in displacement washing. This is the term used to define that wash in which the liquid entrained in the voids of the cakes is pushed ahead of the wash water without the latter mixing with the liquid. In practice it is the simple filtering of the wash water through cakes the surfaces of which are equi-resistant.

All credit is assuredly due George Moore, who first realized the value of an equi-resistant cake and made it the foundation of his patents, both process and apparatus. His discovery was the factor which saved the cyanide process of gold extraction from being a pretty laboratory experiment and made it the forerunner of the efficient systems now employed.

Uniform Resistance to Flow Desired

The explanation for the practical production of an equi-resistant surface is had by reference to Fig. 5. Take any points *A*, *B* and *C* on the cakes, which may have been uniformly built up or may be tapering cakes the bottom of which is thicker than the top. The resistance to the flow is the same at all of them while filtration is taking place. The proof of this is found in assuming that at *A* the resistance is less than at any other point; then, according to the law of the flow of liquids, which seek the path of least resistance, a greater flow must pass through at the point *A*. Since, however, muddy liquor enters the filter and clarified liquid issues from it, the greater flow at *A* creates a greater deposit of the solids of suspension and this obviously increases the resistance to the flow until it is equal to the point *B* or the point *C*. It must, therefore, be acknowledged that during filtration, and at the close of the filtering cycle, the cakes present an equi-resistant surface to the flow of the filtrate.

The advantage of an equi-resistant cake surface must be apparent in obtaining a uniform wash of the cake. When the wash water cannot penetrate any part of the cake faster than any other, it forces the liquid entrained in the voids of the cake through as undiluted filtrate. This, of course, is the end desired, but it must not be thought that all the soluble can be recovered without some dilution even with the best types of filters and with the most expert manipulation. The bulk of the soluble can and should be so regained, but due to capillary attraction and dead end pores of porous material some soluble is retained and lags behind that forced out from the interstices of the cake. This liquid is recoverable by diffusion with the wash water and regained as a sweet water or weak liquor.

These facts are brought out in the graph known as the Washing Curve shown in Fig. 6. This is a plot obtained from periodic readings of the amount of wash filtrate flowing and its density. The abscissæ are the gallons flow and the ordinates the density.

Wash Liquor Displacement of Filtrate

Assuming the density of the filtrate to have been 32 deg. Bé., the curve of the theoretical ideal displacement wash is seen to be a broken straight line and is interpreted as meaning that all of the soluble is recovered at the high density and when all is forced out the density falls to that of the wash water. This is, as explained above, impossible in practical operation and has its value only when serving to note the efficiency of the practical operation.

The leaf-displacement curve is typical of good operation in leaf type or continuous filters. It will be noted that there is a gradual fall from the maximum density before the sharp break occurs. The explanation for this is that the viscosity of high density liquids is greater than that of the wash water or low density liquids. When washing commences the cakes present an equi-resistant surface, but as the wash water penetrates the cake some parts of the cake are made slightly less resistant so that the water flows through somewhat faster at such points. The turn of the curve before reaching zero is the result of the capillary attraction above referred to.

Washing Efficiencies of Plate and Frame Presses

The curve depicting the wash in plate and frame presses is representative of that obtained from alternate plate system of washing. Here the wash water finds channels and quickly weakens the strong effluent, causing a fall in the specific gravity. For the same reason, an effluent of a gravity equal to the wash water is obtained only by using excessive quantities of wash water. The reason for this is quite evident when we comprehend the conditions obtaining. In a plate and frame or chamber filter press initial filtration is analogous to that of leaf type filters and varies from this latter practice only when the cake on adjacent filter cloths in each frame meet. From that point on, the pump, feeding the press, does work not of cake building but cake compressing. This of itself is not a serious drawback, but it is practically impossible to compress all of the cake evenly or completely. It must

*For Parts I and II, see CHEM. & MET. ENG., vol. 22, Nos. 22 and 23, June 2 and 9, 1920, pp. 1,015 and 1,077.

also be remembered that the initial path of the wash water from the alternate plates is in a direction counter to that of the filtrate which produced the cake. This counter-current of the wash water is vital. The resistance of the cake to a counter-current wash is seldom equi-resistant, for it is the exception when the frames are completely and evenly packed. Consequently, it is obvious that paths of less resistance are open to the flow of the wash water and universal practice demonstrates the inadequacy of alternate plate methods of washing filter press cakes.

Plate and frame presses of a sluicing type such as the Merrill Press and automatic discharge type such as the Atkins-Schriver employ the displacement system of washing and have registered marked successes in their washing efficiency. To work ordinary plate and frame presses on this system is to invite nice control if discharging troubles are not to be encountered.

Original Formation of Cakes Must Be Preserved

From the foregoing it is seen that the formation of the cakes must be preserved if true displacement wash is to be obtained in leaf filters. Most materials in plant operation vary from time to time in their filtering characteristics so that in leaf filters it is generally found that there is too much unfiltered material to allow the wash water to be turned on directly at the close of the filtering cycle. To do so would surely mean a dilution of the strong liquor lying in the filter and to increase unduly weak liquor production. Practice, therefore, requires drawing the excess from the filter before the introduction of the water. This method allows materials to be washed at the end of their economical filtering cycle and is equally applicable whether the cakes are thick or thin. This feature of leaf filters is an important one and is in contrast to the operation in plate and frame filters, where the cake must be built up until it fills the frames and filtration ceases when the frames are filled. With raw materials varying in percentage soluble so that the material of suspension varies in amount and character, filtering until the frames are full often entails filtering long after the economical limit is reached.

Skill Required in Operation

Unfortunately this method of washing is successful in direct proportion to the ability of the operator. It is in his power to transfer the unfiltered material and fill with wash water so that the cakes remain in a condition practically as equi-resistant as when finishing filtration or he can defeat the desired ends by failing to maintain the equi-resistant surface. It is positively important that he be instructed not only what valves to operate but should be impressed with what he is trying to effect so that he can visualize the conditions inside of the machine. If he fails to maintain a positive pressure, usually by means of compressed air, some cake will slough off the cloths and surely create a path of less resistance for the passage of the wash water. The same is true if he drains or blows back the excess liquor at too great velocity. Again, if he uses too high air pressure, when holding the cakes on the leaves, he is almost positive to dry the upper part of the cakes in advance of the lower part and will either crack the cake or cool it so that in either case it is conducive to the formation of unequal resistances to the flow of the wash water. Obviously this makes for selective washing. Then, too, if he takes too long time in substituting wash water for the excess unfiltered liquor the conditions are the same as though he used too high air pressure. Experimentation will dictate the best pressure to use and the operator when once realizing what he must safeguard against has no trouble in effecting admirable results.

The Direct Washing Method

When handling materials that run uniformly the filters can be designed so that the space between adjacent cakes at the end of the economical filtering cycle will be minimized. With Sweetland type leaf filters, in which excess space in the filter is small, it is then practical to switch on the wash water simultaneously with the closing of the liquor valve. The excess unfiltered liquor is forced through the cake ahead of the water and the dilution of the strong liquor by the water is negligible. The same is true of Merrill type and Atkins-Shriver type plate and frame presses.

The direct washing method, the name given this system of admitting the wash water without withdrawing the excess unfiltered material, is not only advantageous on the score of simplicity of operation and saving of time but allows the greatest approximation to the true displacement wash. The reason is clear, for there is no possibility of any cake sloughing off the filter cloth, no cracks to be developed by air drying and the equi-resistant condition of the cake is automatically preserved so long as there is a positive pressure maintained in the filter during the transfer from feeding liquor to admitting wash water.

It is interesting to note that the quantity of sweet water or weak liquor produced should approach as an ideal that amount which equals the volume of the voids in the cake. It has been explained wherein capillary and absorptive action require something in excess of

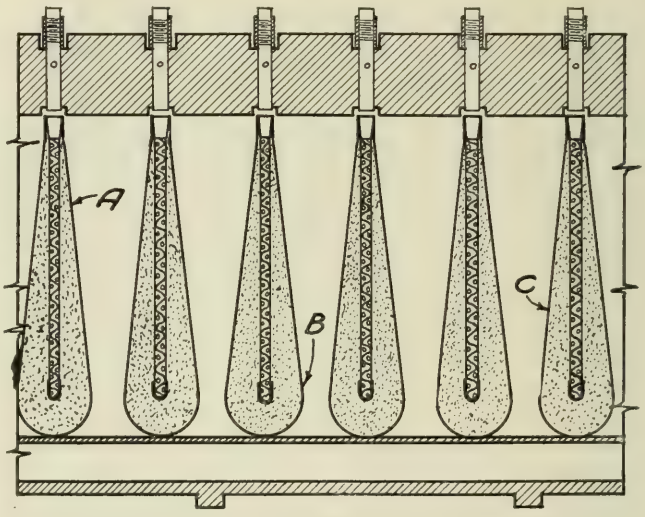


FIG. 5. EQUI-RESISTANT CAKE FORMATION

this in practice, but the actual amount required is oftentimes reduced when the impoverishment of the strong liquor is done by degrees.

By this means the gravity prevailing when fresh water is turned on is much reduced from the original gravity. In practice weak liquor washes are used for this purpose so that all water entering the process leaves it as a strong liquor. The same scheme is worked with marked success in continuous counter-

current decantation installations save that a semi-dewatered solid instead of an equi-resistant surface is subjected to the weak liquor washes.

Spray Wash for Continuous Filter Cake

All of this discussion relative to an equi-resistant surface is equally pertinent to washing the cake in continuous vacuum filters. Here the wash water is applied as an atomized spray, but in theory at least the water sprayed on the cake should, in its passage through the washing arc, envelop the cake and be equivalent to submergence. Excessive amounts of water are unnecessary and will run off the cake. This is, of course, objectionable, but the operator should not go to the other extreme of applying too little water, for then air-drying commences and the wash water will often be short-circuited. It is for this reason that with cakes difficult to wash out the soluble it is advisable to augment the spray wash with a repuddling of the discharged cake with water or weak liquor and filtering and washing on a second machine. This makes for fool-proof and efficient washing especially if the spray wash on the first machine is the effluent from the second machine. Then the strong liquor in the cake of the first machine is recovered at a high gravity.

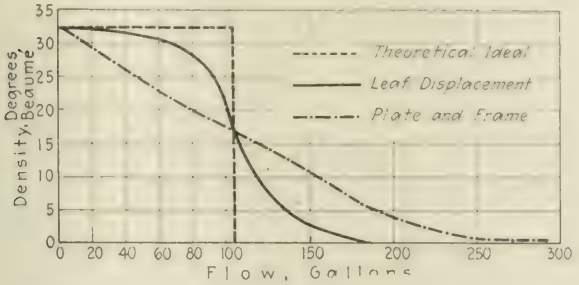


FIG. 6. CHANGE OF DENSITY OF WASH LIQUOR

Advantages of Open Gravity Filters

When handling extremely free-filtering solids such as calcium sulphate from phosphoric, citric, etc., acid manufacture, it is surprising how well the soluble can be extracted in open gravity filters. These filters can usually be home-made machines with false bottoms covered with cocoa matting, burlap, etc., or with the old cinder bed bottom. The one essential point is that the liquor and the wash water must drain by gravity so that the cake is built up uniformly. The cake formed is granular and allows considerable flow per unit surface, but the percolation of the wash water is slow enough so that shortly after the heavy liquid in the voids of the cake is displaced the remaining soluble has had time to diffuse through the wash water. This accounts for the admirable wash obtained in this class of filters, which obviously is confined only to those materials of an extremely free-filtering character. New means of discharge of the cake from this type filters will be described in the article under "Discharging" appearing in a later issue, wherein the manual labor hitherto entailed with this type of machine is obviated.

Drying the Cakes

Drying the cakes is a part of the operation of industrial filters often definitely required but too often thought unnecessary. Dryness of discharge is obviously advantageous when a further drying operation is required. When recovering the soluble from the cakes, oftentimes the cake is a waste product and the percentage of moisture in the cake is not a vital consideration save as a safeguard against high losses of soluble in the discharge cake. If the washing operation has been efficient, drying the cake is superfluous, but if defective washing has taken place, then decreasing the moisture content decreases the soluble in the cake.

Drying the cake is fundamentally dependent on the formation of the cake. If a compact cake is produced, the voids in the cake are minimized; if a fluffy cake is formed, the percentage of voids is large. In either case the work of drying the solids is the removal of the liquid in the voids. Obviously those cakes having low percentage voids require less duty on the drying operation than those with high void content.

Advantages of Recessed Plate Filter Presses

Plate and frame or recessed plate filter presses stand in a class by themselves as filters delivering dry cakes. The reason for this is explained in that the cakes are more compact than those obtained from any other type filter. The initial filtration in filter presses is identical with that in leaf or continuous filters except when filtration has progressed so that the cakes on adjacent filter cloths meet; then the filtration in filter presses varies from the filtration in modern type filters in that the pump begins to do work of cake compression rather than continuing that of cake forming. It is this cake-compressing action that helps so materially in the production of cakes of low voidage.

With the above in mind it is therefore evident that there is a definite width of frame for each material in order that efficient operation of the filters and the discharge of the driest cakes be obtained. Too wide a frame requires too long a cake-building period and allows too great a resistance to the flow to be set up before the work of cake compression commences. It is thus seen that for any particular material there is a balance between the maximum caking capacity of a press and the dryness of the cake, consistent with efficient operation. In the writer's experience these data are best determined by experimentation on a single leaf filter when the filtering characteristics of the material are determined without giving thought to dryness of discharge.

The principle of cake compression for dryness of discharge is unfortunately not applicable to leaf type filters. Here the cakes must not be allowed to form so as to touch each other or otherwise all the advantages of displacement washing and self-discharge are jeopardized. Also overcharging in pressure leaf filters is insidious in its evil effect of warping the filter leaves. The difficulty from tearing the cloths on distorted leaves and from straightening the drainage members is apparent, but in a well-designed and well-operated machine the filter leaves are spaced so that the cakes do not meet. When the leaves are bent out of shape it is practically an impossibility to straighten them completely, at least while in the filter, so that the original spacing is changed and some of the leaves are on closer centers. This, of course, is a condition ripe for continuing this difficulty and becomes a constant source of trouble. It is not generally understood just what produces the distortion of filter leaves. It is not that the leaves bend away from the cakes which have joined together but that by their having joined together the pressure between them is lowered while the exposed

sides of the leaves are subject to the full pressure. This gives an excess force which, acting over the entire surface, exerts enough pressure to cause the leaves to bend in toward the joined cakes.

Moisture Displacement by Compressed Air

Drying the cakes in leaf type filters, therefore, must be obtained by displacing the entrained liquid in the voids of the cakes by some gas (compressed air, steam, etc.). This part of the filtering cycle is undoubtedly the weakest in the operation of leaf filters. To start with, the cakes, as built up, are high in percentage voids, a mere examination of the cake showing the exterior of the cake to be far wetter than that against the filter cloth, and the bulk of the liquid extracted from the cakes must pass through an ever-increasing resistance until penetrating the filter cloth. This, of course, entails a high duty on the drying agent.

When drying with compressed air, which is in reality filtering compressed air through the cakes, the effect is to supplant the liquid in the voids of the cake with air. This obviously is less support for the particles of the cake, so that there is a rearrangement of the particles—generally spoken of as the "shrinking of the cake." This shrinking results in cracks developing which immediately form paths of less resistance for the passage of the compressed air. At this stage the drying effect is negligible in comparison with the work of compressing the air and best practice is to halt the drying operation at this point.

Prevention of Cracking of Cake

Best drying operation in leaf type and continuous vacuum filters is obtained, therefore, by proceeding in that manner which decreases the early formation of cracks. With granular and similar materials this is so practical that the difference of percentage moisture in cakes of such materials as discharged from modern filters and moisture in cakes as discharged from filter presses is not large. When handling fine, flocculent materials it is more difficult to prevent early cracking. The procedure in such cases is to build up as dense a cake as possible before admitting the compressed air and to remove as much moisture in the cake at as low a pressure as possible. The means of forming the dense cake can best be determined by experimentation, but it is often found that if the initial filtration be carried on at a low pressure and allowed to rise to a point considerably less than that used during the washing operation, good results are obtained. In vacuum continuous filters, especially those of the drum type, flapping and cake-compacting mechanisms can effect this result mechanically. In any design of vacuum continuous filters where cake cracking cannot be avoided there is a big saving on the duty of the vacuum pump if the automatic valve be constructed so as to shut off the suction at the time of crack formation.

Leaf type filters constructed so that the outlet of the leaves is at the top of the leaf are not as satisfactory as those that drain from the bottom. The reason for this is quite apparent, for bottom-discharge leaves drain out all the liquid, whereas the top discharge pockets the liquid and on discharge that liquid is forced back through the cloth and mixes with the discharge cake. This is the advantage of bottom-drainage filter leaves and is the only reason for drier cakes being obtained from their use.

It is a proved fact that many materials may be discharged from leaf or continuous type filters higher in percentage moisture than cakes of the same materials discharged from filter presses and yet in subsequent driers will be found to work better. This is due to the cake formation admitting a better heat conductivity and escape of the steam vapor. True, if the cake from the filter presses be broken up, then the advantage lies with the filter press cakes.

Firmness of Cake

It is somewhat academic but nevertheless important to understand clearly the theory of cake formation, which bears such a relation to drying efficiency. When a filter is first started up or when a section of a continuous filter first dips into the liquor the rate of flow is the greatest. The flow may quite as readily be conceived as the summation of the delivery from every square inch of surface. On each unit area, cake is being deposited and its compactness is in direct proportion to the velocity of the liquid being filtered. When the velocity is high the stream lines are said to be strong, and weak when the velocity is low. Therefore, if the velocity be maintained at a high rate for a long period, the stream lines are strong and the cake firm. This then gives the reasoning on which better drying effect is obtained when starting with low pressure for the handling of difficult filtering materials because this low initial pressure does not build as resistant a cake and admits of a greater flow throughout the cycle thereby. Obviously the cake produced by strong stream lines must be a dense cake if we consider the cake as being built up by arresting the particle of suspension carried by the stream lines (its momentum being in direct proportion to the velocity of the stream line). The greater the momentum the greater the impact upon the cake and the denser the cake produced.

(Part IV, dealing with Discharging, will be published in a subsequent issue.)

Hongkong's Imports of Chemicals

The trade in chemicals at Hongkong in 1919 showed little life and very little increase over that of 1918. The total value of the trade is given by Hongkong official statistics at $2,572,755, compared with a value of $2,265,582 in 1918.

The chief items in the trade were saltpeter, which reached a value of $459,659 and came almost entirely from India; camphor, valued at $288,935, supplied mainly by north and middle China and Japan; soda ash, $228,342, almost entirely from Great Britain; caustic soda, $194,696, of which two-thirds came from the United States and most of the rest from Great Britain; and the usual run of miscellaneous drugs and chemicals, none of which reached $100,000 in value. There was a marked decrease in the imports of acids, most of which came from Japan, and also smaller imports of bleaching powder (in quantity, though the value stayed about the same for the two years), calcium carbide, phosphorus and glycerine. There were increased imports of alum, borax, quinine, chlorate of potash and sulphur.

In a general way Hongkong importers found it difficult to secure supplies from the United States and most of them returned to their old British connections as rapidly as conditions permitted. Present exchange conditions militate against local industries, and this is reflected in the lessened demand for chemicals.

Extraction of Tannin From Indian Myrabolans

THE following note on myrabolans (myrobalans), the fruit of *Terminalia chebula*, prepared by the tannin expert of the Government of India, appeared in a recent issue of the *Indian Trade Journal:*

The myrabolan fruit—or, as it is often incorrectly called, the "nut"—is usually collected when still green. After collection it should be promptly dried in the sun. The best grades of myrabolans, viz., the Bhimlis and Jubbulpores, are collected in this way. Bombay nuts are riper when collected and are apt to be somewhat soft, waxy and spongy. They have a smoother skin with larger wrinkles than Jubbulpores and Bhimlis, and are, as a rule, less liked by the trade, but have been reported to be actually richer in tannin than the harder, shriveled, first-grade nuts.

In Europe myrabolans are the best-known Indian tanstuff, and find a very wide application in mixture tannages. In India myrabolans are largely used in mixture tannage, and perhaps still more largely as a "bleaching" agent at the end of the tanning process. This is especially in the case in the tannage of the "crust" leathers of Bombay and Madras with avaram or turwad (*Cassia auriculata*), when the tannage is completed by a bleaching process in a brew of myrabolans. For this purpose, myrabolan extract would not be suitable, but in mixture tannages extract could be utilized to replace the myrabolans at present used. For tannery use myrabolans should be crushed before extracting the liquors.

Myrabolans have also long been known as a dyestuff. They are, for instance, used in Bombay for the production of yellowish-buff shades on cotton. Myrabolans also find some application in the manufacture of inks, which are produced by the addition of iron salts, suitable gum, and some "soluble blue" dye. In Europe, myrabolans are used in the dyehouse for the mordanting of cotton as a preparation for the application of basic dyes, the weighting of black silk, etc.

Nuts for Export

Spongy nuts, which do not keep so well as shriveled nuts, might be used for the preparation of a "No. 1 crushed" myrabolan product. For this, the nuts would be crushed with a wooden mallet as soon as collected, and the comparatively valueless stones removed. The remaining flesh should be dried in the sun, when, if the nuts were in sound condition when crushed, the product should show approximately some 50 per cent tannin.

From the economic standpoint it would really be better to crush all myrabolans intended for export abroad and to dry the flesh in the sun. Removing the useless stones would effect considerable economy in freight while enhancing the proportion of the valuable tannin constituent in the product exported. There is, however, a prejudice on the part of the European public against crushed myrabolans, because, when exported in this finely divided form, the addition of adulterants is easy to effect and difficult to detect. Crushed myrabolans, therefore, could only be exported where an absolute and unimpeachable guaranty of genuine purity could be given and the quality always maintained over a long period. On the other hand, whole nuts cannot well be adulterated, and if of good grade will always secure their prices, even when sold by an unknown vendor. They should contain 30 to 40 per cent tannin.

The percentage of tannin in a solid extract should approach very nearly to 60 per cent. The gain in concentration over the best whole nuts is therefore very considerable, although much less so in the case of the pure crushed product without stones.

Advantage of Extract Over Raw Product

Although a solid myrabolan extract is not much richer in tannin than the crushed stoneless product, it consists, in the main, of soluble matters plus water, whereas the crushed raw product contains vegetable fibrous matter which adheres to fabrics in the dyehouse and also to the leather in the tanyard. In the latter case, however, it is not a very serious objection, and in the case of bleaching with myrabolans the product crushed is in its most effective form for the purpose; but crushed myrabolans could not be used to strengthen tan liquors materially, as the tannin principle is dissolved from it relatively slowly, whereas solid myrabolan extract is readily soluble.

Myrabolans will produce a very good paste extract of, say, 40 or 50 deg. Tw. The solid extract, also, has long been a commercial product. It is, however, inclined in moist, warm weather to become soft and sticky, at least on the surface of the block; this owing to the affinity for water of certain of the non-tannin constituents in the extract. Their presence makes it doubtful whether it would be advisable to prepare the myrabolan extract in crystal form except for use in cold countries. In hot, moist climates such crystals would be likely to re-cohere into a solid mass, though it is possible that this difficulty may be overcome in the course of time. Apart from this hygroscopic tendency, myrabolans produce a good, clear extract which is fairly free from insolubles and has good keeping qualities. The extract is readily soluble in water, but dilute solutions very soon deposit "bloom" or ellagic acid. It is the loss of some of this "bloom" during concentration to solid extract that renders the extract less suitable than the raw material for the so-called "bleaching" process.

Process of Manufacture of Extract

The process of manufacturing the extract may be divided into three sections—(*a*) crushing, (*b*) leaching or extracting, and (*c*) conversion of relatively weak leach or extractor liquors into extract.

(*a*) Suitable machines are available for crushing the myrabolans in such a way that the useless stones drop out. The tannin principle of myrabolans is so inclosed in the cells that it is not very easy completely to extract the raw material, and it is for this reason that figures of yield nearly approaching the theoretical possible are so seldom attained.

(*b*) For the best extracting or leaching, series of connected leaches or extractor pits or vats are required. Water passes first over all but exhausted raw material and then into a series of pits over less and less exhausted material, until in the final pit, before it is drawn off, it passes over absolutely fresh material, this pit being regarded at the moment as the head of the series. The pit, however, over which pure water had been passed to extract the last traces, is now emptied and filled up with fresh raw material, and in its turn becomes the head of the series, the pits always being worked in a circular rotation.

(*c*) The liquors from leaches are allowed to settle in a suitable pit, or in some instances are subjected to

filtration at this stage. The clear liquors are then drawn by vacuum into a multiple-effect vacuum evaporating system in which they are rapidly concentrated (in a few hours at most) to a liquor of say, 50 per cent solids strength. The liquors are then pumped, or drawn by vacuum, into a finishing evaporator which is usually of the Calandria type. Here the thick liquors are further concentrated during several hours to a paste, which will just flow from the pan while still hot. The extract in this form is collected in paper-lined boxes, and in the course of a night will set to solid. When properly prepared, myrabolan extract should be readily soluble in water, giving an amber to amber-brown solution. The solid extract should have a clear, bright, vitreous fracture.

If myrabolan liquors are concentrated to solid in the air, much decomposition of the tannin ensues; the extract is black in color and contains objectionable tarry decomposition products.

The Alsatian Petroleum Industry

During the present time of fuel shortage the petroleum wells at Pechelbronn, in Alsace, have taken on a new importance. These wells are of considerable value. They were first discovered in 1735; a few years later a small refining plant was constructed, and the wells have been worked for about 180 years. They are among the oldest petroleum wells in the world. In 1888 underground digging was replaced by the modern boring method; but during the war the older method had to be resumed, and shafts were driven to a depth of 275 yd. These petroleum deposits are now the only ones in the world worked by shafts. This method of exploitation is made difficult by the fact that the beds of sand under the earth become impregnated with inflammable gases and a slight accident will cause a serious explosion. Two thousand workmen are now engaged at Pechelbronn in various kinds of work, including the location of new deposits of oil, the extraction of the crude oil, distilling, refining, etc. Pechelbronn produces 50,000 tons of petroleum products per year.

Modern Equipment—New Deposit Recently Tapped

All branches of this flourishing plant are equipped with the best modern machinery. The drilling machines, of which there are forty-four, are run by electricity or steam and are distributed over a surface of 110,000 acres. A network of electric wires, over 42 km. (26 miles) in length, furnish power to about 500 oil pumps. Three shafts, with 4,000 m. (13,000 ft.) of subterranean galleries, produce more than 25,000 tons of crude petroleum per year.

Recently a drill driven to a depth of 435 m. (1,427 ft.) in a region hitherto untouched located a new deposit, and the well is now spouting petroleum at the rate of fifty tons a day. New refineries are to be installed capable of distilling 73,000 tons of crude petroleum per year. The distillation is to be by the "continuous" process, with perfect vacuum.

These Pechelbronn petroleum deposits are of great value to France at the present time, not only because of the fuel which they yield but because of the information which French capitalists are able to obtain from them as to the best method of handling petroleum deposits in which they are interested or have concessions in foreign countries.

Legal Notes

By Wellington Gustin

Rodman Patent for Method of Making Case-Hardening Material Held Valid

The Rodman patent, No. 1,076,453, for a method of making case-hardening material, has been held valid and infringed by the United States Circuit Court of Appeals, Seventh Circuit, reversing the District Court. Suit for infringement of the patent was instituted by the Rodman Chemical Co. against the Deeds Commercial Laboratories. The invention relates to improved methods of manufacturing carbonizing material for dry packing. The product of this process is small masses or pebbles of carbonizing material, made out of what was theretofore largely waste dust. The advantage over other carbonizing products was its reduced costs, due to the utilization of a waste product, its greater thermal conductivity, easier handling over powdered or dusty carbonizing materials, and especially its retention of identity under heat.

The claims of the Rodman patent in the suit were Nos. 1, 7, 10, 17, 22, and 25. Claim 1 follows:

"1. The method of adapting finely divided material for use as carbonizing material, which consists in mixing the material with a binding agent and forming small masses which will maintain their identities when heated."

Claim 22 differs only in describing the binding agent as "tacky" and claim 25 by adding after the words "binding agent" the phrase "such as molasses." In claim 7, the method of forming "small rounded pebbles," instead of "small masses," is stated as "tumbling to form." Claim 17 reads:

"17. The method of preparing carbonizing material which consists in fashioning finely divided material into substantially smooth-surfaced pebbles and in then applying heat thereto."

The Deeds Commercial Laboratories defended the suit, claiming that the process had been used for more than two years prior to application for patent. Another defense was that the process had been anticipated and was invalid for lack of invention, while still another was non-infringement. The District Court for Indiana found for the defendant on these grounds, but this judgment was reversed on appeal.

Claims of Prior Use Denied by Court

On the question of prior use it was found that the Rodman Chemical Co. manufactured successively and contemporaneously several kinds of carbonizing materials; and that the product from the method of the patent under suit was the final and most successful one. This differed in substance, in form and in quality from the others, each marking an advancing step in the manufacture of a valuable commercial product, yet each produced by a definitely distinct method. Proof showed that the method of the patent was not used prior to 1912, and the patent was granted Oct. 21, 1913.

On the question of infringement the court said there was infringement, except as to claim 7, if the claims are to be broadly interpreted. The defendant used charred carbonaceous materials in powdered form and

a solution of molasses and water; they are mixed in a mixing machine, small balls or pills being produced The proper sized ones are first air-dried, and are then dried in a revolving drum with heat applied. The purpose of this final heating was alleged to dry out the excess moisture, yet the effect thereof in this revolving drum is to reduce the size of the pills and to compact and harden them. Whether this be technically a "tumbling" operation or not, it is the equivalent thereof; the sole purpose of tumbling is to compact or harden the pill; and whether this be accomplished in one operation, during their formation as pills, or in two, is immaterial. In his claims Rodman is not confined to the use of such carbonaceous material as requires coking, and the court said that defendant's use of coked or charred powder as against Rodman's preferential method of using coking coal dust does not therefore avoid infringement.

While some carbonaceous materials, like charred leather, require no special preparation, others, like charcoal, coke, or coal, require, for commercial use at any practicable temperature, the addition of a chemical energizer, such as lime, in order to activate the carbon. But the patent is not limited to the use of a carbonaceous material requiring the addition of an energizer. The carbonizing material in each of the claims covers as well carbonaceous materials, such as charred leather or corncobs used by defendant, having in themselves sufficient energy to activate the carbon.

Court Discusses Case Hardening

On the question of anticipation and want of invention in the patent, the court discussed case hardening as presented to it. Case hardening is a species of carbonizing. If it be desired to harden the metal throughout, carbon is dissolved into the molten metal. If, however, only the surface is to be hardened, so-called case hardening, the finished product is packed in dry carbonizing material; the box is sealed and placed in a red hot furnace for several hours; the carbon gases produced are absorbed only by the surface of the metal. When the required depth of carbonization is secured, the article is dropped, red hot, into cold water; this makes the carbon skin or "case" perfectly hard. The interior of the article, not having been carbonized, remains soft and tough. The desirable and sought-after product for case hardening was one that would be susceptible of repeated use; the small pill, maintaining its identity when heated, answered this need. The uniform distribution of carbon and energizer, resulting from their use in powdered form, and the maintenance of this relation by the permanent binding together of the particles, as well as the freedom from dust, were additional advantages of this pill or pellet formation. Moreover, a waste material, the coal or coke dust, heretofore discarded was utilized.

A new product was thus created; a product of commercial value for definite uses, said the court. Earlier patents, Dodds, British, No. 571; Aube, British, No. 738; Demenge, No. 564,053; Logan, German, No. 181,-531; all of which mention incidentally case hardening, and Meyer, No. 524,904, while referring to the use of carbonizing briquets made of powdered materials or of balls of carbonizing paste, give no hint that these products will not be completely absorbed in a single carbonizing process, or that they will maintain their identity under heat; nothing whatever is said in any of them as to the method of manufacture. The court said they were different products than those made under the process of the patent in suit.

While each step in the process of making these pellets may be old as applied to other articles, the conception of this novel product and of the combination of acts necessary to produce it is novel, said the court. In the light of the present knowledge, it may have been a simple matter for defendant's expert, from a reading of the earlier patents, to create a product identical with that of the process in suit and by the same means; this, however, is no demonstration that the product or method would have been obvious to one skilled in the art but ignorant of the patent in suit.

Rodman's essential contribution to the art through the patent was the step by which the identity of the small pellets was maintained, and their continued use in actual practice for about 500 hours made possible. And the court held that defendant made a substantially identical product by a substantially identical method, resulting in infringement.

Uses of Duralumin in Aëronautics

The National Advisory Committee for Aëronautics at its recent semi-annual meeting acted favorably upon the recommendation of the committee on materials for aircraft and adopted the following resolution:

> *Resolved*, That the executive committee be instructed to communicate with various manufacturing companies, inviting their attention to the importance of duralumin products, especially tubing, for airplane wings, and endeavoring to secure their co-operation in the development of duralumin products for airplanes.

It is considered to be a highly essential matter that duralumin and similar wrought aluminum alloys, as well as aluminum castings alloys, be made available for military use. It is also anticipated by the metallurgical experts that a large commercial future can be expected for these materials, not only in commercial exploitation of airplanes, but also in automotive construction and in other industrial work where strong, light alloys are much needed.

Metal parts of Zeppelins were made of aluminum alloys and the later ships were all of duralumin. In the United States a considerable amount of duralumin metal has been produced in simple shapes, while in England, France and Germany the production has been carried to almost all conceivable wrought shapes. For example, Fokker all-metal planes have duralumin wing coverings replacing fabric, duralumin frame-work in various welded and formed shapes and duralumin tubing for the supporting members.

German Potash Situation

In the *Times Trade Supplement* (London) of April 10, 1920, the following interesting article on the German potash situation was published:

"At a general meeting last month of one of the most important concerns in the German potash combine it was reported that the present position of the German potash industry is very unhealthy. Exports in 1919 were 3,000,000 metric hundredweight, as against a pre-war exportation of 12,000,000 to 16,000,000. The home supply was actually worse in 1919 than in the previous year, falling from 16,000,000 to 12,000,000, whereas before the war about 24,000,000 metric hundredweight was furnished. Of the 200 potash works in the combine 80 were shut down entirely last year. It is noted that the individual output of the workers fell from 149 tons in 1918 to 65 tons in 1919."

Vulcanized Fiber

By L. R. W. Allison

The increasing popularity and utility of vulcanized fiber for electrical, mechanical and other purposes lends particular interest to this material and its composition. Up to the present time but brief information has been published on the subject, indicating that a broadened knowledge will prove decidedly advantageous in various channels of operation.*

Vulcanized fiber has assumed an important status in the manufacture of parts, tubing, rods, bushings, washers and disks, etc., replacing die-stampings and other metal productions for numerous specialties. Its use is not only becoming standardized, but phases of manufacture are being improved to that degree to insure absolute certainty as to service and life.

The industry as a whole has grown to a noticeable extent during the past few years, and leading manufacturers, not content with immediate accomplishments, have been studying further possibilities.

How Vulcanized Fiber Is Made

Vulcanized fiber is manufactured from cotton rag stock, which, after being cut into small pieces, is boiled with soda, washed, bleached and beaten to a pulp; it is colored red or black, or left in its natural gray state, and then run off on paper machines, which convert it into a high-grade cellulose paper, both unsized and unadulterated. The paper subsequently is passed through a bath of zinc chloride in which its surface is gelatinized to such an extent that, on being "built up," the various layers become as one homogeneous sheet of any thickness desired.

These sheets are in turn treated to remove and neutralize the chemical reagents, after which they are dried and calendered, then cured or seasoned for a period varying up to one year, according to the thickness. The importance of natural aging or seasoning will be appreciated when it is understood that any attempt to force this process, for the purpose of cheapening the product, invariably results in an inferior material. In such event, the ultimate life of the fiber is lost or shortened and its dielectric strength impaired.

Properly prepared vulcanized fiber, because of its toughness, elasticity and durability, is superior to hard rubber and porcelain for electrical or mechanical purposes. In its finished form it does not shrink, warp, twist or expand unless exposed to moisture; and when used in moist places, gives satisfactory service if coated with shellac or other moisture-excluding compound.

Fiber Tubing and Fiber Rods

Fiber tube has become an important material in electrical insulation, due to its properties and the ease with which it may be made into any desired shape. This tubing is prepared in the manner explained above. The paper is gelatinized and run on steel mandrels of a size which determines the inside diameter, while the number of turns establishes the wall thickness, or the outside dimension. In the electrical industry, fiber tubes are being used very generally for flashlight cases, cable conductors on automobiles, vacuum-cleaner nozzles, and the like.

Fiber rods are made from sheet fiber. The sheet is cut into square bars and then run through a rod or dowel machine. Accurate diameters are obtained to 2 in., with 5 ft. as the standard length. This rod may be used for the same purposes as metal rod and for any special parts usually made from metal, such as bushings, screws, push buttons, and so on.

Fiber can be machined very easily and accurately, and into practically any shape. It can be embossed with equal facility and takes a very fine finish.

Standard Sizes Manufactured

Standard sheets of vulcanized fiber as produced by the Mitchell-Rand Manufacturing Co., New York, come in a size of 44 x 72 in. The thickness varies from 0.005 in., weighing approximately 0.8 lb. per sheet, to 1 in., which weighs about 160 lb. per sheet.

Fiber tubing is manufactured with an inside diameter varying from $\frac{1}{8}$ in. to 6 in., and with thickness of wall in $\frac{1}{32}$-in. variations, from $\frac{1}{16}$ in. to $\frac{3}{8}$ in. Up to 1 in., the inside diameter increases by $\frac{1}{16}$-in. measurements, and above this diameter by $\frac{1}{8}$-in. variations. The lengths vary from 2 to 3 ft.

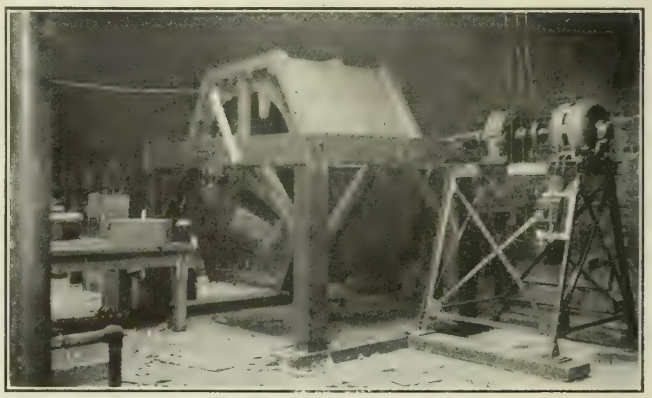
Newark, N. J.

*A concise statement of the manufacture and properties of vulcanized fiber, by Charles Almy, Jr., appeared in Metallurgcal & Chemical Engineering, vol. 13, p. 746 (Oct. 15, 1915).

Drum Tester

In a test for strength of shipping boxes, the object of which is a simulation of the rough knocks, bumps and jars of handling which a loaded box may encounter in railroad traffic, there has been designed a machine by which the railroad usage which a box may meet in a 2,000-mile haul can be duplicated in four or five minutes.

The first machine of this kind—known as the drum box-testing machine—was designed by the U. S. Government Forest Products Laboratory at Madison, Wis.



DRUM BOX-TESTING MACHINE

The machine installed at the Mellon Institute is an improvement over the original tester in that the inconvenience of overhead pulleys and shafting has been done away with by the substitution of a reduction gear for cutting down the motor speed to the drum speed of 2 r.p.m.

A valuable field of investigation and scientific study of the construction and materials of packages is opened up by the new machine, such as best methods of interior and exterior packing for fragile or irregular shaped objects; the determination of proper specifications for containers carrying various commodities, etc.

The Container Club of Chicago, an association composed of corrugated and solid fiber box manufacturers of the United States, offers free service in the designing of scientific packing methods for the various commodities capable of being shipped in fiber containers.

Recent Chemical & Metallurgical Patents

Toluene From Xylene.—To the fraction of solvent naphtha which is obtained between 135 and 145 deg. C. and which consists principally of metaxylene, is added 5 to 10 per cent of anhydrous aluminum chloride. The latter combines with a portion of the xylene to form the active catalyst, which is a reddish liquid not miscible with the hydrocarbons. Upon distilling this mixture under suitably regulated conditions, the toluene is removed as rapidly as formed. Plugging of the column and condensers due to volatilized aluminum chloride is avoided by distilling under a 14 in. vacuum. (1,334,033 and 1,337,317; ARTHUR E. HOULEHAN of Wilmington, Del., assignor to E. I. du Pont de Nemours & Co.; March 16, 1920 and April 20, 1920.)

Continuous Electrical Mechanical Filter.—For removing colloidal and other fine suspensions from liquids, ARCHIBALD F. MESTON, of New York, has devised a continuous filter in which the colloidal particles are agglomerated prior to filtration by electrostatic action. The revolving drum forms one electrode. The other electrode is hollow so that the liquid to be filtered may be fed in through it. Difference of potential is maintained by current from the secondary winding of a transformer. (1,334,160; assigned to Research Corporation; March 16, 1920.)

Metallic Sodium.—Many of the difficulties encountered in the Castner process for the production of metallic sodium by the electrolysis of fused NaOH are overcome in the process devised by ALBERT W. SMITH and WILLIAM R. VEAZEY, of Cleveland. The electrolysis of a mixture of 35.6 parts of sodium chloride and 64.4 parts of sodium carbonate yields metallic sodium equal in quality to the present commercial product. This mixture melts at 600 deg. C. (1,334,179; assigned to the Dow Chemical Co.; March 16, 1920.)

Sulphuric Acid Plant Construction. — It has been customary to support the lead curtain walls and tops of sulphuric acid towers and chambers by means of independent wood or steel structures, whether or not such towers or chambers contained interior masonry walls or packing. These methods have involved heavy and expensive framing especially in those cases where it was desirable to use towers or chambers of considerable height. ELDON L. LARISON, of Anaconda, Mont., proposes to construct towers or chambers of this type in such a way that the lead sheathing of sides and tops with the necessary light framing to which the supporting lead straps are attached shall be supported on the masonry walls. Construction details are given. (1,334,384; March 23, 1920.)

Adsorption of Vapors and Gases by Silica Gel.—Silica gel is an efficient adsorbent for many gases and vapors. During adsorption, the evidence seems to indicate that under certain conditions the gas is actually liquefied in the pores. This effect is obtained under conditions of temperature and pressure widely different from those under which ordinary liquefaction takes place. Thus 100 to 200 atmospheres pressure is required at 0 deg. C. to liquefy the SO_2 out of air containing 1 per cent SO_2. On the other hand, air containing 0.5 per cent SO_2 may be passed through 29 g. of silica gel at 0 deg. C. at the rate of 400 c.c. per minute for two or three hours before the exit gases will show more than a trace of SO_2.

The adsorbed SO_2 may be recovered by passing a slow stream of air through the gel at a higher temperature. By proper regulation of temperature, pressure and rate at which air is admitted during liberation of the adsorbed SO_2, any desired mixture up to practically 100 per cent SO_2 may be obtained. Several drawings of apparatus for the recovery of sulphur dioxide evolved during metallurgical operations are given in the patent specification.

For a brief review of the theory of the adsorption of vapors by silica gel, see CHEMICAL & METALLURGICAL ENGINEERING, vol. 22, p. 949, May 19, 1920. (1,335,348; WALTER A. PATRICK, BENJAMIN F. LOVELACE and ERNEST B. MILLER, of Baltimore, Md.; March 30, 1920.)

Use of Sludge Acid in the Manufacture of Hydrochloric Acid.—A mixture of equal parts of sludge acid and sodium chloride is diluted with 10 per cent of water and heated to not more than 284 deg. C. in a still composed of a lead-lined pan covered by an acid-proof tile arch. The addition of water causes the asphalt and tarry matter to be liberated and to rise to the surface of the solution, so that loss of sulphuric acid through reduction by the carbon in these materials is avoided. The hydrochloric acid gas given off during the heating is purified by passing through towers containing sodium chloride. For the purpose of absorbing the gas in water, the inventor, HENRY M. LASHER, of Kansas City, Kan., describes three types of apparatus: a closed tank into which the gas is passed through a perforated coil; a horizontal absorber in which the flow of gas and water is concurrent; a horizontal counter-current absorber. (1,335,743, 1,337,141, and 1,339,519; assigned to Kansas City Refining Co.; April 6, April 13, and May 11, 1920.)

Magnesium Chloride.—A process for the recovery of magnesium chloride from Michigan brines containing, in addition, calcium chloride and sodium chloride, was described by EDWIN O. BARSTOW in U. S. P. 1,209,245 issued Dec. 19, 1916. It was based upon the reaction:

$$CaCl_2 + MgSO_4 = CaSO_4 + MgCl_2$$

An improvement in this method has been devised by HERBERT H. DOW and EDWIN O. BARSTOW, of Midland, Mich. The calcium is removed from the brine by treatment with sodium sulphite obtained as a byproduct in the manufacture of phenol. Since such Na_2SO_3 contains some carbonate, two reactions occur:

$$CaCl_2 + Na_2SO_3 = CaSO_3 + 2NaCl$$
$$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl$$

After filtering off the insoluble $CaSO_3$ and $CaCO_3$, the solution contains $MgCl_2$ and NaCl. By evaporating to 34 deg Bé. the NaCl separates out. The mother liquor is further evaporated until it corresponds in composition to $MgCl_2\ 6H_2O$, when it is drawn off into drums and allowed to cool and solidify. (1,336,425; assigned to Dow Chemical Co.; April 13, 1920.)

Nitric Acid From Ammonia.—In order to avoid the use of large and expensive absorption towers for the conversion of nitric oxide into nitric acid, ELIHU

THOMSON, of Lynn, Mass., proposes to absorb the nitric oxide produced by the oxidation of ammonia in nitric acid of 60 to 70 per cent strength cooled to —40 deg. C. by the evaporation of liquid ammonia. The solution is then passed to an electrolytic cell in which the nitric oxide and nitrous acid are oxidized to nitric acid. (1,337,106; assigned to General Electric Co.; April 13, 1920.)

Acetates From Carbohydrates.—Carbohydrate material is treated with caustic soda solution to give a mixture having a specific gravity of about 1.4. To the hot causticized solution is added 40 to 50 per cent by weight of powdered quicklime. Slaking occurs with consequent evolution of heat which drives off considerable quantities of water. The product, consisting of damp porous lumps, is heated in a sealed container at 250 to 300 deg. C. for five or six hours. After cooling, the acetates may be extracted by leaching or the mass may be distilled to produce acetone. When corn glucose is treated in this manner, the product is found to contain about 15 per cent of acetates. (1,338,040; JAMES W. H. RANDALL, of Western Port, Md., assignor to Industrial Chemical Co.; April 27, 1920.)

Chlorine Liquefaction.—Chlorine gas may be liquefied at atmospheric pressure by refrigeration to approximately —35 deg. C. or at normal atmospheric temperatures by compression to several atmospheres. A compromise between the two methods appears to be the usual method of liquefaction, the chlorine being compressed about 2.23 atmospheres and refrigerated to approximately —15 deg. C. Heretofore it has been the general practice to secure the compression of the chlorine by means of gas pumps. These pumps are necessarily of very special construction and require high maintenance. CLARK T. HENDERSON, of Milwaukee, Wis., proposes to eliminate the compressor by taking advantage of the fact that chlorine is very soluble in cold carbon tetrachloride. Upon heating the solution, chlorine is evolved and in a confined space sufficient pressure is generated to liquefy the gas. Carbon tetrachloride will dissolve, at —15 deg. C., approximately 122 volumes of chlorine at atmospheric pressure and will give up approximately 100 volumes of this chlorine when heated to approximately 100 deg. C., even though the solution be under a pressure of 45 lb. per sq.in. Carbon tetrachloride is not a good solvent for carbon dioxide, air or hydrogen, the usual diluents of commercial chlorine, nor is it miscible with water, and, at any pressures within the desired working limits for chlorine liquefaction, the boiling point of carbon tetrachloride is materially higher than the temperature at which the chlorine gas is driven off. A detailed description of a continuous apparatus for applying the process indicates some of the precautions which must be taken to insure efficient heat transfer. (1,338,654; assigned to Niagara Smelting Corporation; April 27, 1920.)

Separating Wood Tars and Pyroligneous Acid.—It is the accepted practice in practically all of the wood distillation plants in this country to collect the total distillate of tar and pyroligneous acid in one large tank, from which it is pumped to a battery of settling tanks. The tar which separates in these contains 20 to 30 per cent of pyroligneous acid which is removed by distilling with a steam coil and live steam in copper stills. The condition of the remaining tar is such that further distillation for the purpose of recovering the tar oils is rendered difficult. WILLIAM E. CLIFFORD, of Memphis, Tenn., has found that the pyroligneous acid content of the tar from the settling tanks can be reduced to 2½ to 4 per cent by agitating with air at a temperature not above 85 deg. C. Treatment for two or three hours results in almost complete separation of the mixture into two layers. The tar can be successfully distilled in direct fired stills. (1,339,022; May 4, 1920.)

Carbo-Hydrogen Gas.—Carbo-hydrogen gas which is used in cutting and welding consists of approximately 85 per cent hydrogen and 15 per cent hydrocarbons of high heating value such as gases of the CH_4 and C_6H_6 series. According to JAMES R. ROSE, of Edgeworth, Pa., such a mixture is formed when methane or natural gas is fed into an electric arc through one of the electrodes. The hydrogen content can be varied by changing the rate of supply of the methane. Finely divided carbon is obtained as a by-product. (1,339,225; May 4, 1920.)

Aluminous Abrasive.—When abrasives are used in conjunction with an adhesive, such as glue, for abrasive purposes, in the form of an abrasive paper, cloth or buffing wheel, the efficiency of the abrasive depends largely upon the amount of adhesion between the grain and the glue. The amount of adhesion obtained is a function of the roughness of the surface of the abrasive. Artificial aluminous abrasives have normally a very smooth surface, and consequently, when used in conjunction with glue, do not exhibit this property of adhesion to the extent of certain abrasives having rough surfaces, such as natural emery. The smaller the crystals are, the rougher the surface will be. OTIS HUTCHINS, of Niagara Falls, N. Y., finds that the addition of strontium oxide reduces the size of the crystals in fused alumina abrasives. The charge may consist of 300 parts aluminous waste, 170 parts calcined bauxite and 30 parts strontium carbonate. (1,339,344; assigned to the Carborundum Co.; May 4, 1920.)

Sulphur Chloride.—A layer of molten sulphur is introduced into a steam-jacketed still and covered with sulphur chloride. Dry chlorine gas is passed in through a number of pipes which dip below the surface of the molten sulphur. As soon as the exothermic reaction is well under way the steam valve is closed and the temperature of the still controlled by regulating the temperature and rate of flow of water in a water jacket. The nature of the product is determined by: the depth of the $S + S_2Cl_2$ mixture in the still; the rate of flow of the chlorine; the temperature. To obtain pure sulphur monochloride, S_2Cl_2, the depth of the $S + S_2Cl_2$ is maintained equal to about 0.5 to 0.75 of the total depth of the still and the rate of flow of chlorine and the temperature are regulated until the temperature in the still head is 138 to 140 deg. C. Monochloride containing 5 per cent dissolved sulphur (such mixtures are used in the rubber trade) may be obtained by shutting off the cooling water so that the temperature in the still head rises to 225 deg. C. Sulphur dichloride will be formed when the depth of the $S + S_2Cl_2$ is decreased or the rate of flow of chlorine increased. The whole operation is preferably carried out under slightly diminished pressure. (1,341,423; RALPH E. GEGENHEIMER and MAX MAURAN, of Niagara Falls, N. Y., assignors to Mathieson Alkali Works; May 25, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 2s6 to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Glycerine.—Glycerine is obtained by fermenting sugar in alkaline solution with or without the use of a catalyst. Suitable alkaline substances are: Ammonium phosphate, ammonium carbonate, sodium phosphate, carbonate or bicarbonate, an amine, a salt of an amine, or mixtures of these. Suitable sugars are: Grape sugar, invert sugar, saccharified starch, maltose, and purified molasses, or sirup. Commercial yeast, yeast cultures or other species of yeast may be used for fermenting, and food for the yeast may be added to the liquid. Manganese sulphate and iron sulphate are suitable catalysts. In an example, 20 g. of sugar and 140 g. of disodium hydrogen phosphate are dissolved in 2 l. of water and fermented by 50 g. of commercial yeast at 30 deg. C. The liquid is afterward decolorized by boiling with animal charcoal, filtered, evaporated, and the glycerine extracted by alcohol, which is then distilled off. The yield is 12 per cent of the sugar. The fermented liquid may be purified by lime, magnesia, or iron compounds before concentration. (Br. Pat. 138,099—1919. VER. CHEMISCHE WERKE AKT. GES., Berlin. See also patents 138,328—1919 to 138,331—1919, March 24, 1920.)

Purifying Oils.—The bleaching and refining of oils, fats and other substances by means of earths, such as fullers earth, "tonsil" and "panconite," is conducted in the presence of hydrogen. In an example a strong current of hydrogen is passed through 1 kg. of rapeseed oil and 50 g. of "tonsil" gradually raised to 250 deg. C. and maintained at this temperature for 4 to 5 hr.; the mass is allowed to cool to 80 deg. C. and filtered. Oils and fats so treated are said to be particularly suitable for hardening by catalytic processes. (Br. Pat. 138,115—1919. V. SCHWARZKOPF, Bremen, March 31, 1920.)

Cellulose Compounds.—A cellulose compound suitable for use in the manufacture of non-inflammable films and in the preparation of a substitute for gelatine is prepared by treating ordinary or mercerized cellulose with a halogenized fatty acid such as chloracetic or chlorpropionic acid, in the presence of caustic alkali. In an example, cellulose is mercerized in alcoholic soda lye, separated from the excess of soda lye, treated with monochloracetic acid, and the mixture left to stand; when the reaction is complete, water is added with stirring to form a clear thick paste which is neutralized and from which the compound is afterward precipitated by the addition of alcohol. In another example, mercerized cellulose is moistened with soda lye and kneaded with the sodium salt of monochloracetic acid suspended in alcohol; when perfect solubility in water is obtained excess of liquid is removed, and the products washed with dilute alcohol, and then neutralized. The sodium salt so obtained dissolves readily in hot or cold water, forming clear viscous solutions. The free acid resembles cellulose; the copper, lead and aluminum salts are insoluble in water. (Br. Pat. 138,116—1919. DEUTSCHE CELLULOID FABRIK., Eilenburg, March 31, 1920.)

Nitrogen Oxides.—In the production of nitrogen oxides by the catalytic oxidation of ammonia by air, loss of heat is prevented and the reaction rendered self-supporting by arranging in front of a platinum gauze diaphragm, which is the catalytic material, and in proximity thereto one or more screens of metal gauze such as nickel, which is non-catalytic toward ammonia. This screen receives the heat radiated from the diaphragm or conducts the heat therefrom, and thereby acts as a pre-heater for the gases. For similar purposes another screen is arranged to the rear of the diaphragm. In addition to the use of the first screen as a pre-heater, it also serves to remove dust and to oxidize impurities such as hydrocarbons or sulphur present in the gases, which tend to poison the catalyst. (Br. Pat. 137,036—1919. C. TONIOLO, Legnano, Italy, Feb. 18, 1920.)

Alloy.—An alloy specially suitable for making castings for floats for feed water regulators and for other purposes where the articles are subjected to high temperatures and pressures is made by first preparing a white metal alloy of 61 per cent tin, 29.7 per cent copper and 9.3 per cent zinc, and afterward mixing 19.64 per cent of this alloy with 80.36 per cent of copper. (Br. Pat. 138,228—1919. A. G. MUMFORD, Colchester, March 31, 1920.)

Alkaline Earth Chlorides.—An alkaline earth sulphate, such as barytes, celestite or gypsum, is heated with magnesium chloride and coal or other carbonaceous reducing agent. Sulphuretted hydrogen is evolved and an alkaline earth chloride and magnesia are produced. The alkaline earth chloride is leached out, and the magnesia may be dissolved in sulphuric acid. When it is desired to make barium sulphate by treating the barium chloride with sulphuric acid, the hydrochloric acid evolved may be used to convert the magnesia into magnesium chloride so as to make the process cyclic. The alkaline earth sulphate may be heated with magnesium chloride without a reducing agent, at a higher temperature, but with inferior yield of alkaline earth chloride. Br. Pat. 138,486—1919. F. B. SCHOTOFF, Gwalior, India, April, 1920.)

Chrome Alum.—Chrome alum is obtained by dissolving ferrochrome in sulphuric acid, the ferrochrome being ground to a fine powder and the mixture well heated and stirred, and adding a soluble potassium salt to the resulting solution of chromic and ferrous sulphates, when pure chrome alum is crystallized out. The content of iron may be previously reduced by in part crystallizing out the ferrous sulphate. The solution of ferrochrome in sulphuric acid proceeds more rapidly in leaden vessels. (Br. Pat. 138,594—1919. G. H. HULTMAN, Stockholm, April 8, 1920.)

Detinning Process.—Tin waste materials containing tin in the form of sulphide, oxide, oxychloride, etc., are dissolved in hydrochloric acid in presence of an oxidizing agent such as niter or chlorine and heat, and the solution is then reduced to obtain stannous chloride by means of tin waste containing metallic tin, such as tinplate. The stannous chloride solution is electrolyzed, using carbon or scrap tin or iron-tin alloy as anode and sheet iron or tin as cathode. The electrolysis is started at 0.5 to 1 volt and is interrupted when the pressure rises to 2 volts. The spent electrolyte in presence of an oxidizing agent is then used as solvent for the waste tin compounds and the process is continued as above described. (Br. Pat. 138,622—1919. T. A. ELKUNE, Stockholm, April 14, 1920.)

Melting and Refining Metals.—Metals and alloys are melted and subjected to a prolonged action of a vacuum. Spongy and powdered metals may thus be converted to a coherent state. (Br. Pat. 138,648—1919. HERAEUS GES. HANAU. See also 138,651—1919. April 14, 1920.)

Synopsis of Recent Chemical & Metallurgical Literature

Effects of Strain and of Heat Treatment on Metal Structure.—The more or less slow changes in crystalline structure which take place in metals after cold work and after annealing can, according to S. NISHIKWA and G. ASAHARA, be followed by means of X-ray examination. They apply (*Physical Review*, January, 1920, pp. 38 to 45) the original method of Laue, by letting a pencil of the rays, 3 mm. in diameter, fall normally on the rolled sheet of metal (from 0.1 mm. to 0.54 mm. in thickness); the sheet is fixed about 5 cm. from the photographic plate on which spots grouped in characteristic patterns are produced.

Rolled aluminum, cadmium, copper, zinc and brass gave ill-defined patterns, but a symmetry with respect to the direction of rolling was noticeable. Silver and tin showed similar patterns immediately after rolling; when the specimens were kept at ordinary temperature for a week or two, the patterns changed into those characteristic of the annealed metals. In the case of lead and thallium no symmetry was visible after rolling, indicating either that the rolling did not distort the structure or that the crystalline recovery is rapid. The annealing was effected in an electric furnace at temperatures up to 800 deg. C. The metals, of course, differed greatly in their response to annealing. In the case of silver and tin, annealing for 30 min. at 80 deg. sufficed to obliterate all traces of the previous cold work; for copper, 2 hr. at 800 deg. was insufficient. Thallium annealed at various temperatures from 100 deg. up to 250 deg. indicated the existence of a transformation point at 227 deg. C., which would agree with observations by other methods; in tin, however, the X-ray examination did not reveal any transformation near 160 deg.

Arnold's Vanadium-Molybdenum High-Speed Steel.—In view of the excited comment in America following the newspaper announcement of a sealed patent given J. D. ARNOLD for an improved high-speed steel, a brief article by him in *The Engineer*, May 7, 1920, p. 480, will be interesting. After briefly recounting the history of Sheffield tool steels, he remarks that their steel first produced in 1892-93 containing C 0.6 per cent, Cr 4.0 per cent, W 20.0 per cent "marked the high-water mark in quality of high-speed steel." The cutting power was doubled about 1896-97 by adding to it about 1 to 1.5 per cent of Va and this composition represented the best efforts of metallurgists for many years.

"The patent taken out by the present writer in 1918 substituted, say, 6 per cent of Mo associated with a little over 1 per cent of Va, the key element of the chemical composition." This produces a steel distinctly better than the 1896-97 combination, providing the heat treatment specified is carefully carried out. The author emphasizes this point, that the heat-treatment specification is as indispensable as the chemical specification—a requirement honored largely by its neglect in America. "The functions of the key element Va appear to be: (*a*) The stabilization of the variable properties of molybdenum steel, and (*b*) the prevention of cracking during the water-hardening operation, thus securing a steel not only of notable hardness but also of remarkable thermal stability." It does not "let down" until about 700 deg. C., as compared to 300 deg. C., which ruins a carbon tool, or 550 deg. C., a temperature where low-grade high-speed steel rapidly becomes useless.

Fifty Years' Progress in Iron and Steel.—Dr. J. E. STEAD'S presidential address before the recent meeting of the Iron and Steel Institute was a very voluminous review of the industry for the past half century, covering a wide range of collateral subjects in great detail. English blast furnaces have not followed the American lead in great size and hard driving, except in one notable instance, which, as a matter of fact, did not produce iron any more cheaply than the smaller English stacks. Britishers believe that rapid driving means brief life of linings and low-silicon iron, which latter is especially undesirable for local hematite users requiring pig iron containing from 2 to 3 per cent Si. One great advance is general adoption of modern recording pyrometers for indicating blast temperature. However, despite every metallurgical effort, the general deterioration of coke quality has actually increased its consumption per ton of pig delivered. If but one-third of the heat wasted in slag could be recovered, this would reduce the fuel consumption approximately 100 lb.—a total saving of 350,000 tons coke per year, a result worthy of the best efforts of engineers.

Puddling requires fundamental reorganization. Liquid blast-furnace metal should first be dephosphorized and reduced to 1.75 per cent carbon in a tilting basic open-hearth furnace, and then transferred to a rotary furnace with permanent lining, there to be further refined by adding the exact amount of melted cinder.

Basic steel makes very slow headway, due, in Dr. Stead's opinion, to prejudice inherited from the early days when the new product was somewhat non-uniform. Acid open-hearth steel, however, is supplanting bessemer metal—not a single converter is in operation in any large works on the northeast coast. Armco iron is now being made in England by the Shelton Iron & Steel Co., and during the war was substituted for Swedish iron in the manufacture of crucible steel with most satisfactory results.

Electric furnaces increased in great number during the war, the combined available capacity now being about 300,000 tons per year. This tonnage is less than that of Germany, largely due to the fact that British furnaces melt scrap, while German furnaces refine hot basic bessemer metal. On the Tyne electric steel is being made at a price competing wth acid open-hearth, cheap power being available from coke-oven gas.

Interesting byproducts of the change in smelting practice from basic bessemer to basic open-hearth mentioned by Dr. Stead are the decreased demand for high-phosphorus puddling cinder to make high-phosphorus bessemer pig, and the decreasing amount of basic slag the farmer so tardily recognized as being the phosphorus fertilizer par excellence. Open-hearth slag has reduced phosphoric acid to about 11 per cent, and the solubility is often further lessened by the use of fluorspar or $CaCl_2$ during the heat.

Current Events
in the Chemical and Metallurgical Industries

Contempt Proceedings Dismissed

The following is the full text of the decision of Judge Bourquin in the contempt proceedings instituted by Minerals Separation against the Butte & Superior Mining Co.:

Minerals Separation, Ltd.
vs.
Butte & Superior Mining Co. } Contempt Proceedings

JUDGE BOURQUIN: Subsequent to the decision of the Supreme Court of the United States and pending accounting herein complainants instituted these proceedings in civil contempt based upon allegations that an account filed herein by defendant discloses it was and has been operating with methods of the patent process with less than 1 per cent of oil and contrary to the injunction. Hearing was had and it appears that at the head of the machine (see 245 *Fed. Rep.*, p. 583 for description) defendant adds to the pulp less than 1 per cent of oil but that the circulating load there entering the pulp contains sufficient oil to constitute the total 1 per cent and more. It incidentally appears that when the pulp arrives at the tail cells, at last of the machines, the oil is less than 1 per cent. Complainants contend that the oil in the circulating load is without efficacy and that both the situations aforesaid involve use of oil less than 1 per cent and are contrary to the injunction and contempt. During proceedings upon the merits, complainants urged that both these situations then existed and involved infringement, but not being vital and being rather doubtful in respects to both facts and law, the courts made no express reference or decision in respect to them. To now conclude that the Supreme Court's decision impliedly determines them favorably to complainants is mere conjecture and inadmissible. That either situation involves infringement and violation of the injunction is by no means clear. In these circumstances, having also in mind the severity and delays of contempt proceedings to the defeated party, complainants cannot be permitted to transfer the controversy from the merits to contempt. They must fully litigate upon the merits what they have half litigated so that the defeated party may have prompt review rather than suffer hardships from delays due to inability to appeal from the decision in contempt until some time after final decree in accounting. It is believed equity, patent law, discretion requires that complainants be remitted to some one of the familiar methods to secure determination upon the merits of these alleged infringements. Accordingly the contempt proceedings are dismissed.

The National Research Council Elects Officers

The National Research Council has elected the following officers for the year beginning July 1, 1920: Chairman, H. A. Bumstead, professor of physics and director of the Sloane Physical Laboratory, Yale University; first vice-chairman, C. D. Walcott, president of the National Academy of Sciences and secretary of the Smithsonian Institution; second vice-chairman, Gano Dunn, president of the J. G. White Engineering Corporation, New York; third vice-chairman, R. A. Milliken, professor of physics, University of Chicago; permanent secretary, Vernon Kellogg, professor of entomology, Stanford University; treasurer, F. L. Ransome, treasurer of the National Academy of Sciences. All of the chairmen of the various divisions of the Council have not yet been selected, but will be announced later.

New Nitrogen Fixation Plant at Syracuse

The Atmospheric Nitrogen Corporation, a company organized and incorporated in New York State with an authorized capital stock of $5,000,000 by the General Chemical Co. and the Solvay Process Co., has purchased a 60-acre tract of land near the Solvay Process Co.'s works on the western outskirts of Syracuse, N. Y.

Ground has already been broken for a new plant to manufacture 20,000 lb. anhydrous ammonia per day on a plan worked out by DeJahn, similar to the Haber process, using hydrogen from water gas, nitrogen from the air, and a suitable catalyst.

An interesting feature of the plant is the utilization of the byproducts. CO from the water gas is to be converted into CO_2, which will be used by the Solvay Process Co. as a raw material in its manufacture of soda ash, and in return, coke, a byproduct of the Solvay process, will be used to make water gas, thus closely correlating the operations of the two plants.

At present under the direction of the J. G. White Engineering Corporation of New York the company is erecting a process building, gas producer, two large gas holders, service buildings and boiler house, all of steel and brick construction, at an approximate cost of $2,500,000. Electric power will be furnished by the Niagara, Lockport & Ontario Power Co. from Niagara Falls.

Citations by Federal Trade Commission

The Federal Trade Commission has cited the following concerns for unfair competition in trade:

John Bene & Sons, Inc., Brooklyn, for compounding and selling hydrogen peroxide.

Samuel Weinberg, doing business under the name of the International Flaxol Co. at Boston, Mass. This company advertises and sells a certain commodity which it has named "Flaxol," thereby indicating that it is a derivative of flax and the equivalent of well-known products of flax, such as linseed oil, sometimes called flaxseed oil.

The United Indigo & Chemical Co., Ltd., Boston, Mass., which is engaged in the manufacture and sale in interstate commerce of dyestuffs, chemicals and other dyeing goods and products. This company is accused of secretly giving cash commissions and other rewards to employees of its customers and its competitors' customers to induce the purchase of its products.

Forty days have been given these companies to reply, after which the cases will be set down for trial on their merits.

Chicago Chemists Inaugurate Weekly Luncheon

The first regular weekly luncheon of the Chicago Chemists' Club was held on June 1 at the club quarters. Dr. A. I. Kendall, dean of Northwestern Medical School, delivered a most interesting discourse on industrial bacteria. Among the out-of-town visitors were Dr. A. V. H. Mory, of Cincinnati, and H. C. Parmelee, editor of CHEMICAL & METALLURGICAL ENGINEERING.

Budget Bill Rejected

The bill to create a national budget system, which was vetoed by President Wilson, was amended by the House to conform with the President's views and was again passed, but the Senate failed to take any action in the matter because of the opposition to the measure by Senators Harris and Reed. Anticipating the provision of budget system, the House of Representatives provided for the reorganization of its appropriations committees, forming a single committee of thirty-five members to replace the eight committees which previously had handled various parts of this work. The Smoot-Reavis resolution providing an investigation of the Federal executive departments, in anticipation of complete reorganization, was defeated in the House of Representatives by a strict party vote. The Democratic membership opposed the measure on the ground that the director of the budget should do this work, but the failure of the budget bill subsequently leaves the matter without any agency to conduct the investigation contemplated.

Byproduct Coke Plant at Birmingham, Ala., Completed

The Sloss-Sheffield Steel & Iron Co. has just completed a new byproduct coke plant at its works in Birmingham, Ala., at a cost of approximately $2,500,000. Equipment includes 120 Semet-Solvay coke ovens, buildings for byproducts, cooling pond, machine shop, engine house, stacks, offices, etc., and two 2,000-kw. electric turbines. Additional 2,000 hp. is transmitted from an electric plant about two miles away.

This plant will consume 2,500 tons of soft coal per day and yield 20,000 gal. of crude tar, 60,000 lb. of ammonium sulphate or its equivalent in liquor, 7,000 gal. of light oil, and 7,000,000 cu.ft. of marketable fuel gas in addition to that required for plant operations. About 2,000 tons of coke, or enough to operate the company's five blast furnaces, will also be produced.

Fund to Investigate Power Supply

The U. S. Geological Survey received a fund of $125,000 with authority to accept additional sums to be expended by it for an investigation of power supply throughout the Washington to Boston territory. This so-called super-power investigation contemplates a study of water-power and fuel-power developments that will undoubtedly demand consideration of byproduct coking, large steam power plants and all other possibilities. The technical, economic and resource conservation aspects of each situation will receive attention. It is hoped, therefore, that the industrial chemical possibilities of fuel-using industries will receive considerable attention in the investigation.

Great Western Sugar Co. to Build New Plant

Announcement has been made that the Great Western Sugar Co. is to erect a 600-ton plant in Weld County, Colorado, at the junction of the Union Pacific and Great Western railroads. This plant is expected to be ready for operation by next October and is similar to the Brighton plant.

This plant will have a great advantage in being situated in one of the finest sugar beet-growing sections in Colorado.

Chemical Warfare Service Continues

Under the provisions of the Army reorganization bill the Chemical Warfare Service has been continued as a permanent branch of the Army. The present provision is for 100 officers and 1,200 men, the command being headed by a Brigadier General. The appropriation bills for the coming fiscal year provide new appropriations of about $2,000,000 in addition to approximately $2,000,000 available in funds which continue for the coming fiscal period. Approximately $25,000,000 of the funds available during the past and previous years, however, revert to the Treasury unused.

All regular Army officers in this service as well as other services revert to their regular Army rank on June 30, as emergency commissions in all grades are cancelled as of that date.

Any persons contemplating application for commissions in this service must make application on form 739 before June 23.

In contrast with the continuation of this service is the fact that the construction corps was not provided for, as had been expected.

New Jersey Chemical Society Year Book

Although the New Jersey Chemical Society was organized less than two years ago, it has already assumed a position of importance among the scientific societies of the metropolitan district. Its rapid rise is best understood from a study of the recently issued year book. In this the reasons for the formation of the society are set forth, followed by a brief review of the activities and meetings of the society from Nov. 11, 1918, to Feb. 9, 1920.

In order to increase the usefulness of the volume, a chapter on chemical education in New Jersey, a list of chemical and allied periodicals available for reference in the Newark Public Library, and a classified index of chemical manufacturers and supply houses in the state have been included. The classified index also serves to indicate the extensive and varied chemical industries which form the foundation of this society and which guarantee its successful development.

Increase of Salaries for Government Technical Men Contemplated

Continuing the effort to secure better salaries for the technical services of the Government, a number of scientific men have actively participated with others in the appointment of committees to work during the summer on this problem. Two sets of committees are being provided: the first to consider classification of present employees under the system which has been recommended to Congress; and the second group of committees, one from each department, to aid in the publicity and educational work required to make the needs of the services generally known.

Internal Revenue Bureau After Alcohol in Patent Medicines

In order to minimize the consumption of patent medicines for beverage purposes where an appreciable percentage of alcohol is contained, the chemical division of the Internal Revenue Bureau is making special effort to have manufacturers of these preparations change their formulas by adding some ingredient which will discourage beverage use.

British Units to Be Used in War Department

To avoid confusion, the Secretary of War has ordered the British units of weight and measure be used as far as is practicable. The instructions issued in that connection are as follows:

"As an incident to the World War, metric units of weight measure were necessarily used in instruction and training. As a result, more or less confusion now exists as to what units should be used normally. Hereafter, the customary former units of weight and measure (including the degree Fahrenheit) will, as far as practicable, be used throughout the Army as they were before the war.

"Material and equipment now graduated in metric units will, when worn out, be replaced by articles graduated in British units in such manner as will cause all parts of a regiment or similar organization (or smaller organization when there is no regimental organization) to be provided at all times with material and equipment graduated alike.

"This order shall not be construed to prevent the utilization of metric units of weight and measure when desirable in connection with specifications and contracts, medical and scientific supplies, scientific research and developments, international meteorology, foreign maps, monographs and handbooks and similar subjects."

Hongkong Markets Shut Out American Dyes

Consul General George E. Anderson at Hongkong points out in a brief survey of the American dye industry in southern China that the United States has built up quite an extensive trade in aniline dyes and synthetic indigo during the last two years. Switzerland also shipped considerable quantities during 1919 and was one of the chief competitors in the trade.

At that time Great Britain was not exporting colors to China. Suddenly after the trade with United States was fairly well established, the Hongkong Government, at the behest of the Imperial Government in London, prohibited the importation of any but British manufactured dyes, thus shutting out American products except for reshipment. This of course gives the British dye makers a decided advantage over foreign competitors, but as they have not met the demands of the trade in the way that was expected the result has been to throw the entire dye industry into a state of uncertainty while plans are being considered to relieve the situation.

War Minerals Relief Act Amendment Fails

The war minerals relief act amendment which was intended to put war minerals claimants on the same footing as claimants seeking relief from other contract losses passed the Senate shortly before the end of the Congressional session. However, it contained an error which made it ineffective and a resolution to correct this was not considered. The bill did not receive consideration in the House of Representatives.

Japan Shipping Sugar to United States

Advantage of the high price of raw sugar is being taken advantage of by the Japanese sugar merchants to ship their surplus stock. The price of refined sugar in Japan has been 15c., but has now risen to 18c.

Consignment of Swiss Dyes Arrives

A large quantity of Swiss dyes consisting of 181 cylinders of assorted colors from Havre arrived recently. This shipment was consigned to New York firms which, it is understood, have already disposed of most of the consignment.

Although up to the present time there has been a ready market for foreign dyes, it is admitted in the trade that demand from the textile industry is disappointing. Settlement of the labor difficulties among the textile plants has not resulted in the expected increase in activity in the industry. Tightening of credits by banks, a lessening in public buying, together with the freight congestion due to strikes and difficulty in transportation of raw materials and finished products, have had a depressing effect.

Output of direct colors has been limited due to scarcity of H acid, while shortage of dimethylaniline has restricted production of basic colors. The vat color situation has somewhat improved. Two large concerns have been reported as about to market a wide range of fast colors equal to those produced by German or other foreign manufacturers. Vat yellow R is the only item that is being produced in quantity in this list at present.

Wool green S, rhodamine and patent blue are to be put on the market on a large scale as soon as general business conditions will warrant it.

Meeting of the New Haven Section, A. C. S.

The May meeting of the New Haven Section, A. C. S., was held May 14 at the Graduates Club, New Haven, Conn. After dinner at the club, a short business meeting was held, presided over by President Walter R. Hibberd. It was voted at this meeting not to publish in the *Chemiker Zeitung* results of research in chemistry by members of the society. After the meeting the members gathered at the Kent Laboratory to hear the lecture by E. M. Symes, assistant chief chemist of the Hercules Powder Co., on "The Manufacture of Dynamite and Gelatine, Including the Manufacture of Nitric and Sulphuric Acids."

This lecture was well illustrated by both moving pictures and lantern slides, and gave in a general way a good idea of the processes used and also the plants of the company.

Some idea of the tremendous force of some of the explosives manufactured was shown when 700,000 tons of rock were broken down by one blast of 120,000 lb. of dynamite at a cost of $12,500. The whole face of a cliff about 600 ft. long and 150 ft. high was blown off at one charge.

The lecture was well attended by both students and members of the society.

German Syndicate to Operate Spanish Potash Deposits

Reports are current to the effect that German interests have acquired control of Spanish potash production and that German capital and labor will work the deposits. Herr Gunte and Herr Ziervogel, two potash experts, have examined and reported on the deposits, with the result that important concessions for working these deposits are expected to be made to the German syndicate by the Spanish Government.

Swansea Patent Fuel Industry

Consul A. B. Cook reports that five patent fuel works in the city of Swansea and one plant at the sub-port of Port Talbot are now in operation. These plants are engaged in the manufacture of briquets from coal dust, a byproduct of the local coal mines.

Port statistics show reports of patent fuel from Swansea and Port Talbot as follows: 1918, 1,014,603 long tons; 1919, 1,092,803 tons; first three months of 1920, 329,402 tons.

Large quantities of tar and pitch required as a binding material are imported, as there is no production of them in Great Britain.

Personal

Prof. CHARLES BASKERVILLE, in recognition of his investigations on inhalation anesthetics, has been elected a member of the research committee of the National Anesthesia Research Society.

KENNETH E. BELL has resigned his position of research associate, research laboratory of applied chemistry, Massachusetts Institute of Technology, to accept one as chemical engineer with the Lewis Recovery Corporation of Boston.

W. F. BLEECKER of the Tungsten Products Co., Boulder, Col., has just completed an extended trip through Eastern points.

Dr. MARSTON TAYLOR BOGERT, professor of organic chemistry in Columbia University, has been appointed by President Wilson as a member of the United States Tariff Commission.

W. C. BUELL, JR., formerly engineer of tests and later chief engineer of Tate-Jones & Co., Inc., on June 1 became associated with the George J. Hagan Co., Pittsburgh, Pa., as chief engineer of the newly organized liquid fuel department.

HARMON F. FISHER has been engaged by the United States Bureau of Mines as liquefaction engineer in charge of the helium experimental plant at Petrolia, Tex.

LUCIEN H. GREATHOUSE recently resigned as assistant chemist of the Fixed Nitrogen Research Laboratory, War Department, to accept a position in experimental work with the Atmospheric Nitrogen Corporation, Laurel Hill, N. Y.

GUY C. HOWARD of the Tacoma Smelting Co., Tacoma, Wash., is visiting New York City and other Eastern points on a business trip.

A. H. KROM, assistant secretary of the American Association of Engineers, has resigned to enter business. Mr. Krom was one of the organizers of the association.

Dr. C. E. K. MEES, director of the research laboratories of the Eastman Kodak Co., Rochester, N. Y., will deliver lectures on various aspects of photographing and on the general subject of industrial research before various scientific bodies while he is in England.

H. C. PARMELEE, editor of CHEMICAL & METALLURGICAL ENGINEERING, has returned from a two months' trip to the Pacific Coast, visiting St. Louis, Omaha, Denver, Pueblo, Salt Lake City, Los Angeles, San Francisco, Portland, Tacoma and Seattle.

G. ARNCLIFFE PERCIVAL has arrived in New York City from England and expects to make a close study, from the technical point of view, of some of the larger industrial plants of this country.

The board of directors of the American Electrochemical Society at its meeting April 30 appointed the following executive committee: W. S. Landis, chairman, ex officio; J. W. Richards, ex officio; H. B. Coho, J. V. N. Dorr, C. G. Fink, Carl Hering and H. C. Parmelee.

Current Market Reports

The Non-Ferrous Metal Market

New York, June 11, 1920.—Copper market slightly weaker, with one large producer reported to be willing to sell at 17½c. on large tonnages. Large stocks are on hand. Tin has declined 5 points, to 46c., in sympathy with the London market.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent	32@33
Antimony, wholesale lots	8.87½
Nickel, ordinary	45.00
Nickel, electrolytic	45.00
Tin, Straits, spot	46.00
Lead, New York, spot	.00
Lead, E. St. Louis, spot	8.50
Zinc, spot, New York	7.90
Zinc, spot, E. St. Louis	7.55

OTHER METALS

Silver (June 10)	oz.	$0.87
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.70@3.00
Cobalt	lb.	2.30@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	90@95
Iridium	oz.	300@400
Palladium	oz.	90@100
Mercury	75 lb.	93.00

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33.50
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	25.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	43.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	24.00@25.50
Aluminum, sheet scrap	24.00@25.50
Copper, heavy machinery comp	15.00@16.00
Copper, heavy and wire	15.50@16.00
Copper, light and bottoms	14.00@14.50
Copper, heavy cut and crucible	16.25@16.75
Brass, heavy	9.50@10.00
Brass, light	8.00@8.50
No. 1 clean brass turnings	9.25@9.75
No. 1 comp. turnings	13.50@14.00
Lead, tea	5.00@5.50
Lead, heavy	7.00@7.25
Zinc, scrap	5.00@5.25

The Iron and Steel Market

Pittsburgh, Pa., June 11, 1920.

The American Iron and Steel Institute reports that in May 2,883,164 tons of steel ingots was produced by thirty companies which in 1918 made 84.03 per cent of the total output. Allowing for unreported production and computing annual rates on the basis of the number of working days, the annual rates in each month this year, in gross tons, are found to have been approximately as follows: January, 40,700,000; February, 44,200,000; March, 45,200,000; April, 37,550,000; May, 41,050,000.

The rail strike began April 1, but did not seriously affect the valleys, the lake front and Pittsburgh until about Monday, April 12. The low point in pig-iron and steel production fell at about that time or shortly after, and there was only slight recovery during April, while during May the improvement grew more and more pronounced. One may therefore conclude that a low point in production fell at about the middle of April, under 34,000,000 tons per annum, and that the rate at the close of May was nearly if not quite 43,000,000 tons. As conditions have continued to improve, it seems probable that a 45,000,000-ton rate will be regained by the end of this month.

SHIPPING CONDITIONS BETTER

Car supplies are improving at nearly all points, but at a slow rate. A few mills may now be shipping as much steel as they produce, but in general a little is still accu-

mulating, and it may be the end of the month before there is an even break. Past experience with freight congestions has been that the beginning of relief is the difficult matter, and that as small inroads are made at congested yards the improvement grows apace. It is on account of such analysis, rather than on account of the actual improvement that has occurred to date, that the steel makers have their present sanguine views as to the nearby future of transportation conditions. At the same time it is recognized that if the railroads get into normal working order they will not be able to carry much of an overload, hence it will probably require a long time to work off all the steel now stocked at mills, probably between 1,500,000 and 2,000,000 tons.

There are conflicting reports as to the relation between shipments and receipts of finished steel. At some mills the claim is made that although cars are being loaded they are not reaching destinations in fair time, which would mean that the number of loaded cars is increasing. From this it would be far from difficult to deduce that the number of empty cars available for loading would be decreasing. In other quarters, however, the observation is that loaded cars are reaching consignees much more freely than formerly, which would mean that more cars are getting into service and that practical progress is being made.

In the matter of both coal and coke there is a freer movement. Even for last week, when there was a holiday to interfere, the Connellsville *Courier* reported a slight increase in coke production in the Connellsville and lower Connellsville region. Car supplies to the Pittsburgh coal district are slightly increased.

Trends in Order Books

The Steel Corporation and the independents are getting farther and farther apart as to the size of their respective order books. May was described by independents as a dull month marketwise, and there is no doubt that it was decidedly dull from that viewpoint. On the other hand the Steel Corporation's report of unfilled obligations at the end of May shows that the corporation's bookings during the month were not simply in excess of the month's shipments but in excess of a full month's capacity. The increase was 580,719 tons, to 10,940,466 tons, the increase being equal to 44 per cent of capacity, on the corporation's own rating of 52,500 tons per working day. The month's shipments may be estimated at about 68 per cent of capacity, which would make the bookings in the month 112 per cent of capacity. Bookings similarly computed were 94 per cent in April, 124 per cent in March, 108 per cent in February and 162 per cent in January.

The unfilled obligations at the beginning of June would carry the corporation, at 52,500 tons per working day, to about Feb. 6, 1921, as an average date, or to about March 1 on the basis of a 90 per cent operation. Of course the orders are not equally distributed according to capacity of the various departments, so that such dates are merely average.

Prices of Larger Mills Firm

The independents as a whole are not booked one-half as far ahead as the Steel Corporation, though of course they have understandings with various customers to supply them with monthly quotas of steel, at prices to be set from time to time. The independents, having prices higher than those of the Steel Corporation, cannot secure orders for the late deliveries that are acceptable to Steel Corporation customers, while they cannot reduce prices without jeopardizing some of the business they now have on books. This is a principle that has always obtained in the steel trade when demand tends to fall off, but in former cases all producers were in much the same position. The mills with but little business ahead have been yielding in their prices for several weeks past, but the larger mills, booked for two to five months ahead, have been standing quite firm. Apart from the smaller mills with the leanest order books being disposed of their own accord to ask smaller delivery premiums there is another influence, that some of the mills booked for several months ahead have lately been finding it possible to make quite early deliveries at their regular prices, and this again has tended to bring down prices in the prompt market. A few weeks ago the condition was clearly defined of there being three markets, one prompt market, the moderately extended delivery market, two to five months, and the far forward market, made by the Steel Corporation. Now it can hardly be said that there are more than two markets, one for prompt or moderately early delivery and one for extended delivery, the Steel Corporation being alone in that market.

Pig Iron

Merchant furnaces can now reach almost all their customers with deliveries, and the demand for spot or prompt iron has dwindled to very small proportions, while no particular interest is aroused in late deliveries. Some furnaces now have fairly large stocks, owing to the traffic difficulties, but consumers, on the other hand, are rather bare of stocks. The market is stagnant, with no change in quotable prices, which remain: Bessemer, $43; basic, $43.50; foundry, $45, f.o.b. valley furnaces, freight to Pittsburgh being $1.40.

Semi-Finished Steel

Billets are stagnant, quotable at the last market of $60@$65, consumers being interested in deliveries of steel already ordered rather than in the making of fresh purchases. To an extent the same condition obtains in sheet bars, but there is some business from time to time. The last sale reported is of a round tonnage of bessemer bars, two or three months' delivery beginning July 1, at $75, the transaction indicating a slightly stronger tone in the bessemer market than had been assumed. Open-hearth bars are $75@$80.

Finished Steel

The merchant bar list is now split, as to early deliveries, small sizes being so scarce that a higher base, up to 4c., obtains than on moderate and large sizes, which can be done even for early shipment at about 3c.

The season cotton tie price of the Carnegie Steel Co. has been announced at $2, this being the price in lots of 3,000 bundles or more, 45 lb. per bundle, for June shipment, the carrying charge for later deliveries being 1½c. a month. One of the independents at least will follow this price, but another announces it will make no ties, and will probably await the possible development of a scarcity and bids at higher figures.

Ferro-Alloys

While small prompt lots of forromanganese might bring close to $250, delivered, the market has continued to ease off. Second half or third quarter contracts remain at $200, delivered, with little interest exhibited. Spiegeleisen remains quiet at $72.50@$75, furnace. Electrolytic ferrosilicon is stagnant, prices being largely nominal at about $78@$80 for 50 per cent and $150@$155 for 75 per cent. Bessemer ferrosilicon remains at $62.50 for 10 per cent, $65.80 for 11 per cent and $69.10 for 12 per cent, f.o.b. furnaces at New Straitsville and Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, June 11, 1920.

Changes in the chemical market during the interval have been very few and confined to the more active items of the list. Producers are limiting their output for one of two reasons; recently the theory has been advanced that a slump in the market is anticipated and the manufacturer is wary of being caught with stored supplies on hand, but the more obvious reason is the pronounced shortage of cars at the plants in which to ship the product. As a result the market remains in a strained condition with spot supplies very low and selling at a premium.

Acetic acid, glacial, 99½ per cent, is firmer at $16.50@$17.50 per cwt. than it was last week, with buying interests considerably more active. *Oxalic crystals* is in a similar position and 60@65c. per lb. is the ruling figure for spot material. The heavy chemicals have been well sustained with the exception of *potassium prussiate*, yellow, which came down slightly and is now listed at 35@36c. per lb.

for less than car lots, against 36½@37½c. of the last report. Enough has been said about the more active items on the list, so it is sufficient to say that *bleaching powder, ammonia* and *barium* products, *epsom salts* and *soda ash* remain in the same nominal position, with prices quoted varying according to the necessity of the buyer. Offerings of *potassium* and *sodium bichromate* (resale material) have been received from Japan at figures below the present market, but so far buyers have refrained from contracting because of the uncertainty as to the condition of the material and the possibility of prompt delivery.

Coal-Tar Products

As has been said frequently and truthfully, there is no activity in prices or of material changing hands in this market. Slight as it is, there is a still further decline being noticed in some quarters due to the coming summer season, but there is so very little material being offered and so few buyers at the prevailing prices that it is hardly worth while noting. On the other hand, *alpha-naphthol*, crude, is being offered at $1.40@$1.50 and refined at $1.60@$1.70, against $1.35 and $1.50, respectively, as high-water marks of the previous week. *Naphthalene* shows no signs of decline and former figures of 15@17c. per lb. for *flake* and 16@18c. per lb. for *balls* hold firm.

Waxes

The *paraffines* furnish the only interesting movement in this branch. For the past few months this movement has been steadily upward and according to many there is no break in sight, either in demand or in prices, The available stocks are so small as almost to warrant placing these waxes in a nominal position. The other grades—*carnauba* and *bees*—are plentiful with moderate orders.

Naval Stores

Predictions of an early settlement of the coastwise shipping strike, which has seriously affected this market for some time back, are heard in the trade, but as to the details of the where and when and how, nothing is definite. Small quantities of *rosin* are coming into the local market, but not nearly enough to meet requirements. All grades have been dropped to new levels which will prevail upon the resumption of normal business. *Turpentine* is available in small quantities at $1.92½@$1.95 per gal.

Vegetable Oils

Linseed has been quiet during the week with a slight drop in quotations, with $1.67@$1.70 per gal. as the prevailing figures. Crushers report business at a standstill and can see no improvement for a month at least. The rest of the list is firmly maintained, with very little activity throughout the list.

The Baltimore Market

Baltimore, Md., June 10, 1920.

The fertilizer manufacturers in this section are rapidly winding up the spring season, which has been delayed on account of labor and car shortage. There will be no intermission between seasons on account of the labor situation, and as fast as spring business is being disposed of, they are starting on fall goods.

Comparatively little interest is shown in futures, except for low grade *ammoniates*, such as garbage tankage, which is very scarce and nominally quoted at $8 per unit of ammonia, 10c. per unit of bone phosphate of lime and $1 per unit of potash, c.a.f. Baltimore. Material in good granular condition is well sold up and almost unobtainable. The demand is very heavy due to fall mixtures of *complete fertilizer* being for goods of much lower grade than for the spring season.

Phosphates

Acid Phosphate.—Producers are well sold up for June, July and August and prevailing quotations for run of pile, testing 17 to 18 per cent available phosphoric acid, vary according to tonnage and specific delivery from $18.50 to $19 per ton, basis 16 per cent A.P.A., in bulk, f.o.b. cars Baltimore, with 16 per cent grade being held at 50c. per ton higher. Actual stocks of acid phosphate which producers have on hand are very low, and all manufacturers are experiencing considerable difficulty in securing supplies of phosphate rock. While summer deliveries are usually the lowest of the year, in anticipation of augmented supplies of phosphate rock later on, October-December deliveries are obtainable at 50c. per ton below summer prices, and a fairly important business has already been booked for October-December deliveries.

Nitrogenous Materials

Blood and Tankage.—Little interest is being manifested at prevailing prices, which hold firm at the equivalent of about $8.25 and 10c. basis c.a.f. Baltimore, and manufacturers expect lower prices to rule, as the demand for tankage for feeding purposes is not brisk at present.

Nitrate of Soda.—The market for spot and nearby ranges from $3.80 to $3.85, which is below the actual cost to import, based on the market in Chile, but some resale lots which arrived too late for use during the spring season are available at 10c. to 15c. per hundred less. These, however, have not been of sufficient importance to establish a lower market.

Cyanamide.—Producers are now sold up to March, 1921, and the only material available for delivery between now and that time is resale. Resale lots for early delivery and now en route are being held at $4.75 per unit f.o.b. Baltimore, and deliveries over the balance of the year are obtainable at about $4.65 per unit.

Potassium Salts

Potash.—The Nebraska producers have disposed of their present stock and production to November, 1920, and are holding shipments beginning November and forward at $2.25 per unit f.o.b. Nebraska producing centers. There have been several arrivals during the past week of Alsatian kainit and manure salt, from which resales have been made at $2 per unit, although the most of the manufacturers are taking deliveries and storing the potash for next season's use to guard against a shortage such as existed during the early part of the past season. New prices for July and forward deliveries of the Alsatian and German products have not yet been announced.

The St. Louis Market

St. Louis, Mo., June 8, 1920.

There has been little change in the chemical market during the past two weeks and prices of most chemicals are stationary. The demand continues to be good and local producers report that a gradual resumption of normal production is taking place.

The local railroad situation shows a healthy improvement, especially for shipments to the West and Southwest. Less than carload lots are being accepted by all lines except where shipments are destined for points on connecting lines or large Eastern industrial centers. Carload shipments are moving slowly on account of the congested condition of the freight terminals. The movement of coal is being materially improved and the possibility of further curtailment of production is apparently past.

Acids.—The demand continues to be heavy and prices are unchanged. *Sulphuric* acid is quoted for carload lots at $15@$16 per ton for the 60-deg. grade and $22 per ton for the 66-deg. grade. *Oleum* is quoted at $27.50 per ton. The supply of *muriatic* acid is limited, 18-deg. grade being quoted at $21 per ton in carload lots. *Nitric* acid is quoted in carload lots at $7 per hundred for 36-deg., $8 for 38-deg., $9 for 40-deg., and $10 for 42-deg.

Sodium Bisulphate. — Supply very limited; price unchanged at $4 per hundred.

Phenol.—Demand good and supply plentiful, due to local firm disposing of surplus Government stock. Quotation unchanged at 12c. per lb., in carload lots.

Zinc Oxide.—Local supplies are low and producers are booking orders for third quarter delivery. Quoted at 10c. per lb. in large lots.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots		Less Carlots	
Acetic anhydride	lb.			$0 62	$0 65
Acetone	lb.	$0 15	$0 20	.21	.24
Acid, acetic, 28 per cent	cwt.	3 50	3 75	4 00	4 25
Acetic, 56 per cent	cwt.	6 00	6 50	8 75	9 50
Acetic, glacial, 99½ per cent., carboy	cwt.	15 50	16 00	16 50	17 50
Boric, crystals	lb.	.15	.15½	.15	.16
Boric, powder	lb.	.15	.15½	.15	.16
Citric	lb.	1 05	1 12	1 17	1 25
Hydrochloric (nominal)	cwt.	2 00	2 50	3 50	4 00
Hydrofluoric, 52 per cent	lb.	.12	.12½	.13	.14
Lactic, 44 per cent test	lb.	.11	.11	.12	.13
Lactic, 22 per cent test	lb.	.04½	.05	.06	.07
Molybdic, C. P.	lb.	4.00	4.50	4.50	5.00
Muriatic, 20 deg. (see hydrochloric).					
Nitric, 40 deg.	lb.	.06	.07	.07½	.08
Nitric, 42 deg.	lb.	.07½	.08	.08	.09¼
Oxalic, crystals	lb.	.55	.57	.60	.62
Phosphoric, Ortho, 50 per cent solution	lb.	.14	.23	.24	.25
Picric	lb.	.28	.35	.40	.50
Pyrogallic, resublimed	lb.	2 25	2 55	2 60	2 65
Sulphuric, 60 deg., tank cars	ton	14 00	19 00		
Sulphuric, 60 deg., drums	ton				
Sulphuric, 66 deg., tank cars	ton	23 00	25 00		
Sulphuric, 66 deg., drums	ton	35 00	40 00	45 00	50 00
Sulphuric, 66 deg., carboys	ton	36 00	40 00	50 00	55 00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27 00	30.00	37 00	42 00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00	30 00	38.00	42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00	35 00	40 00	
Tannic, U. S. P.	lb.	1 45	1 50	1.55	1 60
Tannic (tech.)	lb.			.60	90
Tartaric, crystals	lb.			.80	85
Tungstic, per lb. of WO	lb.			1 20	1 40
Alcohol, Ethyl (nominal)	gal.	5.10	5.50	6 00	7 00
Alcohol, Methyl, 95%	gal.			2 50	2.70
Alcohol, Methyl, pure	gal.			3 50	3.55
Alcohol, denatured, 188 proof (nominal)	gal.			1 10	1.15
Alcohol, denatured, 190 proof (nominal)	gal.			1 05	1.10
Alum, ammonia lump	lb.	.04½	.05	.05½	.06
Alum, potash lump	lb.	.07½	.08½	.09	.09½
Alum, chrome lump	lb.	.15½	18	.19	.20
Aluminum sulphate, commercial (nominal)	lb.	.01½	02	.02½	.03
Aluminum sulphate, iron free	lb.	.02½	03	.04	.04½
Aqua ammonia, 26 deg., drums (730 lb.)	lb.	.07½	.10¾	.11	.12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32	.35	.35	.40
Ammonium carbonate, powder	lb.	.16	.16½	.17	.17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16	.16½	.17	.18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½	.13½	.13	.14½
	lb.	.08½	.09½	.10	.11
Ammonium nitrate	lb.	.07	.07½	.08	
Ammonium sulphate	gal.			5 00	
Amylacetate	gal.			4 75	5 25
Amylacetate, tech.	lb.	.13½	.14½	.15½	.16½
Arsenic, oxide, lumps (white arsenic)	lb.	.23	.24		
Arsenic, sulphide, powdered (red arsenic)	ton	150 00	160 00	170 00	200.00
Barium chloride	lb.	.21	.23	.24	.25
Barium dioxide (peroxide)	lb.	.09½	.11	.11	.12
Barium nitrate	lb.	.04½	.05	.05½	.06
Barium sulphate (precip.) (Blanc fixe)					
Bleaching powder (see calcium hypochlorite)					
Blue vitriol (see copper sulphate)					
Borax (see sodium borate)					
Brimstone (see sulphur, roll)					
Bromine	lb.	.70	.90	1.00	1.05
Calcium acetate	cwt.	3.50	3.55		
Calcium carbide	lb.	.04½	.04½	.04¾	.05½
Calcium chloride, fused, lump	ton	23 00	25.00	30 00	40 00
Calcium chloride, granulated	lb.	.01½	.01¾	.02	.02½
Calcium hypochlorite (bleaching powder)	cwt.	4 00	4 25	4 50	6 50
Calcium peroxide	lb.			1 50	1 70
Calcium phosphate, monobasic	lb.			.75	.80
Calcium sulphate, pure	lb.			.25	.30
Carbon bisulphide	lb.	.08	.09	.10	.11
Carbon tetrachloride, drums	lb.	.11	.11½	.12	.15½
Carbonyl chloride (phosgene)				.80	1.05
Caustic potash (see potassium hydroxide)					
Caustic soda (see sodium hydroxide)					
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09	.09½	.10	.10½
Chloroform	lb.	.30	.35	.36	.38
Cobalt oxide	lb.			2.00	2.05
Copperas (see iron sulphate)					
Copper carbonate, green precipitate	lb.	.27	.28	.29	.31
Copper cyanide	lb.			.65	.70
Copper sulphate, crystals	lb.	.08	.09	.09	.09¼
Cream of tartar (see potassium bitartrate)					
Epsom salt (see magnesium sulphate)					
Ethyl Acetate Com. 85%	gal.	1.35		1 40	
Ethy Acetate pure (acetic ether 98% to 100%)				1 75	
Formaldehyde, 40 per cent (nominal)	lb.	.36	.40	.57	.65
Fusel oil, ref.	gal.			5.25	6.00
Fusel oil, crude (nominal)	gal.				
Glauber's salt (see sodium sulphate)					
Glycerine	lb.	4.30	4.35	4.40	4.45
Iodine, resublimed	lb.			.03	.20
Iron oxide, red	cwt.	1.50	1 75	1.80	2 00
Iron sulphate (copperas)	lb.			13½	15¾
Lead acetate, normal	lb.	.11	.12	.13	.17
Lead arsenate (paste)	lb.			.90	1.00
Lead nitrate, crystals	lb.	.14	.15	15½	.16
Litharge	lb.			1 50	
Lithium carbonate	lb.	.12	.14	.15	.16
Magnesium carbonate, technical	100 lb.	3.00	3.55	4 00	4 50
Magnesium sulphate, U. S. P.	100 lb.			3 25	3 60
Magnesium sulphate, commercial	lb.			.14	.16
Nickel salt, double	lb.			.16	.18
Nickel salt, single					
Phosgene (see carbonyl chloride)	lb.	.50	.55	.60	.65
Phosphorus, red	lb.			.35	.37
Phosphorus, yellow	lb.	.35	.37	.45	.46
Potassium bichromate	lb.	.52	.56	.57	.58
Potassium bitartrate (cream of Tartar)	lb.	.80	.85	.90	.95
Potassium bromide, granular	lb.			.85	.88
Potassium carbonate, U. S. P.	lb.	.21	.25	.26	.28
Potassium carbonate, crude					

Coal-Tar Products

NOTE—The following prices are for original packages at works, in large quantities

Alpha naphthol, crude	lb.	$1 40	$1 50
Alpha naphthol, refined	lb.	1 60	1 70
Alpha naphthylamine	lb.	.65	.70
Aniline oil, drums extra	lb.	.35	.40
Aniline salts	lb.	.42	.54
Anthracene, 80%, in drums (100 lb.)	lb.	.90	
Benzaldehyde (free)	lb.	2	2 10
Benzidine, base	lb.	1 15	1 20
Benzidine, sulphate	lb.	1 15	1 20
Benzoic acid, U. S. P.	lb.		1 90
Benzoate of soda, U. S. P.	lb.	.80	.74
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27	.35
Benzol, 90%, in drums (100 lb.)	gal.	.25	.34
Benzyl chloride, 95-97%, refined	lb.	.35	.4
Benzyl chloride, tech.	lb.	.25	.3
Beta naphthol benzoate (nominal)	lb.	.80	.8
Beta naphthol, sublimed (nominal)	lb.	.80	.86
Beta naphthol, tech (nominal)	lb.	.65	.7
Beta naphthylamine, sublimed	lb.	2 25	2 4
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	.19
Ortho-cresol, in drums (100 lb.)	gal.	1 10	1 25
Cresylic acid, 97-99%, straw color, in drums	gal.	1 00	1 15
Cresylic acid, 95-97%, dark, in drums	gal.	.65	.75
Cresylic acid, 50%, first quality, drums	lb.	.33	
Di-chlorbenzol	lb.	.08	.09
Diethylaniline	lb.	1 40	1 50
Dimethylaniline	lb.	1 25	1 35
Dinitrobenzol	lb.	.30	.35
Dinitrochlorbenzol	lb.	.10	.35
Dinitronaphthaline	lb.	.45	.50
Dinitrophenol	lb.	.40	.45
Dinitrotoluol	lb.	.45	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.35	.40
Diphenylamine (nominal)	lb.	.80	.85
H-acid (nominal)	lb.	2 25	2 50
Metaphenylenediamine	lb.	1 15	1 35
Monochlorbenzol	lb.	.18	.20
Monoethylaniline	lb.	2 00	2 40
Naphthaline, crushed, in bbls. (250 lb.)	lb.	.15	.17
Naphthaline, flake	lb.	.15	.17
Naphthaline, balls	lb.	.16	.18
Naphthionic acid, crude	lb.	.75	.85
Nitrobenzol	lb.	.14	.19
Nitro-naphthaline	lb.	.40	.50
Nitro-toluol	lb.	.18	.25
Ortho-amido-phenol	lb.	3 25	4 25
Ortho-chlor-benzol	lb.	.15	.20
Ortho-nitro-phenol	lb.	.80	1 25
Ortho-nitro-toluol	lb.	.25	.40
Orthonitro-toluol	lb.	.35	.45
Ortho-toluidine	lb.	.25	.35
Para-amidophenol, base	lb.	2 50	3 50
Para-amidophenol, HCl	lb.	2 50	3 25
Para-chlor-benzol	lb.	.08	.12
Para-dichlor-benzol	lb.		1 65
Paraamidoaniline	lb.	1 35	1 50
Para-nitro-toluol	lb.	2 60	3 00
Paraphenylenediamine	lb.	2 00	2 50
Para-toluidine	lb.	.65	.75
Phthalic anhydride	lb.	.12	.20
Phenol, U. S. P., drums (est.) (240 lb.)	gal.	2 00	3 00
Perilin	lb.	4 25	4 50
Resorcin, technical	lb.	5 25	6 75
Resorcin, pure			

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0.50	—	$0.52
Salicylic acid, U. S. P.	lb.	.50	—	.60
Salol	lb.	.90	—	1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	.....
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36	—	$0.39
Beeswax, refined, light	lb.	.39	—	.40
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1. (nominal)	lb.	1.00	—	1.05
Carnauba, No. 2, regular (nominal)	lb.	.85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.43	—	.44
Japan	lb.	.21	—	.22
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09½	—	.10
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.....	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½	—	.12½
Paraffine waxes, refined, 128-130 m.p.	lb.	.13	—	.13½
Paraffine waxes, refined, 133-135 m.p.	lb.	.15½	—	.16½
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb.	.26	—	.27
Stearic acid, triple pressed	lb.	.28	—	.29

NOTE—Quotations on paraffine waxes are nominal

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.80
Pine oil, pure, dest. dist.	gal.	1.60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.50	—	$18.00
Rosin E-I	280 lb.	18.50	—	19.75
Rosin K-N	280 lb.	20.00	—	21.00
Rosin W. G.-W. W.	280 lb.	21.25	—	23.00
Wood rosin, bbl.	280 lb.	17.00	—	17.00
Spirits of turpentine	gal.	1.90	—	1.92
Wood turpentine, steam dist.	gal.	1.75	—	1.85
Wood turpentine, dest. dist.	gal.	1.45	—	1.55
Pine tar pitch, bbl.	200 lb.	.....	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.87	—	.89
Rosin oil, second run	gal.	.89	—	.92
Rosin oil, third run	gal.	1.04	—	1.05
Rosin oil, fourth run	gal.	1.12	—	1.12

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.37½	—	$0.38
Upriver coarse	lb.	.28¾	—	.29½
Upriver caucho ball	lb.	.30	—	.30½
Plantation—First latex crepe	lb.	.38	—	.39
Ribbed smoked sheets	lb.	.38¾	—	.39
Brown crepe, thin, clean	lb.	.37	—	.38
Amber crepe No. 1	lb.	.....	—	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.22
China wood oil, in bbls.	lb.	.22½	—	.23½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½	—	.19½
Corn oil, crude, in bbls.	lb.	.17½	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½	—	.16
Cottonseed oil, summer yellow	lb.	.19	—	.19½
Coteonseed oil, winter yellow	lb.	.21	—	.22
Linsed oil, raw, car lots (domestic)	gal.	1.67	—	.....
Linseed oil, raw, tank cars (domestic)	gal.	1.62	—	.....
Linseed oil, boiled, car lots (domestic)	gal.	1.70	—	.....
Olive oil, commercial	gal.	3.10	—	3.25
Palm, Lagos	lb.	.12½	—	.13½
Palm, bright red	lb.	.13	—	.13½
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.15½	—	.16½
Peanut oil, refined, in bbls.	lb.	.22	—	.24
Rapeseed oil, refined in bbls.	gal.	1.70	—	1.72
Rapeseed oil, blown, in bbls.	gal.	1.80	—	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½	—	.13½

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$20.00	—	$22.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	16.00	—	18.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off-color, f.o.b. Cartersville	net ton	16.00	—	19.00
Barytes, crude, 88%@94% ba., Cartersville	net ton	12.00	—	.....
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00
Casein	lb.	.15	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar (nominal) f.o.b. N. Y. State	net ton	16.00	—	20.00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7.50	—	8.00
Feldspar, ground, f.o.b. Baltimore	net ton	18.00	—	25.00
Feldspar, ground, f.o.b. North Carolina	net ton	16.00	—	20.00
Fuller's earth, domestic, powdered	net ton	25.00	—	30.00
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala.	lb.	.....	—	.01
Graphite (dust facing grade 50%) Ashland, Ala	lb.	.....	—	.02
Graphite, crucible, 80% carbon Ashland, Ala.	lb.	.....	—	.05
Graphite, crucible, 90% carbon Ashland, Ala.	lb.	.....	—	.10
Graphite, crucible, 85% carbon	lb.	.....	—	.08
Graphite, crucible, 88% carbon	lb.	.....	—	.09½
Graphite, crucible, 90% carbon	lb.	.....	—	.10½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	.....	—	10.00
Quartz (acid tower) 1¼@2 in., f.o.b. Baltimore	net ton	.....	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	.....	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange, fine nominal	lb.	1.50	—	.....
Shellac, orange, superfine	lb.	1.30	—	1.40
Shellac, A. C. garnet	lb.	1.05	—	1.10
Shellac, T.N.	lb.	1.10	—	1.20
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	9.50	—	14.00
Talc, roofing grades, f.o.b. Vermont	ton	8.00	—	9.00
Talc, rubber grades, f.o.b. Vermont	ton	9.00	—	15.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00	—	15.00
Talc, talcum powder grade, California	ton	20.00	—	35.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. Works:

Chrome brick	net ton	$75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Fire clay, f.o.b. Baltimore	net ton	5—7
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-90 at Chester, Penn.
Silica brick	1,000	50-55 at Mt. Union, Penn.

Ferro-Alloys

All Prices f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.17	—	.18
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon	lb.	.18	—	.19
Ferro-manganese, 70-80% Mn.	gross ton	200.00	—	250.00
Spiegeleisen, 16-20% Mn.	gross ton	72.50	—	75.00
Ferro-molybdenum, per lb. of Mo.	lb.	2.25	—	2.75
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	.90	—	1.10
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	.....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 35-40%, Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70	—	$0.85
Coke, foundry, f.o.b. ovens	net ton	15.00	—	15.50
Coke, furnace, f.o.b. ovens	net ton	14.50	—	15.00
*Petroleum coke, refinery, Atlantic seaboard	net ton	.....	—	24.00
Fluor spar, gravel, f.o.b. mines	net ton	25.00	—	30.00
*Fluor spar, acid grade, lump, f.o.b. Tonuco, Mex.	net ton	30.00	—	45.00
*Fluor spar, acid grade, ground, f.o.b. Tonuco	net ton	55.00	—	65.00
Manganese ore, 45% Mn and over	unit	.80	—	85
Manganese ore, chemical (MnO_2)	gross ton	80.00	—	90.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.85	—	.....
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	.....
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore per lb. of V contained	lb.	1.00	—	3.00
Pyrites, foreign, lump, per unit of S contained	unit	.16½	—	.....
Pyrites, foreign, fine, per unit of S contained	unit	.16½	—	.....
Pyrites, domestic, fine, per unit of S contained	unit	.16	—	.17½
Ilmenite, 52% TiO_2, per lb. ore	lb.	.02	—	.....
Rutile, 95% TiO_2 per lb. ore	lb.	.20	—	.25
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Nominal

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

CASA GRANDE—The School Bd. has awarded the contract for the construction of a 3-story Class C high school here, to Jay J. Garfield, Miami, Ariz., at $117,958. A chemical laboratory will be installed in same.

California

LOS ANGELES—The Schultheiss Mfg. Co., Boyle Ave., is building a plant on Slanson Ave. for the manufacture of plumbing supplies, to include a 50x225-ft. factory, 20x45-ft. core room, 20x35-ft. coaling room, office, etc.

GLENDALE—The Glendale Sanitarium has engaged Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, to prepare plans for the construction of a septic tank sewer system, in connection with the proposed group of hospital buildings at B'way and Jackson Ave.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Dept., will receive bids until June 21 for improvements to the laboratory here. C. W. Parks, chief of bureau.

Florida

DAYTONA BEACH—The town plans to construct a water-softening plant in connection with the waterworks system here. H. E. Pence offered $10,000 for the project.

HASTINGS—The McGuire Fertilizer & Phosphate Co. plans to construct an acid chamber and mixing plant, etc., here. C. L. Brown, agt.

JACKSONVILLE—The Wilson & Toomer Fertilizer Co., Talleyrand Ave., has obtained a permit from the city to construct a fertilizer factory here. Estimated cost, $75,000.

Georgia

ROME—The International Steel & Motors Corp. plans to build an immense plant here, for the manufacture of standard machinery and standard automobile parts. A blast furnace with 60-ton daily capacity will be constructed in the near future at the company's ore lands north of here. An open-hearth furnace with blooming mill for making hard and soft billets, with an annual capacity of 200,000 tons, will be constructed later, together with a bar and sheet mill.

Illinois

CHICAGO—The Central Steel & Wire Co., 127 North Peoria St., plans to build a large foundry on the southeast corner of Western Ave. and 45th Pl. Estimated cost, $450,000.

GALVA—Clark Aby, city attorney, will receive bids until June 24 for the construction of 2 sewer systems with disposal plants.

Indiana

FORT WAYNE—The General Electric Co., B'way and the Pennsylvania Ry., has awarded the contract for the construction of a 2- and 3-story, 150x300-ft. lamp works on Winter St., to Edward M. Waldron, Inc., 665 Broad St., Newark, N. J. Estimated cost, $400,000.

INDIANAPOLIS—The Westinghouse Lamp Co., 165 B'way, has purchased a site here and plans to construct an electric bulb plant on same. Estimated cost, $2,500,000.

Iowa

BURNSIDE—The Consolidated School Dist. will soon award the contract for the construction of a 2-story, 57x89-ft. consolidated school here. A chemical laboratory and septic tank, etc., will be installed in same. Ed. Midendorf, secy. W. E. Hulse Co., 309-10 Securities Bldg., Des Moines, archt.

CLIMAX—The School Bd. will probably install a chemical laboratory in the proposed school here. William Gordon, 317 Hubbell Bldg., Des Moines, archt.

CORYDEN—The School Bd. is having plans prepared for the construction of a 3-story, 66x121-ft. school building. A chemical laboratory will be installed in same. Estimated cost, $135,000. D. S. Sullenberger, pres. W. Gordon, 319 Hubbell Bldg., Des Moines, archt.

MARTINSDALE—The Consolidated School Dist. has awarded the general contract for the construction of a 2-story consolidated school, to Cork & Farrier. A chemical laboratory will be installed in same.

McCALLSBURG—The School Bd. will receive bids until July 8 for the construction of a 60x100-ft. school building. A chemical laboratory will be installed in same. Estimated cost, $110,000. W. L. Pidicord, Iowa Falls, archt.

PATON—The Consolidated School Dist. has issued bonds for the construction of a consolidated school. A chemical laboratory will be installed in same. J. Miller, secy. W. E. Hulse Co., 309 Securities Bldg., Des Moines, archt.

POCAHONTAS—W. J. Gilchrist, Pres. of the School Bd., will receive bids until June 25 for the construction of a 2-story, 56x110-ft. school building. A chemical laboratory will be installed in same. Estimated cost, $150,000. W. E. Hulse Co., 309 Securities Bldg., Des Moines, archt.

STENNETT—The Bd. Educ., Consolidated School Dist., has awarded the general contract for the construction of a consolidated school, to the Garmer-Stiles Co., 425 Flynn Bldg., Des Moines. A chemical laboratory will be installed in same.

Kansas

PAOLA—The city clerk will receive bids until June 22 for furnishing material and labor necessary to construct a water filtration plant, including a filter house, coagulating basin, clear well, etc. Black & Veatch, Interstate Bldg., Kansas City, Mo., engrs.

SCOTT CITY—The city has awarded the contract for the construction of a sanitary sewer system and sewage disposal plant, to M. R. Ammerman, Box 722, Wichita, at $76,381.

Kentucky

LOUISVILLE—The Illinois Malleable Iron Co., 1801 Diversey Blvd., Chicago, had plans prepared for the construction of a large building here.

Maryland

BALTIMORE—The Baltimore Brick Co., Maryland Trust Bldg., will build a 1-story, 28x116-ft. machine shop at Highland Ave. and Monument St. Estimated cost, $5,000. Work will be done by day labor.

Massachusetts

BOSTON—The Boston Paper Bd. Co., 161 Albany St., will build a 4-story, 40x50-ft. addition to plant on Albany St. Estimated cost, $25,000. Work will be done by day labor.

BOSTON—The city is having plans prepared for the construction of a 3-story, 150x300-ft. school on Avenue Louis Pasteur. Chemical equipment will be installed in same. Estimated cost, $1,200,000. J. E. McLaughlin, 88 Tremont St., archt.

BOSTON—The Metropolitan Lithographing & Publishing Co., Dane St., has awarded the contract for the construction of a 1-story, 50x162-ft. manufacturing plant on Bow St., to the Hudson Constr. Co., 6 Beacon St. Estimated cost, $50,000.

FLORENCE—The International Silver Co., 48 State St., Meriden, Conn., has awarded the contract for the construction of a 1-story, 40x110-ft. forge shop and altering the present building, to J. H. Glazier Co., 721 Main St., Hartford, Conn. Estimated cost, $[illegible]. Noted May 28.

Missouri

ST. LOUIS—The Laclede Gas Light Co., 19th and Olive Sts., has awarded the contract for the construction of a 2-story gas plant at 518 Catalan st., to Lyon Clothier, at $80,000.

ST. LOUIS—The Lutheran Hospital, 5300 Ohio Ave., is having plans prepared for the construction of a 3-story, 40 x 156-ft. hospital addition. A complete equipment laboratories will be installed in same. Estimated cost, $125,000. H. J. Eckert, 3616 Virginia Ave., archt.

New York

BUFFALO—The Barrett Jones Corp., Mutual Life Bldg., plans to build an 85x200-ft. fabricating plant at 60 Hubbard St. Estimated cost, $15,000.

BUFFALO—The Director of the New York State Institute for the Study of Malignant Diseases, 113 High St., will receive bids until July 1 for furnishing anhydrous radium bromide containing 50 to 70 per cent of radium element.

BUFFALO—The Rogemoore Cast Stone Co., 2851 Delaware Ave., Kenmore, plans to build a 1-story, 28x44-ft. factory to manufacture concrete products near the New York Central R.R. tracks between Breckenridge and Ferry Sts. Estimated cost, $11,000.

LOCKPORT—The Upson Co., manufacturer of wall board, has filed plans to build a 1-story, 72 x 170-ft. factory addition to its plant on Bristol Ave. Estimated cost, $35,000.

NIAGARA FALLS—The Carborundum Co., Buffalo Ave. and 11th St., has filed plans with the building comr. to repair fire damage to its building. Estimated cost, $50,000.

NIAGARA FALLS—The International Paper Co., Buffalo Ave. and 13th St., plans to build an addition to its factory here. Estimated cost, $65,000.

RICHMOND HILL—R. M. Krauser, c/o C. Bauer, archt., 788 Manhattan Ave., Brooklyn, is having plans prepared for the construction of a 3-story, 60x150-ft. factory for the manufacture of gold rods, on 129th St. Estimated cost, $8[illegible].

SYRACUSE—The city plans to construct a sewage disposal plant here next spring.

Ohio

CINCINNATI—The Lunkenheimer Co., Beekman & Tremont Sts., has awarded the contract for the construction of a 1-story, 350x400-ft. foundry on Carthage St., to the Fisher Devore Constr. Co., Blymer Bldg. Estimated cost, $[illegible].

CINCINNATI—The Peerless Foundry Co., Township Ave., has awarded the contract for the construction of a 1-story, 120x120-ft. foundry, to the Ferro Concrete Constr. Co., Richmond and Harriet Sts. Estimated cost, $40,000.

CLEVELAND—Walter Nathan, 1383 East Boulevard, has awarded the contract for the construction of a 2-story, 40x105-ft. factory addition at 6202 Cedar Ave., to William Dunbar Co., 8201 Cedar Ave. Central Brass Mfg. Co., 6202 Cedar Ave., lessee.

CLEVELAND—The Strong, Cobb Co. plans to build a 2-story factory for the manufacture of drugs. Estimated cost, $150,000.

EAST CLEVELAND (Cleveland P. O.)—The Natl. Lamp Co. of the General Electric Wks., Nela Park, has awarded the contract for the construction of a 1-story, 55x110-ft. laboratory at Nela Park, to the Heller Bros., Youngstown. Estimated cost, $100,000.

ELYRIA—H. A. Beck, Dir. of Pub. Serv., will receive bids until June 21 for the construction of a filtration plant, substructures and appurtenant works, including coagulating basin, filtered water reservoir and rapid sand filter banks, etc. Noted April 13.

HURON—The Universal Steel Co., 833 Schofield Bldg., Cleveland, has purchased a site and plans to build a 2-story, 78x[illegible]-ft. tube and conduit mills, to equip. Estimated cost, $400,000. F. W. Mettler, engr.

IRONTON—The Sheridan Coal Co. plans to construct a brick manufacturing plant including ovens, kilns, pulverizing machinery, etc., at Sheridan, near here. Estimated cost, $[illegible].

LIMA—The Bd. Educ. will receive bids until June 15 for the construction of a 2-story, 82x124-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $123,000. McLaughlin & Hulsken, Savings Bldg., archts.

STOUTSVILLE—The city received bids for the construction of a sewage disposal plant for school building from the Stout Bros., $5,150; Taylor & Linn, Zanesville, $5,500.

XENIA—The city will soon award the contract for the construction of a 1,000,000-gal. water purification plant, etc. Kenyon Riddle, city mgr.

Oklahoma

PURCELL — The Legislative Council have engaged Johnson & Benham, consult. engrs., 150 Nassau St., New York City, to prepare plans and submit estimates for the construction of an impounding reservoir, intake works, modern filtration and sterilization plant.

Oregon

PORTLAND—The Pub. Dock Comn. will soon award the contract for furnishing $75,000 worth of phosphate handling machinery and 3,900 ft. of 30-in. conveyor belting for same. G. B. Hegardi, engrs.

Pennsylvania

McKEESPORT—The Columbiana Fdry. Co., House Bldg., Pittsburgh, is building a 100x300-ft. foundry and a 40x140-ft. office and pattern shop. Estimated cost, $250,000.

Rhode Island

PAWTUCKET—The Pawtucket Hosiery Co., 107 Rand St., Central Falls, has awarded the contract for the construction of a 1-story, 32x75-ft. textile mill, to the Humes Constr. Co., 76 Dorrance St., Providence. Estimated cost, $15,000.

South Carolina

COLUMBIA—The Colon Ry. Gas & Electric Co., Arcade Bldg., plans to expand present gas plant by building tanks, etc., to provide for several hundred thousand more cu.ft. of gas. Estimated cost, $400,000. J. G. White Eng. Corp., 43 Exch. Pl., New York City, engr.

Tennessee

MEMPHIS—The Memphis Steel & Iron Works plans to build a rolling mill in the northern part of the city. Equipment will be installed in same. Estimated cost, $300,000. J. E. Conley, pres.

Texas

BRECKENRIDGE — The Breckenridge Oil & Refining Co. is having plans prepared for the construction of an oil refinery to turn out gasoline, kerosine, lubricating oils and other refined oil products. The plant will have a 1,000 bbl. daily capacity. Estimated cost, $300,000.

FARMERSVILLE—The Bd. of Directors of the Farmersville Sewer Co. will soon award the contract for the construction of sanitary sewer lines and 2 sewage disposal plants. J. E. Worden, treas.

FORT WORTH—The Physicians & Surgeons Hospital is having plans prepared for the construction of a 4-story hospital on B'way Blvd. Complete surgical equipment will be installed in same. Estimated cost, $300,000. Sauguinet & Staats, 1st Natl. Bank Bldg., archts.

WHITESBORO—Harry Reast, secy., will soon award the contract for the furnishing of all labor and material for the construction of a sanitary sewer system and disposal plant.

Vermont

BRATTLEBORO — The C. F. Church Mfg. Co., Willimansett, Mass., has awarded the contract for the construction of three buildings including a 1-story main building, 1-story dry kiln, etc., to E. F. Carlson Co., 244 Main St., Springfield, Mass. Estimated cost, $80,000.

Virginia

RICHMOND — The Virginia Carolina Rubber Co., Real Estate Exch. Bldg., will soon award the contract for the construction of 50x240-ft. building for the manufacture of tires, etc. Estimated cost, $15,000. J. T. Waddell, engr.

WINCHESTER—The Harloe Tire Co., St. James Hotel, Wash., D. C., plans to construct a building. Estimated cost, $150,000. Address Mr. King.

Wisconsin

FOND DU LAC—The Bd. Educ. is having plans prepared for the construction of a 2-story junior high school. A chemical laboratory will be installed in same. Estimated cost, $300,000. Childs & Smith, 64 East Van Buren St., Chicago, archts.

MADISON—The State appropriated $25,000 for the installation of additional toilet facilities on the state fair grounds, the construction and equipment of necessary buildings, a septic tank and equipment and for the construction of necessary extensions of water mains and sewers.

MADISON—The state appropriated $90,700 for the construction and equipment of the upper three floors of the west wing of the Chemistry Building here.

MANITOWOC—H. Zannacker & Sons, 923 Washington Ave., will receive bids until June 18 for the construction of a 3-story, 50x64-ft. dry cleaning building on 18th St.

WATERLOO—The village will receive bids until July 1 for the construction of sanitary sewers and septic tanks. W. J. Higgins, clk.

Ontario

HAMILTON—The Mercury Mills, Ltd., has awarded the contract for the construction of a 4-story, 50x260-ft. dye house on Cumberland Ave., to W. H. Cooper, Clyde Block. Estimated cost, $150,000.

Quebec

LAPRAIRIE—The Interprovincial Clay Products Co. of Canada, Ltd., a subsidiary company of the Interprovincial Brick Co., will soon receive bids for the construction of a plant and the installation of equipment.

MONTREAL—The Barrett Mfg. Co., 2021 St. Hubert St., has awarded the contract for the construction of a 2-story, 38x54-ft. roofing manufacturing building on Boyer St., to the Sheaver Co., 277 St. Patricks St., at $18,500. Noted April 14.

MONTREAL—The Canadian Con. Rubber Co., 201 Inspector St., has awarded the contract for the construction of a 100x150-ft. rubber goods factory at Guy and St. James St., to Lockwood, Greene & Co., 285 Beaver Hall, at $100,000.

OTTAWA—The Gatineau Co., Ltd., plans to construct pulp and paper mills, 3 dams, etc., in the Gatineau Valley Dist. Estimated cost, $30,000,000. C. B. Thorne, Montreal, engr.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN DROP FORGE ASSOCIATION will hold its seventh annual convention at the Marlborough-Blenheim Hotel, Atlantic City, N. J., June 17, 18 and 19.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its one hundred and twenty-second meeting Aug. 20 to Sept. 3, at Lake Superior.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE FOREST PRODUCTS LABORATORY will hold its decennial celebration at Madison, Wis., July 22 and 23, 1920.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its midsummer meeting at Boston, July 15 and 16.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE ILLINOIS MINING INSTITUTE will meet in Chicago, June 23 to 26.

THE STEEL BARREL MANUFACTURERS' ASSOCIATION will meet in Chicago, June 24.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its fall meeting at Saratoga Springs, N. Y., Sept. 1, 2 and 3.

Industrial Notes

SIDNEY CORNELL, chemical and industrial engineer, has moved his office from 1 West 34th St. to 80 Maiden Lane, New York City.

METALLURGICAL RESEARCH ENGINEERING Co. has moved its office to 427 Reaper Blk., corner of Clark and Washington Sts., Chicago, Ill.

INDIANAPOLIS CHAMBER OF COMMERCE BUREAU OF INDUSTRY has prepared a large map of the City of Indianapolis showing vacant factory sites that are available, street-car service, transportation and all physical features that enter into the selection of industrial sites.

THE U. S. COPPER PRODUCTS CORP. of Cleveland, Ohio, announces the opening of a New York City office at 1123 Broadway, for the sale of seamless brass and copper tubes. This branch will be under the management of Herbert Gnad.

THE GILLESPIE EDEN CORP. is the name of the consolidation of the Gillespie Manufacturing Co., the Gillespie Motor Co., the Gillespie Foundry Co. and the Brokaw-Eden Co. Executive offices are at 50 Church St., New York City.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., announces that the Chicago offices have been removed from the People's Gas Bldg. to the company's own building, 323 No. Michigan Ave. H. L. Dawson is manager.

THE GENERAL CERAMICS CO., 50 Church St., New York City, has established an engineering department at 145 West 45th St., New York City. P. C. Kingsbury is chief engineer of this branch office.

THE STEARNS-ROGER MFG. CO., Denver, with which W. C. Graham of the Great Western Sugar Co. and W. G. Haldane, formerly president of the Colorado School of Mines, are associated as consulting engineers, has taken a contract for the improvement of the processes and practice of the American Potash Co. at Antioch, Neb. The Stearns-Roger organization is one of the few that have specialized in the production of potash from lake waters, and has succeeded in solving some of the difficult problems encountered in this comparatively new industry.

THE MERRILL CO., of San Francisco, has transferred the manufacture of the Nordstrum valve from San Francisco to the plant of the Swenson Evaporator Co. at Chicago.

THE WISHNICK-PUMPEER CHEMICAL CO. has been organized with offices and warehouse at North Pier Terminal, 365 East Illinois St., Chicago, for handling chemicals, oils and colors. The members of the firm are Robert Wishnick, David Pumpeer and Julius Pumpeer, all formerly connected with A. Daigger & Co., Chicago.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

J. A. CHAPMAN
Business Editor
CHESTER H. JONES
CHARLES A. ALAVOINE
Industrial Editors
J. S. NEIGHT
Managing Editor

Volume 22 New York, June 23, 1920 *Number* 25

The Spirit Of the West

IN SPITE of much of the unimpressive "boosting" that is indulged in by the estimable inhabitants of the cities on our Pacific Coast, a visitor among them is constrained to admire the ingenuity, resourcefulness and energy displayed in their industrial and commercial life. One may not be deeply moved by stories of the rising values of real estate, but he cannot escape the conviction that potential wealth in water power and raw material exists in greater concentration in that western empire than in any other part of the country. Handicapped though it may be now by sparsely settled areas, light local demand for its own wonderful resources and immense distances from present domestic markets, this region is nevertheless the one toward which industry and commerce in the United States must ultimately grow.

And not to meet domestic needs alone, but to supply foreign markets as well; for despite the fact that the people of the United States have, or had before the war, little or no international sense and vision, dwellers on the Pacific Coast have a lively sense of international trade and world business. Looking east they face their own country, but to the west is another world teeming with potential consumers of the products of our civilization, and prolific in natural and artificial commodities that will find a ready market here. Like the Atlantic Coast of our country, the Pacific has a double outlook and is just beginning to develop its possibilities.

Its industry is growing impressively. Climate and cheap hydro-electric power developed by the municipality are responsible for the recent location of an immense rubber factory in Los Angeles. Harbor and shipping facilities are making of San Francisco the great port of the Pacific Coast. Portland, though an inland city, is developing an export and import trade; while the two cities on Puget Sound, Seattle and Tacoma, are centers of world-wide trade in edible oils and copper. Notable is the fact that fixation of nitrogen by the arc process is practiced only in our great Northwest, where water power is cheapest, and electric smelting of iron ores is giving promise of developing there into a stable industry.

In short, engineering and technical developments are the substantial things that impress the visitor, even though they are not most often "boosted." But even the "boosting" can be condoned on the score that it creates and supports a spirit of civic loyalty too often lacking in Eastern communities, and is in some degree expressive of that Western hospitality that is as large as the great out-of-doors and which does not find its counterpart elsewhere in the country.

President Signs Water-Power Bill

ANNOUNCEMENT was made at the White House on the 18th inst. that the President had signed the water-power bill on the 11th, within ten days from the time it was delivered to him. The provisions of the bill, outlined elsewhere in this issue, are accordingly the law of the land. In spite of the fact that it was necessary to support the legality of the President's act by a technical interpretation of the Constitution by the Attorney-General, it is not believed that this will have any effect in delaying actual development of water power. Money is now the most necessary item. Had Secretary PAYNE been less solicitous regarding possible damage to our national parks through water-power development, the delay need not have occurred and the bill could have been signed before Congress adjourned. Mr. PAYNE'S reported anxiety regarding the parks was unimpressive and his eleventh-hour conversion unconvincing. One could have wished that Mr. LANE were still Secretary of the Interior. No one had a higher appreciation of our national parks than he; but that did not warp his judgment of the value of water-power development.

Developments in Flotation Litigation

ELSEWHERE in this issue we publish two items relative to the litigation between Minerals Separation, Ltd., and the Miami Copper Co. One relates to a motion by the defendant in the United States District Court at Wilmington to dismiss the petition of the plaintiff seeking to punish the defendant for contempt of court. The other announces the order of the United States Circuit Court of Appeals, Philadelphia, refusing to grant the Miami company's petition to reopen the case to admit newly discovered evidence.

It is a mere coincidence that these two items appear in the same issue, as they are not directly connected with each other. There is, however, a certain relation, since the Circuit Court of Appeals virtually remands the subject matter of the Miami petition to the accounting proceedings before the Master, whereas the petition of Minerals Separation, Ltd., seeks to remove questions at issue from the accounting.

Unfortunately the original decision of the Circuit Court of Appeals in the Miami case stops short of what is, for the general mining public, *the* important question, namely, whether the use of the pneumatic cell itself is, or is not, an infringement of patents. The reopening of the case would have permitted a more prompt adjudication of the question in its broadest sense. However, in the last analysis the determination of this point by the Master will have the same effect, as it will then come by appeal before the same court.

Where Are The Chemists?

SURPRISE was expressed by one delegate to the organizing conference of the Federated American Engineering Societies that the chemists were not more largely represented on the floor. Invitations were sent to a long list of engineering and allied technical associations, and yet the American Chemical Society—the most numerous body of chemists, more or less technical—did not send deputies. However, the matter was briefly dismissed by the statement that chemists are not engineers.

Holding the opinion that the Chemical Society should have been represented, it is not so easy to excuse absence in that manner. Risking the chance of tedium, a few thoughts on the relationships of the numerous engineers served by CHEMICAL & METALLURGICAL ENGINEERING will be advanced.

"Engineering" has been defined by enthusiasts to be as all-embracing as the official statement of scope of the Bureau of Standards: "The establishment of standards of measurements, constants, quality, performance and practice"! A like blanket definition is that which regards engineering as "the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race." Evidently a sailor and a surveyor are both included—the wide reaches of engineering includes Generals GORGAS and GOETHALS!

Obviously a more restricted meaning corresponds with usage, despite the enthusiasts. An engineer is rather an applied physicist, he who understands the laws of heat, electricity, light, sound, dynamics and statics and can make them useful to man in structures and machines. In this way the sailor and General GORGAS—indispensable though they be—are evidently and properly not classified with the surveyor and General GOETHALS.

Now, is a chemist, "versed in the science of the composition of substances and their transformations," an engineer in this sense? If the chemist is a scientist—one intimate with the systematic knowledge of his subject—he evidently is not called an engineer, and rightly so; and it would be no less than a calamity to revise educational methods so that nearly all the students would graduate chemical engineers, to the exclusion of chemists. On the other hand, if he is more the artist—one whose knowledge is made efficient and useful to his neighbors by skill—then he would be welcomed into their fraternity by all engineers. Dr. STIEGLITZ, evidently, is a chemist primarily, and in no sense an engineer; he is a scientist. Dr. LITTLE, on the other hand, is an engineer primarily, even though well versed in chemistry—he is skilled in the art and science by which the properties of matter are made useful to man through structures and machines. "Properties of matter" is evidently a broad term—so is engineering a broad profession. Both are subdivided by using qualifying adjectives—an electrical engineer applies electrical properties of matter to useful ends, a chemical engineer applies chemical properties of matter to useful ends, a metallurgical engineer applies chemical and physical properties of metals to useful ends.

No apology is needed, then, to most of our readers for devoting much space to the Federated American Engineering Societies, whose object is to further the interests of the public through the use of technical knowledge and engineering experience as applied to political economy, and to consider and act upon matters common to the engineering and allied technical professions. It seems most fit that engineers—a group of educated men distinguished from scientists principally because the engineer applies science for human benefit—it seems most fit that they should organize to further, collectively, the interests of the public.

By the same token, it seems incongruous that the American Chemical Society should lag behind the lead of the American Electrochemical Society and the American Institute of Chemical Engineers in its interest in the Federation. It is true that a large proportion of its members is interested in chemical research, chemical theory, or chemical activities very distantly related to industry—but so are numbers of men in the smaller Electrochemical Society. On the other hand, both associations have many members who are distinctly engineers, and many more members whose work—even though it be of the humblest routine variety—is intimately connected with industrial and engineering enterprise. Does not the American Chemical Society publish a *Journal of Industrial and Engineering Chemistry?* Evidently the interest in the society is quite strong to warrant a publication entirely separate from its scientific annals. Then why do they not act like engineeers and electrochemists? The work ahead is big enough so that there is room for all engineers and allied and associated spirits, and hard enough to need all possible shoulders to the wheel. If the American Chemical Society desires to function in public affairs—and we know it has been urging individual chemists to do so—then why has it not embraced this opportunity to join in the creation of a body for that very purpose?

Synthesis and Analysis Of Engineering Formulæ

OF RECENT years the mathematical laboratory has come to be as thriving a workshop as any other place set apart for scientific investigations. As long as bridges and great structures have been designed, the study of lines of force, as theoretically developed in the science of statics and dynamics, has been of fundamental importance. Engineering of every kind has been dependent on the mathematical development of the pure science with which it was concerned. In a way, next to being able to apply known formulæ in an intelligent manner, the greatest asset of an engineer is to be able to synthesize new ones himself or reverse the operation and analyze any that may be presented to him by others.

In this issue we have a mathematical development that should have an important bearing in a number of directions in technology. It will have to be further developed before it will give the distillation engineer a full set of implements for the solution of his problems, but as it now stands it fills a very large gap that has prevented any considerable progress in the direction of applying mathematics to the consideration of saturated vapors. It may now be expected that the lesser devious ways of partial pressures and Raoult's law may be put on a practical mathematical basis, and give the much-needed formulæ for the calculation of distillation problems.

In connection with the formulæ developed by Mr. WILLIAMSON and the method given at the conclusion of the article for facilitating calculations, it should be mentioned that this year is the three hundredth

anniversary of the logarithm scale, which was invented by GUNTER, an engineer, only six years after NAPIER had conceived the idea of logarithms. Many years passed before the slide rule was brought out and still many more before the alignment chart was developed to give a convenient means of using GUNTER'S log scale. GUNTER used a draftman's compass. In all probability there is as much opportunity today for us to improve on the application of this scale as there was in GUNTER'S time. It is hoped that every reader has at least a small corner in his mind for his mathematical laboratory and that he does not neglect to use it in the study of either pure or applied science.

Organized Labor And the Public

BEFORE President WILSON'S first Industrial Conference last October, it was remarked in some quarters that organized labor was on the defensive, and would have to occupy that attitude at the coming conference. No such attitude was taken, however, by Mr. GOMPERS and his associates and the conference broke up.

A good bit of water has passed the mill since that time. The public has been taking more and more interest in the subject of organized workers and unorganized workers and is rapidly coming to recognize its numerical superiority. Mr. GOMPERS has helped the public to an appreciation of the situation and of his own position in many ways, and particularly so by his delayed attempt to answer Governor ALLEN'S question whether in an industrial dispute the public has no rights. Mr. GOMPERS had to take time to reflect and after he had taken the time—we do not answer for the reflection—he said a number of things not precisely to the point. One that is readily recalled was in substance that every worker must get at least $2,500 a year first.

The obvious rejoinder to Mr. GOMPERS' denial of the public having any rights in an industrial dispute is to inquire how it would be if the shoe were on the other foot—if it were a case of a lockout instead of a strike. Mr. GOMPERS should reflect that the ins sometimes become the outs. The public certainly would not stand for an unreasonable lockout, nor is there any prospect of any large employer at any time undertaking an unreasonable lockout. One wonders—or rather one does not need to wonder—what the attitude of the people would be if a large trolley company were to discontinue its service for a while in order to induce its employees to work for lower wages.

There is likely to be a new reaction in the public mind. The doctrine has been preached everywhere that the "vicious circle" of advancing wages and advancing cost of living, turn about, will get us nowhere. The public has not yet reflected sufficiently upon the proportions of the total number of workers that are, respectively, organized and unorganized. The proportions are approximately 10 per cent and 90 per cent, and for the substantial accuracy of these figures ample proof can be furnished by intelligent interpretation of the last census report showing those engaged in gainful occupations, with allowance for increase in population meanwhile, and the number, not of union workmen, but of the membership claimed by the labor unions.

There will be an important mental reaction when the public comes more fully to consider the proportion of one organized worker out of every ten, and the dictum that has been preached that there is a vicious circle. The alleged vicious circle would get us nowhere, but if one-tenth of the population attempts to better itself at the expense of the ten-tenths, being willing to pay its one-tenth of the tax by virtue of the nine-tenths it escapes, then there is another case altogether.

The public is also coming to a clearer realization of the psychology of the labor unions, that in order to keep things going the leaders must be continually promising the rank and file additional things. There is no stopping. The leaders cannot thrive on past accomplishments, but must continually suggest new goals to be reached. In other words, the union leaders can never get things fixed up satisfactorily, and when the public realizes, as perhaps it will, that this is the situation, it is likely to exclaim "What's the use!" Such a reaction, also, would greatly help in putting things where they belong.

Horse Thieves Among Chemists

IN THE chemical profession as elsewhere there are unfortunately a few unethical persons who take advantage of the general high standing of the collective body for personal aggrandizement or dishonest financial gain. From very early times it has been the desire of scientific men to force such members without the pale.

It is related in the biographical writings of Sir HENRY ROSCOE, as told recently at the Chicago Chemists' Club, that a certain chemist working in a research laboratory obtained exact results as to the atomic weight of the metal under consideration. Sodium, for instance, showed an exact weight of 23. The chief, becoming suspicious, gave him for test a mixture of potassium and sodium, telling him it was sodium. The atomic weight was still proved to be 23. Whereupon this chemist was discharged and, affiliated with the Baptist church, became acquainted with the pastor's servant. One Sunday when she was alone in the house, he bound and gagged her, lifted the family plate and fled to America. He was pursued by the authorities, who located him in the West, but alas, too late, as he had just been hanged for stealing horses.

The procedure is applicable in these times. If the professional career of technical immoralists and pirates is not brought to an end through slow workings of the social laws, a little "Western justice" administered by political action in technical societies will not come amiss.

How Consulting Chemists Secure Clientele

A MANUFACTURING chemist once asked, "How do these consulting chemists get business?"

In Chicago there lives a genial chap, gray with years, young in mind, who prospers because he is loved by all who know him. Aside from being a chemist he is a soul of large understanding, a man among men. He lives in his work and delights in the association of those who come within his ken. He is ever ready to assist the younger ones in the pursuit of paths chemical. He's a regular fellow in his own quiet way. He follows ideals, *not* dollars. It is a privilege to enter his office.

So business just comes into his office, for men trust him. The answer is just there—the human touch by an honest hand is the best business getter.

Readers' Views and Comments

Effect of Insulation on Resistor Temperatures

To the Editor of Chemical & Metallurgical Engineering

SIR:—On page 661 of your issue of April 7, you presented an abstract of an article by W. A. Gatward on Nickel-Chromium Alloys. Referring to wire heating-elements of electric furnaces, the abstract says:

"Experience shows that the presence of a cold body near a certain part of a heating element causes that portion to advance slightly in temperature. If the wire possesses too large a coefficient (temperature coefficient of resistance), this will cause that *portion* to become increasingly hotter until it melts."

The presence of a cold body near a certain part of a heating element can only cool that part, and there is not in such instance any paradox.

However, sudden cooling of a sufficiently large part of the heater will frequently allow the heating current to increase to a value which will burn out another part of the heater. I have often observed this, and the reason for such an occurrence is clear. Of course it can happen only if the element has a positive temperature coefficient of resistance.

A close reading of Mr. Gatward's paper makes it clear that what he had in mind is the local action of a heat insulator, for the presence of an insulating body near a portion of the heater will at times cause the part to burn out—and the insulator may be at first a cold body. That he was not strictly quoted may be inferred from the following verbatim extract from his paper:

"The development of hot spots is very much affected by the temperature coefficient. Another effect of high temperature coefficient is as follows: Imagine a heating unit wound around a muffle as generally used in electric laboratory furnaces. The heating unit is a continuous piece of wire. Suppose that the furnace is operating at 1,800 deg. F. and we place on the floor a fireclay brick. The fireclay brick immediately banks up the flow of heat and the temperature of the wire under the brick rises. This is not a theory but a fact, and the rise is very serious. As the wire under the brick gets hotter its resistance increases. Since the current is the same in all parts of the heating coil, the heat developed, I^2R, will be greater on the floor than on the sides and top. Of course this phenomenon is cumulative and is the actual cause of many burn-outs in industrial devices. The higher the temperature coefficient the more serious this will be."

Mr. Gatward would possibly have been more clear if he had said that by placing a firebrick (or other heat insulator) near the heater, local heating occurs. In this way the editor would not have substituted "cold body" for Mr. Gatward's "fireclay brick." It is not that the brick is cold but that it will not conduct heat very rapidly which is the essential quality.

I had thought that some of your readers would be misled by your abstract which states that "presence of a cold body . . . causes . . . advance in temperature," and have commented on this point because the statement is closely related to the requisites for good furnace construction. One of these is that great care must be taken in applying insulation uniformly, especially when the furnace is to be operated at highest safe temperatures. C. O. FAIRCHILD.

Washington, D. C.

A Rapid Method for the Analysis of Monel Metal

To the Editor of Chemical & Metallurgical Engineering

SIR:—May I make a further suggestion on Mr. Covitz's article which appeared in your magazine, issue of Jan. 7, 1920, p. 31, in regard to the "Rapid Method for the Analysis of Monel Metal"?

In determining the nickel contents, he suggests the usual precipitation with dimethylglyoxime, which in my estimation and experience is a slow process of filtering the resultant precipitate, besides the reagent being an expensive one at the present time.

For the copper content, I plate out my copper from the silicon filtrate by Mr. Covitz's plan. Another weighed sample is dissolved in nitric acid and then driven off with concentrated sulphuric acid, using 10 c.c. Take up with water and heat if necessary to get into solution, cool, then neutralize with ammonium hydroxide. Add about 40 c.c. in excess, also introduce 5 g. of ammonium sulphate. Have bulk of solution about 200 c.c. Connect up to the plating apparatus and proceed to plate out the copper plus the nickel, using three amperes and a revolving cathode whereby one obtains all the copper deposit first, then the nickel, without any interruption whatsoever. The operation of electrolysis usually consumes about one hour.

Strange as it may seem, the nickel does not start to plate until all the copper has been deposited. The combined weights of nickel and copper minus the weight of the copper deposit obtained from the silicon filtrate will, of course, give the nickel content.

The writer has taken copper and nickel salts, also samples of various nickel and copper percentages, and has obtained excellent results by following the scheme as outlined.

If the sample contains cobalt, a correction must then be made, although the writer has never encountered it in monel metal. PAUL W. C. STAUSSER.

Detroit, Mich.

Prosperity of Belgian Artificial Silk Industry

Some Belgian artificial silk works are enjoying prosperity despite the fact that they were victims of the German invasion. Thus the Obourg Artificial Silk Co. reports a profit of 2,142,757 francs for four months' operation in 1919. Work was resumed after ten months' work of restoration, only half the company's installation having been put into service. The other part has been restored and will be in operation soon if supplies of raw material are not lacking. The war damage to the company's property is estimated at 2,500,000 francs, 1914 value.

FIG. 1. A. S. & R. CO.'S EXPERIMENTAL FARM

Showing experimental plots of large numbers of common crops for determining effects of SO_2 under varying conditions of light, temperature, relative humidity and stage of growth. During seasons of 1915, 1916 and 1917 more than 3,500 plots were used. Each plot contains 25 sq.ft. and the space allowed for each plant of the various crops is such as should obtain under normal field conditions as determined by good farm practice.

Smoke Litigation in Salt Lake Valley

Notes on the Effects of Smoke Suits and Recent Crop Investigations on Smelting Operations in That Vicinity, the Improvements Made at Murray to Mitigate Nuisances, and the Court's Remarks on the Difficulty of Distinguishing SO_2 Injury

By ERNEST E. THUM

ANOTHER chapter in the smoke litigation involving smelters operating in the Salt Lake Valley, Utah, was brought to a close on Feb. 21, 1920, when Federal Judge T. D. Johnson signed an interlocutory decree permitting, under certain conditions, the continuance of operation of the American Smelting & Refining Co.'s works at Murray and the United States Smelting Co.'s works at Midvale.

In order properly to appreciate the condition surrounding this decree, it is well to turn back fourteen years or more. At that time Salt Lake City was spoken of as the largest smelting center in the United States, with no less than seven different plants, having a combined capacity in lead and copper ores of 8,000 tons of lead and copper ores daily. These seven were doing the work which a long line of foregoing operators had conducted thereabouts in small smelters since the beginnings of mining in Utah. An enumeration of the plants operating in 1906 follows:

Name of Plant	Kind of Smelter	Capacity, Daily Tons
Murray, A. S. & R. Co.	Lead	1,500
Garfield, A. S. & R. Co.	Copper	1,250
Bingham	Copper	1,000
Midvale, U. S. S. R. & M. Co.	Copper and lead	2,500
Yampa	Copper	500
Highland Boy	Copper	1,000
Utah Consolidated	Copper	250

Before 1906, however, all of these plants, without exception, were operating with little or no regard for the recovery of fume and dust. None of them except the newly built Garfield smelter had an organized flue and stack system; each relied upon small individual chimneys located close to each furnace or department.

In the light of our present information about smoke and fume it is not surprising that under such circumstances quite severe damage was done throughout a considerable area surrounding each of the smelters. Consequently, upon suit of 409 farmers, Federal Judge John A. Marshall, on Nov. 5, 1906, enjoined certain of these smelters from continuing the smelting of ores containing more than 10 per cent of sulphur, except after installing satisfactory means for neutralizing the obnoxious fumes resulting therefrom. Pending an appeal on this suit, the smelters continued operating.

However, the Murray plant of the American Smelting & Refining Co. immediately erected a large baghouse (first operated in July, 1907) for eliminating solid particles from the gas. This was in line with the contention made by some of the smelting companies that the damage was largely due to compounds of sulphur and arsenic which condensed on particles of soot or other solid matter and settled with them to the ground. Naturally, then, if soot and solidified vapors could be filtered out of the smoke, little cause for damage would remain. After making the proper financial settlements with the complaining farmers, the American Smelting & Refining Co. was, therefore, freed from the litigation and was allowed to operate nine or ten lead blast furnaces. In its operations it was also allowed to roast ores containing 25 per cent of sulphur and to smelt ores containing more than 10 per cent, if the average of the furnace charge was no more than 10 per cent sulphur and if, in addition, all furnace gases were baghoused, removing lead, arsenic and other solids. The company also agreed to construct an extensive dust chamber at the roaster department to cool the gases from those operations so as to precipitate all the condensable vapors possible.

The same company's plant at Garfield was situated between the Great Salt Lake and Oquirrh Mountains in such a way that the smoke was not carried over farming lands by the prevailing winds. However, in

order to be doubly safe, the company purchased about 35,000 acres of ground along the lake shore to insure against future smoke litigation by the owners.

The United States Smelting Co., however, was not so successful in its negotiations with the farmers and when, on Jan. 11, 1908, the Federal court's injunction was sustained under appeal, its plant closed. Within a couple of months, however, the company petitioned the court for the right to reopen, claiming that its newly perfected Sprague process of introducing zinc oxide into the smoke would remove all cause for crop injury. At the same time the zinc would neutralize sulphuric acid, forming with it a solid which would be caught by the bags. This would improve the quality of the issuing gases as well as prevent rapid deterioration of the bags themselves. On April 5, therefore, the Federal Judge suspended the injunction and allowed the Midvale plant to operate its lead furnaces, treating 25 per cent sulphur ore up to one-third of its capacity. However, it was stipulated that the plant must also remove all solids from its roaster and blast-furnace gases, discharging all smoke through a single smokestack free of lead, copper, arsenic and antimony compounds and all traces of sulphur trioxide. At the same time its percentage of sulphur dioxide must be no greater than 0.75 per cent. Under such circumstances the plant was allowed to run three years in order to demonstrate the efficiency of baghousing in conjunction with the Sprague process.

As a matter of collateral interest the fate of the other plants in that region is more or less interesting. The Bingham copper smelter was abandoned in December, 1907. For some time there were rumors that a more modern plant would be built and placed upon the south shore of the Great Salt Lake, but these plans did not materialize.

Many Plants Dismantled

On the other hand, there were several meetings between representatives of the farmers and the owners of the Highland Boy plant, in which an agreement was sought. It was reported at the time that the farmers demanded a bonus of $175,000 before they would agree to any modification of the injunction against that smelter, while the company said that $100,000 plus actual damages was its limit. On account of this deadlock, a satisfactory arrangement was made with the International Smelting Co. for ore treatment at a new plant, then under contemplation. The Highland Boy smelter was therefore closed down and dismantled, the best of the machinery being reinstalled by the International company at Tooele. This plant was built at Pine Canyon, where prevailing day winds would carry the smoke into the mountains. Preliminary agreements were made with nearly all the land owners within a three-mile radius that in case smoke damage resulted title to the land would be transferred to the company for a certain stipulated value. The Yampa plant in Bingham Canyon was not involved, being out of the smoke zone. However, its life was relatively short.

Under these circumstances it is seen that the smelters at Murray and at Midvale are the two survivors of the cluster operating in that region in 1906, and disrupted by smoke suits. The so-called Godfrey decree and its subsequent stipulations required the American Smelting & Refining Co. and the United States Smelting Co. to install modern fume-collecting and gas-cleaning devices to efface the evident nuisances existing at that time. Subsequent operation of both of the plants proved satisfactory to the farmers for many years. However, during the period from 1912 to 1916 several complaints were made, and in 1916 another suit was entered against the two smelting companies asking damages and other relief.

Investigating Staffs Maintained

During this time both of the companies have maintained investigating staffs which have not only worked upon the question of smoke injury in general, but have also operated experimental farms nearby the smelters (Fig. 1). It was their practice to have members of their staff investigate complaints as they were made. The American Smelting & Refining Co. in many cases found it best to admit damage by sulphur dioxide and settle accordingly. It is interesting to note that it took some years for both sides to become convinced that fume or other solid was not the *sole* cause of plant injury. However, with the operation of well-designed baghouses, the amount of solid matter escaping from the central stack was of negligible quantity, and yet undoubted discoloration and bleaching of foliage occurred at times. However, the United States Smelting Co. would not admit that SO_2, in the concentrations caused by their operators, caused any economic damage—that is, deteriorated the crops in quantity or quality. Their contention was that only on one occasion—in June, 1914—was there a well-defined burn caused by smoke, yet the effects of this gas current quickly disappeared, and no permanent damage was done to the crops nor claimed by the farmers.

Practical Experiments on Nearby Farm

As mentioned above, the United States Smelting Co. had maintained an investigating staff on smoke problems, as well as utilizing the services of independent experts since 1908. In 1914 is acquired a run-down 180-acre farm, one mile from its stack in the direction of the prevailing wind, a farm which had been worked almost continuously since the Mormon settlement without regard to crop rotation or adequate fertilization. Prof. E. W. Ledyard was given charge of this venture, and by proper care, fertilization and drainage he was able to grow successfully over 100 different crop varieties. His studies of the actual SO_2 concentrations led him to the extreme of making determinations at various stations at five-minute intervals for 100 hours. His studies of drainage conditions and ground water were very minute, and led him to maintain that much if not a great majority of the plant bleaching ascribed to smelter smoke was due to improper irrigation or drainage.

Within the last several years the American Smelting & Refining Co. has acted upon the findings of its smoke investigators, headed by Dr. P. J. O'Gara. These conclusions were briefly described in Metallurgical & Chemical Engineering, vol. 17, p. 682 (Dec. 15, 1917). Dr. O'Gara and certain members of his staff by means of experimentation briefly indicated in the article quoted, and illustrated in Figs. 1 and 2, established the standards of plant injury as determined by weather factors and varying concentration of SO_2, and whenever what appeared to them to be actual SO_2 injury occurred they were ready to recommend proper compensation. The logical consequences of these findings involved the construction of a number of improvements at the Murray plant such as the installation of a 455-ft. stack with flues so arranged that it will discharge the smoke from the boiler houses as well as from the roasting depart-

ments. In case the heat derived from this source is not sufficient to insure proper diffusion of sulphur dioxide, an auxiliary coal furnace has been installed at the base of the stack. In conjunction with this device the company has also completed a very fine and efficient Cottrell plant, designed and constructed by its engineer, J. B. McIntosh.

In the decree just issued Judge Johnson notes that conditions at the present time are much better than they were in 1908, but still there was much to be desired in 1916, when the suit was started. He finds that

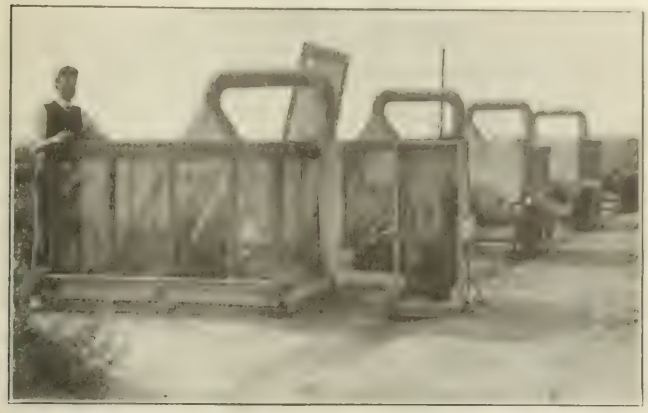


FIG. 2. BATTERY OF CABINETS IN ACTION AT THE A. S. & R. FARM

The cabinets shown are set over the plots when it is desired to fumigate the plants. The light wood frames are covered with thin sheet celluloid, which gives a high light factor. The blower is connected with slip joint to the cabinet delivery pipe, and the volume of air measured by Pitot tube. The SO_2 is measured by a capillary meter shown in the frame above the blower. The temperature and humidity of the air in the cabinets remain essentially the same as the outside air, because of the large volume of air passed through the cabinets. Each blower has a capacity of 10,000,000 c.c. per minute. The cabinets are 6 x 6 x 4 ft. high. In all series of experiments use was made of check cabinets through which air, unmixed with SO_2, was passed. This was for the purpose of checking the light factor.

smoke damage by sulphur dioxide has occurred at many times and many places in Salt Lake Valley in recent years. He also finds that the smelting plants have not at all times been able to control or dilute the sulphur dioxide so as to avoid damage to nearby vegetation. The American Smelting & Refining Co., by its so-called "sea-captain" methods of operation pending completion of the high stack and electrical precipitator, has much more nearly approached perfection—in fact, the Court was able to find no specific case of smoke injury in the Murray zone during the 1916 season. In this system the management recognizes certain optimum conditions of light, temperature, humidity and wind direction, which, when occurring, are bound to cause smoke injury if more than a certain quantity of sulphur is being evolved at that time. By keeping the weather eye out, therefore, the company is enabled to close down certain smelting units (roasters) so as to reduce the actual amount of sulphur evolved during these dangerous times.

Under all of these circumstances the Judge allows operation to continue temporarily, provided that sulphur trioxide or sulphuric acid is neutralized, precipitated or removed to such an extent that "no injurious amount" exists in the gases eventually discharged. All solid products except unconsumed carbon are removed as far as practicable by modern baghouse plants or Cottrell installations, and the resulting fume is resmelted under the same precautions as to smoke and fume which is given the ordinary ore mixture. Sulphur dioxide in the smelter gases at the United States Smelting Co. may not exceed a maximum of 0.75 per cent by volume. On the other hand, the sulphur dioxide analysis on the areas surrounding the American Smelting & Refining Co.'s plant may not exceed an hourly average of one part per million in the growing season of the year, while during the non-growing seasons three parts per million may not be exceeded.

The complaining farmers were awarded $20,000 in costs. The companies are also to bear the expense of a commissioner and his staff appointed by the court to observe smelting operations, to make necessary tests and to propose remedies for smoke nuisances, and to examine complaints, having, together with the smelting companies' agents, full freedom of action and information from both parties to any controversy. Prof. R. E. Swain of Leland Stanford University was appointed commissioner and will make his report to the Judge on Feb. 1, 1921. If Prof. Swain reports and the Court decrees that the methods employed by the American Smelting & Refining Co. will in all probability obviate smoke damage, then the United States Smelting Co. is obligated to take like steps immediately.

Having given the foregoing historical background, some extracts from Judge Johnson's decision will be of interest to those who have been engaged in investigating or fighting smoke damage.

In the case under discussion, the complainants say that sulphur dioxide and sulphur trioxide escape from the smelters and are offensive to the inhabitants, deteriorate wire screens, fencing and metal work, and

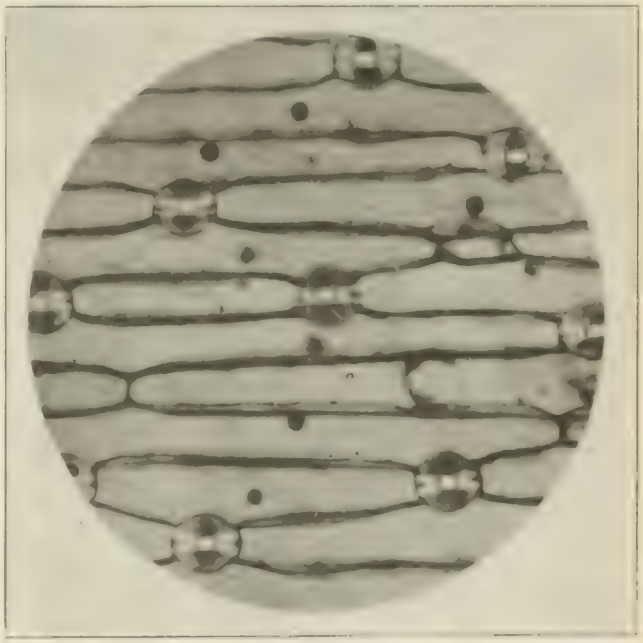


FIG. 3

Stomata or breathing pores of plant leaf, showing open and closed cells. It is through these small openings that gases pass into the leaf. While 100 to 400 stomata may be present on 1 square mm. of leaf surface, there are a few cases where there may be as many as 700. Very young leaves with immature stomata are more resistant to SO_2 and other gases than mature leaves. (Oblique × 175.)

destroy fruit and ornamental trees. Such gases, in connection with arsenic, antimony and zinc compounds, poison crops so that they cannot be used.

On the other hand, the smelting companies contend that no arsenic or sulphur trioxide escapes except when the bags in their baghouses are being shaken, which happens once a day. The amount of noxious fumes

liberated at that time is so small as to be entirely negligible. On the other hand, sulphur dioxide is so diluted by nitrogen and air as to be harmless to animal or vegetable life, and in such quantities is incapable of causing deterioration of metal work.

The Judge finds that practically all sulphur dioxide goes out of the smelters through their main chimneys, except a little "ground gas." In both plants a very efficient smoke-collecting system, flue and baghouse have been installed, which collectively remove all solids from the gas. Sulphur trioxide is sufficiently neutralized by calcium oxide or zinc oxide intentionally introduced into the flues, and thus is converted into solids. Consequently, any damage that is done at the present time is, by exclusion, due to sulphur dioxide.

The evidence shows sharp controversies over the causes of observed plant injury, but a great portion of the evidence was merely a matter of opinion and was of a relative value, being highly influenced by the preconceptions and point of view of the witness. Thus, the plaintiffs and their witnesses were all farmers who were untrained observers and prone to call damage of all sorts "smoke damage," reasoning from conditions which they had observed prior to 1908. They would therefore testify that smoke was responsible even when plant damage was clearly due to other causes. Even the expert witnesses employed by the farmers mistakenly held that leaf injury which looked like sulphur dioxide injury was actually caused by SO_2.

On the other hand, the smelting companies' witnesses were unconsciously biased on the other side—even the farmers who testified for them. The smelting companies' experts often found other sufficient causes than sulphur dioxide to account for all mischief in the smoke zone. However, the testimony of the smelter experts as to fact is far more valuable than other testimony merely founded on opinion.

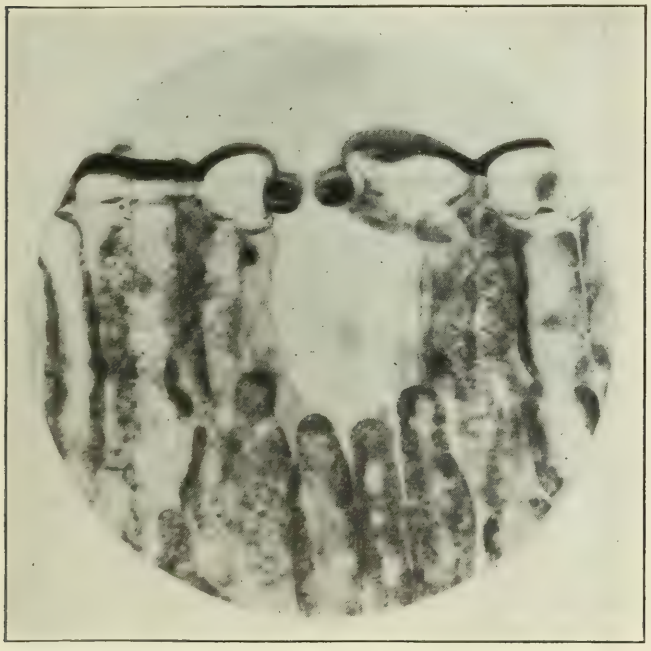


FIG. 4

Cross-section through single stoma or breathing pore of alfalfa leaf. The two guard cells, the sub-stomatic chamber and the palisade cells below and surrounding the chamber are shown. Gases passing through the stoma and into the chamber come into contact with the thin cell walls, and readily diffuse through them into the cells. In this way CO_2 enters the leaf cells and through the agency of light combines with the cell water, sugar being one of the first recognizable products. (O'Gara. × 175.)

The research work of these scientific men has been admirable, and it is unfortunate that the plaintiffs and other farmers of the community have not taken more interest in the experimental farms of the defendants and profited by the information acquired in the operation of said farms and the experiments made at these stations.

Another point in the opinion handed down by the Judge is especially worthy of note and consideration. He says that the experts employed by the American Smelting & Refining Co. have been able to make some settlements with the complaining farmers. Their scientific investigations were of the highest class and their officials were of an open mind. Consequently the settlements which had been made by them tended to establish standards of appearances, circumstances and conditions which evidence injury by sulphur dioxide.

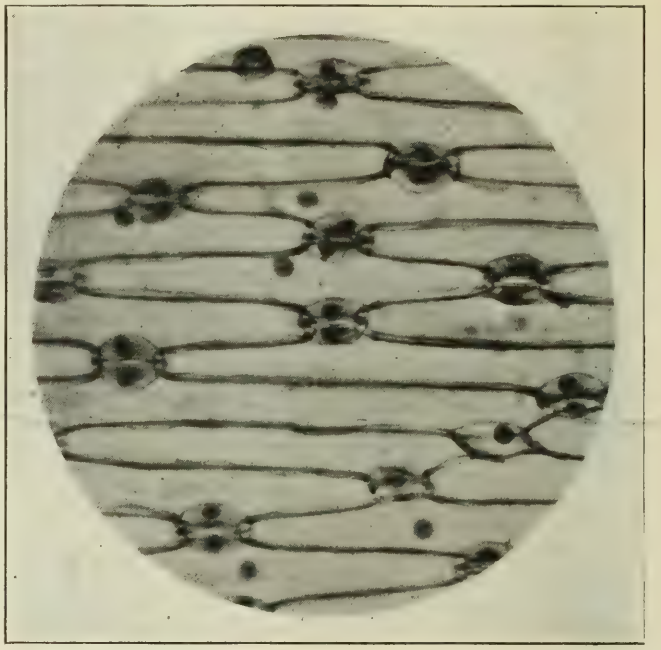


FIG. 5

Stomata or breathing pores of plant leaf, showing closed appearance. In many plants closure takes place in the absence of light, but temperature and relative humidity of the asmosphere are also important factors which govern stomatal movements. The effect of rain drops on foliage is to close the stomata. (O'Gara. × 175.)

Discussing the accepted fact of plant injury by sulphur dioxide, the Judge notes that it is immaterial whether SO_2 is oxidized to SO_3 in the ground, in the air or in the plant tissue itself. The main fact is that under such conditions it actually causes harm to plant life if in sufficient concentration.

He throws out of court, however, analyses showing the sulphur contents of the ground, the plants growing on the ground and momentary quantities in the air. All of these data he feels are too meager for much weight, and sulphur contents in plants might not affect their vitality or their proper use.

> Such a condition evidences a departure from the usual and, perhaps, natural, but the power of adjustment of life to environment is too great to base upon such departure alone the conclusion that it produces a deterioration in the vitality of the plant, or the quality or quantity of yield.
>
> The evidence respecting the effect of the presence of SO_2 or possibly SO_3 in the atmosphere upon wire screening and fencing creates a suspicion that deterioration results, but the evidence is not of that convincing character that I feel would justify a finding in the case to that effect.
>
> The evidence is insufficient to show that the presence

of SO_2 in the atmosphere causes injury to vegetation and plant life, where there is not external evidence of injury appearing in the plant. In other words, the evidence is insufficient to show any invisible injury to vegetation or plant life occasioned by SO_2 acting either through the soil or the atmosphere.

One part of sulphur dioxide to one million parts of air under certain favorable conditions will mark, dry up or bleach foliage of certain non-resistant crops. The skin or bark of growing plants is much more resistant, while young fruit, blossoms, and grain, while it is heading out, are less resistant than the bark, but more resistant than foliage. The effect seems to be that sulphur dioxide passes from the air to the leaf structure through stomata, destroying cell life and drying up the structure in a way which is visibly evident.

Factors Modifying Smoke Damage

"The appearance of SO_2 injury in the foliage of plants and its extent depend upon certain conditions," quoting verbatim the words of Judge Johnson's decision.

"1. The sensitiveness of the plant to SO_2 injury.

"2. The concentration of SO_2 in the atmosphere.

"3. The length of time during which the plant is subjected to SO_2.

"4. The humidity of the atmosphere.

"5. The presence or absence of those conditions which affect or control the opening or closing of the stomata, as light, darkness, heat and cold.

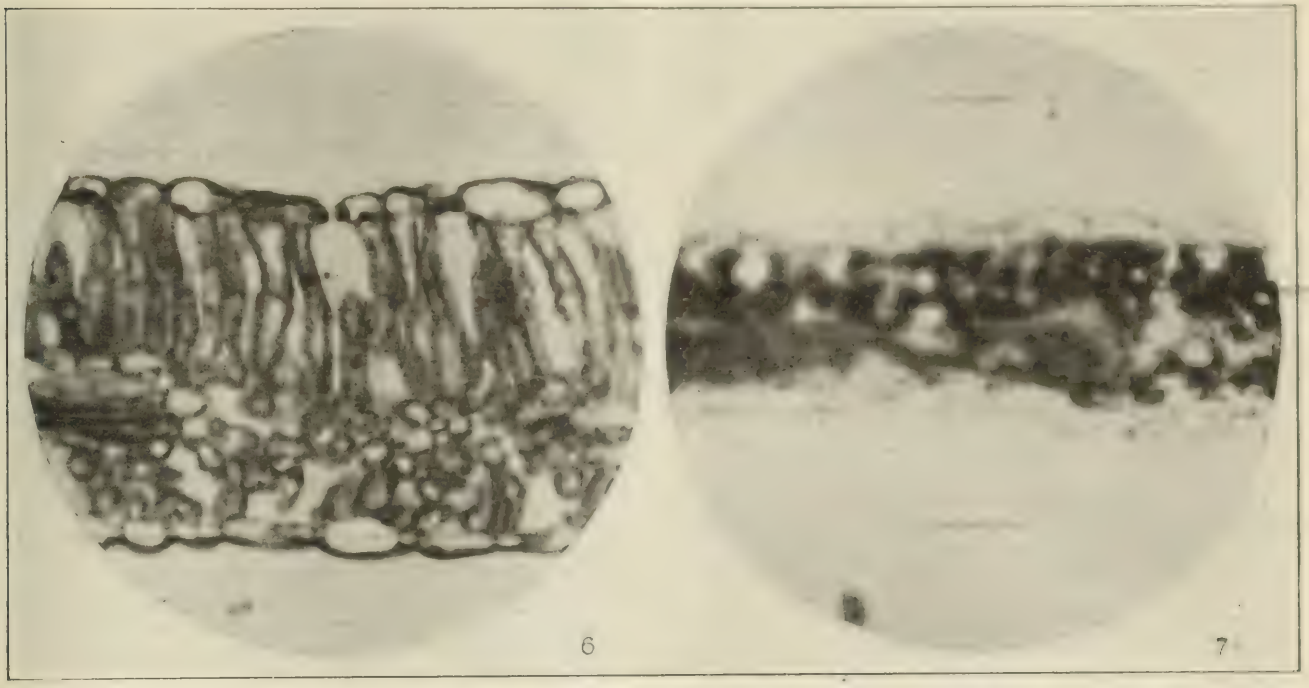
"As a rule SO_2 seems to attack the leaves and foliage at their points and edges, extending into the leaf in proportion to the severity of the injury. The effect of SO_2 injury—that is to say, the markings of the foliage—is observable practically at once. The appearance of the markings of the leaf tends to change somewhat with the lapse of time. The discoloration of the leaves or the appearance of the markings on the leaves resulting from SO_2 injury is not the same in all plants and is not distinguishable from discoloration and markings resulting from many other causes, whether examined by the eye alone or under a microscope, and so far as the evidence discloses there are no structural or chemical characteristics of SO_2 injury which distinguish it from injury by many other causes. Injury caused by frost, sunburn, sun-scald and alkali are among the causes producing leaf injury in every characteristic similar to that caused by SO_2—that is, relatively sudden deterioration, disintegration, and breaking down of the internal cell tissues of the leaf.

"Leaf injury occasioned by insects directly attacking the leaf of the plant is ordinarily readily distinguishable from SO_2 injury. . . .

"Fungous diseases of plants, in many cases, cause leaf deterioration identical with SO_2 injury. These bacterial diseases have each their several characteristics other than leaf deterioration common to them all and to SO_2 injury, and the presence of the characteristics of disease will ordinarily classify the leaf injury as injury resulting from disease and not from the presence of SO_2. . . .

Sulphurous Injury Indistinguishable

"It will be observed that each one of the causes of leaf markings producing injuries identical with and indistinguishable from leaf markings produced by SO_2 has its own peculiar and accompanying factors. For instance, frost is accompanied by a temperature below 32 deg. F., and ordinarily its effect is observed over a relatively large area of country. Sun-scald is accompanied by hot sunshine preceded by irrigation or rain. Sunburn is accompanied by hot weather and lack of



FIGS. 6 AND 7. NORMAL AND INJURED ALFALFA. (O'GARA. × 180.)

Fig. 6 shows cross-section of normal alfalfa leaf with the characteristic cellular appearance or structure. Two stomata, one closed, the other open, are shown in the upper portion of the leaf. The long cells in the upper half are known as palisade cells. Contrast the appearance of the normal structure with that of the injured leaf, Fig. 7, which shows no structure. It is plainly seen that the injured leaf has shrunk to less than one-half its original thickness, as compared with the normal leaf. Fig. 7 shows cross-section of alfalfa leaf after acute SO_2 injury. The cellular structure, as shown in the normal leaf, has practically disappeared. Leaf injury by other gases, fire, frost, drouth and other causes presents the same appearance. There is no distinguishing microscopic picture which will separate one from the other. In all cases the part of the leaf which is injured collapses because the cell water escapes from the injured cells.

moisture. Alkali injury shows on crops in soils containing alkali. Similarly, SO_2 has its accompanying factors—namely, injury from SO_2 always occurs in the path of the wind blowing over and from smelting plant or the stacks from which sulphur dioxide is discharged. . . .

"The lapse of time following an opportunity for injury in any given case is of no aid in distinguishing the cause of the trouble, since under like conditions recovery from the effect of leaf injury caused by sunscald or sunburn, and in some cases alkali, is equally rapid as recovery from injury occasioned by SO_2. . . . It should be noted, however, that in many cases alkali injury persists and is progressive, so that it often happens that a growing crop may show the effect of alkali at first by relatively few and insignificant markings, but these markings, as time elapses, constantly increase in number and extent and persist throughout the growing season.

"The distinguishing factor of SO_2 injury, as already observed, is that it occurs in the path of the wind passing over the smelter. I do not mean to say that it may not occur at times of apparent calm, but in respect to that I think it may be assumed that there is no such thing as absolute calm, or even a practical calm, that extends over any large area for any great length of time. . . .

"Another feature of SO_2 injury distinguishing it from similar markings by other causes is a path or zone of markings showing the course and direction of the gas and which, as above noted, is always in the direction of the wind from the smelter at the time. This path or zone is fan-shaped, increasing in width from the smelter. . . . Yet there are instances shown by evidence of SO_2 injury showing locally and without the accompanying characteristic of a fan-shaped path or zone extending from the smelter, at least observed and traced, and I am led to the conclusion that at times the gas stream is deflected to the ground at points more or less distant from the plant by air currents, with resulting SO_2 injuries. . . .

Economic Loss

"There can be little doubt that SO_2 injury, when occurring at a critical period in plant development, results in economic loss—that is, substantial diminution of crop yield. The tendency of growing crops is to throw off or overcome the injury inflicted by SO_2, or injury caused by any other agent, and the observations of witnesses upon the matter are that markings caused by SO_2 will cease to be noticeable, during the season of rapid growth and development, within a short time, the length of time in any case depending upon the species of the plant affected, the time of year and, generally, upon every factor that promotes or retards plant growth and development.

"The tests made at the experimental farm of the A. S. & R. Co. tend to minimize the economic loss caused by SO_2 injury. There are many factors to be taken into consideration in determining the question of economic loss by SO_2 injury in any particular case.

"Under all the evidence in the case, I am led to the conclusion that SO_2 injury occurring at a critical period in plant developments results in appreciable economic loss. Or, stated another way, SO_2 injury, occurring at a time or under conditions unfavorable to plant development and crop yield, causes more or less economic loss."

Use of Liquid Oxygen as an Explosive

Liquid oxygen as an explosive was first used by the Germans in a coal mine in 1897, following Linde's invention of his liquefying apparatus in 1895. Trials made in the Simplon tunnel are said to have been favorable.

In 1900 Claude of France patented the rectification principle. Linde in 1902 designed his rectification apparatus. Both types of apparatus are extensively employed in liquefying gases. In 1904 Dewar of Great Britain invented the Dewar flask—a container for liquefied gases.

It remained for the war to bring out further developments, and its use was widely extended in Germany during this period. The Allied countries, being able to import nitrates from Chile, did not take up its use, but if the war had continued the United States would probably have been compelled to do so. The use of this explosive commercially will now depend upon its own merits.

Experiments of the Bureau of Mines have shown that a liquid oxygen can be prepared with a blasting strength greater than 40 per cent straight nitroglycerine dynamite. The procedure adopted was to place a No. 6 detonator in the inner cartridge, a cheese-cloth sack containing carbonaceous material. The cartridge is soaked in liquid oxygen ten to fifteen minutes in an improved container devised by the Bureau. The cartridge, frozen stiff, is slipped into a pasteboard container, placed in the hole, a wad of cotton placed on it, a brass tube inserted, and clay tamped around the tube. The hole left by the tube provides an outlet for evaporating oxygen until the shot is fired.

Advantages of this explosive compared with dynamite and black blasting powder are lower cost per ton of material blasted, elimination of dangers in transportation from premature ignition, misfires or unexploded sticks in blast hole, in handling and thawing, or in storage magazines.

Disadvantages are: Liquid oxygen, because of its rapid evaporation, must be used quickly after charging, this limiting the number of shots; the maintenance of a liquefying plant near the mines, and the fact that the explosive cannot be used in gaseous coal mines.

This method offers great possibilities for lessening blasting costs in non-gaseous coal mines, and in metal and mineral mines using a chamber method when only a few shots are fired at one time. The chief cost is that of the oxygen. It is thought that this can be decreased through promised improvements in liquefying machines.

Shipments of Sulphur From Sicily

The export of sulphur from Sicily during 1919 amounted to 147,286 tons, as compared with 231,390 tons in 1918. Of this amount approximately 45 per cent was exported to France, the remainder being shipped to Greece, Turkey, Spain, England and South America. There were no sulphur exports to the United States from Sicily during 1919. The estimated amount of stocks on hand on Dec. 31, 1919, amounted to 136,991 tons.

The production slightly improved in 1919 as compared with the immediately preceding years, but is still far below the pre-war figures. Industrial troubles and fires largely contributed toward curtailing the output last year. The outlook for 1920 is not considered very bright on account of the many industrial, transport and exchange difficulties to be contended with.

Pressure and Temperature Relations for Vapor of Liquids

Derivation of Formulæ Giving the Relations of Vapor Pressures—Boiling Pressure Ratios to the Absolute Temperature—Absolute Boiling Point Ratios From Known Physical Constants—Latent Heat of Evaporation, Molecular Weight and Absolute Boiling Point

By P. B. WILLIAMSON

RECENTLY while working out the design of a cracking process for producing gasoline, it was necessary to have, among several other things, some quantitative idea of the change under different pressures of the boiling points of quite a large number of hydrocarbons—especially of the paraffines. On consulting a number of authorities it was found that very little had been published on the vapor-tension phenomena of those compounds and furthermore that substantially nothing had been done toward determining a general expression involving the pressure on a liquid and the latter's boiling point under that pressure—or, in physicochemical terms, the general relation between the temperature of a liquid and its corresponding vapor tension. A search for information on the subject, including, as it did, correspondence with some of the leading physical chemists and research institutions of America, forcibly brought to mind a statement written by the author several years ago in his physics lecture notes: "No definite law is known (1910) connecting the boiling point of a liquid with the pressure; all we can say in general is that the greater the pressure, the higher the boiling point." It is apparent, however, that if such a law does exist, its application would be extremely valuable: First as a check on experimental work on the vapor-tension variation of liquids; secondly, as a check on the normal boiling point, melting point and density of liquids; and thirdly, for practical determination of the vapor-tension behavior of liquids on which no vapor-tension data have yet been published.

Bertrand's Empirical Formula

In reviewing the literature it was found that Bertrand had investigated twenty-two liquids and found the following equation to be applicable to them:

$$P = G\left(\frac{T_p - \lambda}{T_p - \frac{\lambda}{g}}\right)^g \qquad (1)$$

where

g = 50 for twenty-one of the compounds and 20 for chloroform.

P = pressure in mm. of mercury.

T_p = 274 + pressure boiling point in deg. C.

G, λ = constants peculiar to each liquid.

The use of this formula entails the determination for each liquid of three constants, g, G and λ. In order to simplify the expression the first step made was to modify (1) so as to give the pressure in atmospheres, to do which the following analysis rapidly ensued:

$$P \div p = \text{a constant, } c \qquad (2)$$

where p = pressure in atmospheres, 760 mm.

Then from (1) for p_n = normal pressure, 1 atmosphere

$$c = P_n = G\left(\frac{T_b - \lambda}{T_b - \frac{\lambda}{g}}\right)^g \qquad (3)$$

where T_b = normal b.p. (abs.) of the liquid.

Substituting (3) in (2) and then multiplying through by p gives

$$P = pG\left(\frac{T_b - \lambda}{T_b - \frac{\lambda}{g}}\right)^g \qquad (4)$$

Whence, from equating the identities (1) and (4) and solving for T_p, we get

$$T_p = \frac{\lambda}{1 - \frac{T_b - \frac{\lambda}{g}}{T_b - \lambda}\sqrt[g]{p}} \qquad (5)$$

from which the constant G has thus been eliminated.

Bertrand reckoned from an absolute zero of —274 deg. and obtained the values of λ enumerated in the table given in sec. 5, p. 520, vol. 1, of Castell-Evans' "Physico-Chemical Tables" (Griffin, London, 1902-11). For an absolute zero of —273.1 deg. those values must be modified accordingly.

Vapor Tension Constant Expressions

Having derived equation (5) it was decided to determine whether there exists a definite relation for each compound between its "vapor-tension constant," λ, and certain of its properties, such as melting points, boiling points, densities and molecular weights.

It is hardly necessary to state that considerable disagreement arises in several instances as to the value assigned to the various properties, such as, for example, the melting point of CO_2, the boiling points of H_2S, CH_3Cl, etc., and on various densities. Naturally the densities must be reduced to some standard; which was taken as 273.1 deg. abs.

Omitting quite a lot of detail, it would appear that λ is given by an equation, say, of the form

$$\lambda = \alpha T_b^{\beta} T_m^{\gamma} d^{\delta} (\log W)^{\epsilon} \qquad (6)$$

in which the coefficient α and the exponents β, γ, δ and ϵ are probably universal constants. The most probable values of these constants may be found from a large number of liquids (using the most positive values of their properties) by solving by the method of least squares the following equation:

$$\log \lambda = \log \alpha + \beta \log T_b + \gamma \log T_m + \delta \log d + \epsilon \log \log W \qquad (7)$$

Not having good facilities for the immense amount of calculation the above method involves, nor the opportunity of determining the correct data needed therefor, no attempt has been made to derive the above constants precisely. It will be shown, however, that a general formula for λ can be found involving only the

comparatively well-known constants of the specified liquid—if not of the form just suggested, yet of some other type of algebraic expression.

According to Bertrand, in his equation (1), for chloroform $g = 20$ and $\lambda = 120$. But using equation (5), for chloroform $g = 50$, as with the other liquids investigated by Bertrand, and $\lambda = 61.6$, which agrees with (6) within the limits of error of the data used. Furthermore, approximate calculations on a large number of compounds picked out at random from the vapor-tension tables in Castell-Evans, pp. 451-523 (vol. 1), considering the limits of error established by the agreement of the authorities quoted therein, make it appear that Bertrand's constant $g = 50$ is probably universal.

The constant λ may be experimentally determined for liquids having no published vapor-tension tables. Thus, rearranging (5) and putting $g = 50$, we get

$$\lambda = \frac{T_p T_b (\sqrt[50]{p} - 1)}{T_p \sqrt[50]{p} - T_b} \qquad (8)$$

When the pressure is normal ($p = 1$ atmosphere), then $T_p = T_b$, and those values substituted in (8) give $\lambda = 0 \div 0$ (indeterminate). Neither by rearrangement nor by successive differentiation of the numerator and denominator of the right-hand side of (8) can the indeterminate form be got rid of. That fact can be proved mathematically, but the proof is too long for inclusion here; and, anyhow, it is apparent that any reduction of (8) to normal pressure will give the constant λ in terms of the normal boiling point T_b. That λ does not depend upon T_b alone readily shows from even a casual inspection of the table. However, by finding a number of boiling points for different pressures (other than normal) a mean value of λ follows from (8).

Degree of Precision of Application of λ

Remarking further on positiveness of tables: Probably the most reliable vapor-tension table given in Castell-Evans is that for water, on p. 461 (vol. 1). Substituting pairs of corresponding values from that table in equation (8) shows that the different values of λ thus obtained do not coincide. Thus, for example,

p	T_p	λ
10	453.41	78.41
50	537.67	78.35
170	625.1	78.94

Since the values of λ thus calculated do not vary uniformly with the pressure p (as they should do, were there any theoretical variation), but, rather, "oscillate," it follows that the thermometry of the table is not exact. In the same manner and, it is reasonable to suppose, on the same account the values of λ calculated from the tables for other liquids vary according to the positiveness of the thermometry involved.

Bertrand's value for water of λ, referring to absolute zero as —274 deg., is 78.3. That value referred to an absolute zero of —273.1 deg. becomes 78.112. By striking a mean among the values calculated back from the table for water by (8), we get $\lambda = 78.5$. The same order of difference applies to λ for those of the other liquids checked. It would appear, then, that Bertrand's values need revision. For engineering calculations, however, all of the variations mentioned so far may be overlooked.

In conclusion, referring to equation (19) it follows the following relation should hold:

$$\lambda = 0.0081 W L_b \qquad (19a)$$

More or less empirical methods have been tried above, deriving expressions involving a constant to be found for each liquid either by experiment or by possibly evolving a general equation for the constant itself. As the first determination, for authoritative purposes, would require considerable laboratory work and the second determination might entail no less and probably much more labor for the theoretical chemist, it seemed desirable to approach the subject from another angle, with the rather astonishing results below.

BERTRAND'S λ TABLE

Substance	Formula	λ	T_m	T_b	W	Log W	d
Carbon dioxide	CO_2	35	195	217	44	1.6435	1
Hydrogen sulphide	H_2S	37.1	188	212	34.1	1.5326	0.88
Ammonia	NH_3	46.7	195	235	17	1.2313	0.623
Cyanogen	(CN)	47.3	239	252	26	1.4151	0.88
	$(CN)_2$	...	...	...	52	1.7162	...
Boron trichloride	BCl_3	48.8	...	291	117.4	2.0696	1.434
Sulphur dioxide	SO_2	49.5	197	263	64.1	1.8067	1.434
Ethyl chloride	C_2H_5Cl	50.5	132	293	64.5	1.8096	0.921
Cyanogen chloride	(CN)Cl	53.1	255	289	61.5	1.7887	1
Carbon disulphide	CS_2	54.8	163	319	76.1	1.8816	1.292
Ethyl bromide	C_2H_5Br	55	157	312	109	2.0373	1.45
Ethyl ether	$C_2H_5OC_2H_5$	55.4	156	308	74.1	1.87	0.73
Silicon tetrachloride	$SiCl_4$	57.9	184	332	170.1	2.2308	1.524
Ethyl iodide	$CH_3.CH_2I$	60.6	165	345	156	2.193	1.96
Phosphorus trichloride	PCl_3	61.6	161	349	137.4	2.1381	1.613
Chloroform	$CHCl_3$	61.6	210	335	119.4	2.077	1.526
Carbon tetrachloride	CCl_4	61.7	248	350	153.8	2.1871	1.6
Methyl alcohol	CH_3OH	71.5	179	340	32	1.5056	0.81
Ethylene bromide	$CH_2Br.CH_2Br$	72.9	283	405	187.9	2.2739	2.1
Ethyl alcohol	C_2H_5OH	76	161	351	46.1	1.6632	0.81
Pinene	$C_{10}H_{16}$	76.8	...	429	136.1	2.134	0.89
Water	H_2O	78.3	273	373	18	1.2557	1
Acetic acid	$CH_3.COOH$	78.6	290	391	60	1.7784	1.03
Sulphur	S	135	390	717	32.1	1.5061	2
	S_2	...	...	...	64.1	1.8071	...

Differential Relations

Consider the unsaturated vapor of a pure liquid: From the standpoint of differential relations, it seemed possible that a general solution might ensue from the familiar linear equation always coming up when dealing with "single-energy" effects, viz.:

$$\frac{dT}{dp} + X_1 T = X_2 \qquad (9)$$

where X_1 and X_2 may or may not involve p.

The standard solution of (9) is

$$T = e^{-\int X_1 dp} \cdot \left(\int X_2 e^{\int X_1 dp} \cdot dp + C\right) \qquad (10)$$

where e is the Napierian base and C is an integration constant dependent upon the terminal conditions of the problem.

From the nature of the problem the standard solution (10) calls for any of three combinations, viz.; X_1 and X_2 both involve p; X_1 is a constant and X_2 involves p, and X_1 involves p and X_2 is a constant. The simplest choice is the last. Now the curve plotted between absolute temperatures as ordinates and corresponding pressures as abscissæ theoretically is parallel to the axis of abscissæ when the pressure is infinite; *i.e.*, when $p = \infty$ then $dT \div dp = 0$ and $X_1 T = X_2$. But if X_1 involves p in a certain way then $0 = X_2$ when $p = \infty$, or by the third assumption X_2 is constantly zero; which reduces (10) to

$$T = Ce^{-\int f(p) \cdot dp} \qquad (11)$$

Since the temperature of the liquid has only a theoretical value when the vapor pressure of the liquid is zero, consideration of the terminal conditions as those when p is zero takes us rather too much into the abstract. It is more convenient to consider the integration-constant reference conditions as those under the

normal pressure of one atmosphere; thus obtaining from[1]

$$T_p = T_b\, e^{\tau(p^\zeta - 1)} \qquad (12)$$

where

T_p = temperature of the liquid (absolute C.)
T_b = normal boiling point (abs.) of the liquid
T_p = vapor tension of the liquid in atmospheres
τ, ζ = constants peculiar to each liquid.

Upon applying (12) to over 125 liquids for which the writer had to hand vapor-tension tables, it was found that while $\zeta = \frac{1}{9}$ (approx.)[1] for all of those liquids, on the other hand, τ varied from $\tau = 0.567$ for arsenic trioxide to $\tau = 2.17$ for liquid helium, with an average around 0.8.

Solution of the Vapor Tension Constant Tau

The difficulty with indeterminate forms is met with upon attempting to evaluate τ from (12). But, taking another tack (cf., e.g., "The Principles of Physical Chemistry," by E. W. Washburn, 1st ed., 1915, McGraw-Hill, N. Y., Chap. XII., esp. secs. 1, 2, etc.) this obstacle may be avoided by the use of the well-known expression

$$\left(\frac{\delta p}{\delta T}\right)_{p_1, x} = \frac{L_v}{v_0 T} \qquad (13)$$

where

L_v = molal heat of vaporization of the liquid
v_0 = molal volume of the liquid in the vapor state under conditions p_1, x.

For a theoretically perfect vapor (13) is integrated by

$$\ln \frac{p_1}{p_2} = \frac{L_v}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad (14)$$

in which

ln = natural logarithm
R = the universal gas constant dependent only upon the units employed.

Now if we put $p_1 = p$, $p_2 = 1$ atmosphere, $T_2 = T_b$, and $T_1 = T_p$ in (14), then

$$\ln p = \frac{L_v}{R}\left(\frac{1}{T_b} - \frac{1}{T_p}\right) \qquad (15)$$

But L_v varies with the temperature in the same manner but in different degree for each liquid and, therefore, introduces the necessity for its positive determination accordingly—as a general rule quite a task within itself. But by considering differential increments Δp and ΔT as added, respectively, to the normal pressure and boiling point, it may be written

$$\left.\begin{aligned} p &= 1 + \Delta p = p_\delta \\ T_p &= T_b + \Delta T = T_\delta \\ L_v &= L_{v_b} \end{aligned}\right\} \qquad (16)$$

But

$$L_{v_b} = WL_b \qquad (17)$$

where

L_b = latent heat of vaporization (say, in calories per gram) at the normal boiling point of the liquid.
W = molecular weight of the liquid.

The last assumptions, then, transform (15) into

$$\ln p_\delta = \frac{WL_b}{R}\left(\frac{1}{T_b} - \frac{1}{T_\delta}\right) \qquad (18)$$

which rearranged gives

$$T_\delta = 1 \Big/ \left(\frac{1}{T_b} - \frac{R}{WL_b} \cdot \ln p_\delta\right) \qquad (19)$$

Now from (12)

$$\tau = \frac{\ln (T_p \div T_b)}{p^\zeta - 1} \qquad (20)$$

Substituting (19) in (20) gives

$$\tau = \frac{1}{p^\zeta - 1} \cdot \ln \left(1 - \frac{RT_b}{WL_b} \cdot \ln p_\delta\right) \qquad (21)$$

The smaller the value assigned to Δp, the more accurate is the relation (21) and, at the same time, the closer to an infinitesimal[2] is $\ln p_\delta$. Hence, taking advantage of the expansion

$$\ln(1 - x) = -x - \tfrac{1}{2}x^2 - \tfrac{1}{3}x^3 - \tfrac{1}{4}x^4 - \ldots\ldots \qquad (22)$$

the terms beyond the first on the right-hand side may be disregarded and thus enable us to reduce (21) to

$$\tau = R_1 \frac{T_b}{WL_b} \qquad (23)$$

where R_1 involves R and ζ, which are practically the same for all the liquids investigated. Checking (23) against water, mercury, ether, etc. (in fact, against over fifty liquids, and solids and gases in the liquid state), gives the almost exactly general value $R_1 = 17.42$ (slide rule); that is,

$$\tau = 17.42 \frac{T_b}{WL_b} \qquad (24)$$

an expression involving only the comparatively better known constants of a liquid—the normal boiling point, the molecular weight, and the latent heat of vaporization (at normal b.p.) of the liquid.

A General Vapor Tension Temperature Law

The foregoing analysis gives a basis for the statement that: The temperature of a liquid varies with changing vapor tension according to the logarithmic law; the natural logarithm of any particular temperature (absolute) being equal to a known function of the vapor pressure, plus the natural logarithm of the normal boiling point, or, algebraically

$$T_p = \text{illn}\left[17.42 \frac{T_p}{WL_b}(\sqrt[9]{p} - 1) + \ln T_b\right] \qquad (25)$$

or, using common logarithms,

$$T_p = \text{illog}\left[7.56 \frac{T_p}{WL_b}(\sqrt[9]{p} - 1) + \log T_b\right] \qquad (26)$$

By rearranging (26) an expression for vapor pressure (atmos.) is obtained (27)

$$p = \left[1 + 0.1325 \frac{WL_b}{T_b}(\log T_p - \log T_b)\right]^9 \qquad (27)$$

and for latent heat (calories per gram at normal b.p.) in (28)

$$L_b = 0.1325 \frac{W}{T_b}(\log T_p - \log T_b)(\sqrt[9]{p} - 1)^{-1} \qquad (28)$$

Since the pressure on a liquid is equal in magnitude to the vapor tension (pressure) of the liquid when boiling under that pressure, equation (26)—or (25), or

[1] Thus corresponding to the linear equation $\frac{dT}{dp} - \frac{\tau}{9} p^{\frac{8}{9}} T = 0$

[2] of a higher order than $p^\zeta - 1$

(12) with (24)—arrives at an answer to the question often asked in practice:

"What will be the boiling point of so-and-so when the pressure on it is increased or decreased to such-and-such a value above or below normal?"

Cracking-process engineers, among others, will quickly recognize the query. In applying (26) to petroleum, however, Dalton's Law of Partial Pressures must be considered. In fact, the application to any mixture, whether a constant-boiling one or a fractional-distillation one, supplies enough material for another paper on the subject.

Equation (27), inversely, arrives at conclusions regarding pressures—coming up, say, in superheating problems, etc.

Equation (28) might lead to another method for checking the latent heat of vaporization at the normal boiling point. By experimenting upon a substance whose latent heat determination presents especial difficulty by former methods, a table of temperatures and corresponding pressures may be developed (for the sake of obtaining a mean), and therefrom the value of L_b computed by (20).

Going further, if a substance should present itself and its latent heat and a table similar to that just mentioned can be found, then the molecular weight of the substance directly follows from (28) as

$$W = 7.56 T_b L_b (\sqrt[9]{p} - 1)(\log T_p - \log T_b)^{-1} \quad (29)$$

From Berthelot's equation (cf. Washburn, *loc. cit.*, Chap. II, p. 36, etc.)

$$W = DRT_b \left[1 + \frac{9T_c(T_b^2) - (6T_c^2)}{128 p_c T_b^3}\right] \quad (30)$$

where

D = density of vapor at normal b.p.
T_c = critical temperature (abs.)
p_c = critical pressure (in atmospheres)
R = the gas constant (dependent upon density unit employed).

From (30) there may be obtained an equation for T_c, the critical temperature, or for p_c, the critical pressure, which in connection with (26) or (27) gives a check on either of those properties of a substance. The equations are rather involved—yet worse things could be encountered. It is hardly necessary to state that any property sought in one of the above ways should depend only upon data from other sources, and not upon values previously found by (26) or its modifications.

Appended herewith is a table showing, within the limits of error or of agreement of the data consulted, the remarkably close toeing-to-the-mark of enough substances to justify the above theoretical conclusions. For quite a number of substances no latent-heat figures could be found in references at hand; in which cases, for the purpose of comparison, the latent heat was computed by Trouton's Rule, viz.:

$$\frac{WL_b}{T_b} = \tau_1 \text{ (a constant)} \quad (31)$$

where τ_1 is the same for similar liquids. Referring (31) to (24) shows that

$$\tau = 17.42 \div \tau_1 \quad (32)$$

Application of the Relationships

Discussing the general results of the application of the formulæ, it must be said at the outset that they checked much better than had been anticipated. Only three really glaring departures occur—those of formic acid, acetic acid, and acetic anhydride. But it is to be noted that τ approaches 0.75 from the tables for those three; which is following Trouton's assumption. Also, according to Trouton's Rule, if the latent heats of the three variants are correct as given, then the acetates and the formates should also prove exceptional; but those last, as seen, are among the best performers. Only one latent-heat reference each for formic acid and acetic anhydride could be found; but no less than three widely different values (all at the b.p., of course) were in evidence for acetic acid. Until something more definite regarding the latent heats of those discrepant liquids is forthcoming, the writer feels justified in believing that some peculiar difficulty is attached to the determination of that property of theirs.

The latent-heat data on sulphur were also hopeless (as is usual with $S_?$), and that particular instance was dismissed with the "stroke" of using for S_2 the Trouton Number (τ_1) of O_2.

The propionates, butyrates and volerates appear a little irregular, but a reasonable doubt may be cast upon the thermometry of the tables consulted for them, as well as upon the latent heats given.

In numerous instances of iso-compounds τ is checked better by the formula if the latent heat of the corresponding normal compound be substituted therein.

Only in two or three instances did there seem to appear any tendency to stray away from the value $\frac{1}{9}$ for ζ (in which cases the thermometry was clearly equivocal). The value of ζ begins to change, however, near the melting point. For example, $\zeta = \frac{1}{9}$ for water from 50 deg. (cf. K. & L., p. 40) to the critical temperature. Below 50 deg. ζ changes. That was to be expected from the fact that the present analysis assumes an unsaturated vapor.

Some of the rather pleasing results obtained are the apparent agreement of the gases of extremely low boiling point, of niton (radium emanation), and the figures for arsenic trioxide. The last is a subliming substance, and no boiling point has been found for it heretofore. A theoretical boiling point was, therefore, deduced for As_2O_3 by determining τ from simultaneous equations, thus:

$$\tau = \frac{\ln T_p - \ln T'_p}{\sqrt[b]{p} - \sqrt[9]{p'}}. \quad (33)$$

Then, having τ, the theoretical value of T_b is obtainable from (12); proving to be 650.1 deg. abs. or 377 deg. C. Using that value gives the proper agreement, and the check for τ (against $AsCl_3$) is very close, considering. But what to do with carbon dioxide is a question.

The desirability of using the most positive data obtainable should be emphasized, or in the case of having several authorities, of striking a most probable mean (if necessary, drawing an average curve), it being also advisable, when a lone table is in doubt, to plot a curve which will show whether or not the tabulated data give all points on or very nearly on a smooth curve: e.g., plot a curve between x = mm. and $y = t$ from the table cited for m-amidoxylene. In the heading (p. 42) to their vapor-tension tables Kaye and Laby advise caution: "The thermometry is in many cases somewhat dubious."

Some of the earlier investigators performed monumental labors in producing tables and in working out interpolation formulæ; yet more modern workers, notably Ramsay and Young, with advantage of more

refined methods and apparatus and using stricter criteria, have obtained results that in quite a number of instances, especially at extreme pressures and temperatures, differ very appreciably from those of their predecessors. But it is wonderful, indeed, how much, aside from laying foundations, those searchers of the middle nineteenth century accomplished!

No attempt, therefore, has been made to give long-drawn-out accuracy either to the numerical values in the foregoing equations or to the figures in the table, owing, as just explained, to certain doubts about single-source data and to the disagreement, sometimes close, sometimes wide, of the authorities consulted for multiple-source data. The main thing is a desire to point out that here is a case wherein all liquids—whether mercury, sulphur, cadmium, xenon, water, ether, alcohol, normal compounds, iso-compounds, or what not—apparently follow the same law; which, naturally, leads one to believe that similar general laws exist for other property variations (or for the properties themselves) —such as, for example, variation with temperature of latent heat of vaporization, of viscosity, etc.

Calculations With the Williamson Formula

By Wallace Savage

Some months ago Mr. Williamson contributed his modification of Bertrand's empirical vapor pressure formula in editorial correspondence. Publication of it was withheld until the present time because it did not seem to offer sufficient aid to the overburdened-with-computations engineering profession. However, a new formula, as subsequently developed, can readily be worked with by means of a ln-log slide rule or an alignment chart having similar scales together with a special ninth root scale. Such a chart was designed by the writer and is included herewith.

Upon inspection of it, the reader will observe first the three equidistant scale lines X, Y and Z. Z and X are simple 6-in. log scales and Y has a log scale unit one-half as long, the initial points of the units being in line (1.00, 100 and 100). It is mathematically evident[1] that any straight line connecting an X number with a Z number will give the product of the XZ numbers on Y. Thus, 150 connected with 2 intercepts 300 on Y.

In the formula $\tau(P^{\frac{1}{8}} - 1) = \ln T/T_B$, the values of tau, being simple, are assigned directly to the Z scale. Values of the expression $(P^{\frac{1}{8}} - 1)$ are then computed and scaled at any convenient intervals above X on the the three lines 1, (Values of P 1.002 — 1.02 and 0.998 — 0.098 atmospheres); 2, (1.2 — 2.0 and 0.98 — 0.50) and 3, (1.2 — 100 and 0.83 — 0.005). Thus on the third line, 2 atm. and its reciprocal 0.5 are placed at $(2^{\frac{1}{8}} - 1)$ or $(1.08 - 1) = 0.080$, or 80 as expressed in the X scale units. Ln T/T_B are then scaled in a similar manner over Y on the three lines 1, 2 and 3 so as to be equidistant from Z and the corresponding P lines. Thus four separate alignment charts are obtained in a stack having the Z scale in common.

Upon making many calculations on liquids having known vapor pressures, it was found that the formula was very accurate at temperatures above the boiling point. Very large relative errors were found at lower temperatures, making it seem necessary to vary zeta or tau of the original formula. The latter seemed the more logical because tau is inversely proportional to W, the molecular weight of the liquid, which increases with polymerization, and L_B, the latent heat of evaporation, which also increases. The following data on water and benzol may be taken as typical:

WATER $T/T_B = T$ 373

Deg. C.	370	250	200	150	79	40	20	0
T/T_B	1.72	1.40	1.27	1.13	0.92	0.84	785	732
Press. Atm.	207	39.1	15.3	4.85	507	073	023	006
Cal. Tau	0.67	0.67	0.67	0.67	0.67	0.62	0.47	0.43

BENZOL $T/T_B = T$ 353.4

T/T_B	1.49	1.35	1.20	976	0.89	833	776
Press. Atm.	29.3	14.0	5.70	0.72	238	048	033
Cal. Tau	0.89	0.89	0.89	0.65	0.67	0.63	0.57

Thus readings for water on the chart are correct with tau at 0.67 on Z for all points connecting it with the T (1) — P (1), T (2) — P(2) and T(3) — P(3) scales excepting from 0.30 to 0.005 on the lower side of P(3). However, if a point opposite 0.71 and one-third distant to the T(3) scale is taken, it will be found to determine these lower temperature ratios and pressure readings to a fair degree of accuracy.

The reader is cautioned not to get his scales mixed, bearing in mind that he has four separate and distinct alignment charts, the T and P scales of which have reciprocals, which are always to be used together. The X, Y and Z chart is given for use in the simple multiplications and divisions required in calculating millimeters, absoulte boiling fraction temperatures, etc.

The table of constants included here has two tau values, the first as determined empirically from known vapor pressures and the second from the substitution of L_B in the formula for tau. Where molecular dissociation occurs, the values of tau tend to increase greatly. To make the formula and chart 100 per cent reliable, it will be necessary to have empirical tau values throughout the entire range of temperature to be considered.

Problem Solutions

What is the vapor pressure of mercury at 450 deg. C.? The absolute temperature is first found by adding 273, giving 723 deg. for T_p. Upon looking through the constants of the elements in the first column, the absolute boiling point of mercury is found to be 630 deg. and tau 0.80. The ratio of T_p to T_B is then found to be 1.15 by aligning 630 on X with 723 on Y and taking the point of intersection on Z of this line. The pressure is then found by aligning 0.80, the value of tau, on Z with 1.15 on T(3), the point of intersection on P(3) giving the pressure as 4.4 atmospheres. This is readily converted to millimeters of mercury by aligning 760 on X with 4.4 on Z, giving a line that intersects Y at 3340. Upon looking up the determined mercury vapor pressures in Landolt and Börnstein Tabellen, page 376, five values are given as follows:

Regnault	450 deg. C.	3281.4 mm
Hertz		3429
Ramsay & Young		3296.1
Jewett		3450
Young		3395

If it had been desired to know to what temperature mercury would have to be heated to give a pressure of 10 atmospheres, the procedure would be: Align 10 on P(3) with 0.80 on Z and read 1.255 on T (3). Align 630, the T_B of mercury, on X with 1.255 on Z and read 790 on Y. Then 790 minus 273 gives the temperature as 567 deg. C.

In conclusion, it may be well to point out that the three P scales could have been made to read in any pressure units directly. The T scales can be scaled for any given boiling point liquid, thus forming a direct reading graphical chart of vapor pressures.

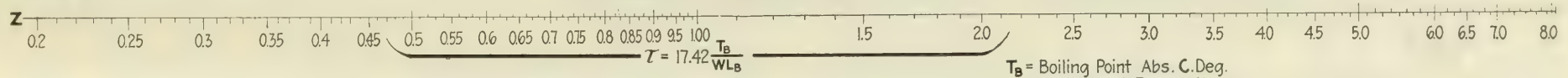
[1] For a geometrical proof and discussion, see Lipka, Graphical and Mechanical Computations, p. 45.

WILLIAMSON FORMULA CONSTANTS AND AN ALIGNMENT CHART FOR GRAPHICAL COMPUTATION

	T_B	τ	τ_L	L_B
Hydrogen	20	1.4	1.4	123
Sodium	1,150	1.1	.....	.....
Potassium	1,030	.....	0.78	592
Magnesium	1,390	.....	.....	.....
Aluminum	2,470	.....	.....	.....
Tin	2,540	0.7	.....	.....
Lead	1,800	0.8	0.80	450
Bismuth	1,690	.....	0.60	234
Arsenic	890	0.55	.....	.....
Phosphorus	560	1.1	0.60	130
Nitrogen	79	0.96	0.96	50
Oxygen	90	0.85	0.84	58
Sulphur	717	0.84	0.84	232
Chlorine	239	0.86	0.88	67
Bromine	332	0.80	0.80	45.6
Iodine	458	0.79	0.80	39.4
Manganese	2,170	.....	.....	.....
Chromium	2,470	.....	.....	.....
Iron	2,720	.....	.....	.....
Copper	2,580	0.65	.....	.....
Zinc	1,180	0.77	0.80	401
Silver	2,230	0.71	0.77	480
Cadmium	1,040	0.80	0.80	203
Gold	2,800	0.79	0.78	318
Mercury	630	0.80	0.80	68
Water	373	0.67	0.67	537
Hydrogen sulphide	211	0.85	0.86	126
Hydrochloric acid	190	0.77	0.74	122
Hydrobromic acid	204	0.84	.....	.....
Hydriodic acid	238	0.87	.....	.....
Ammonia	240	0.74	0.72	341
Nitrous oxide	183	0.85	.....	.....
Nitric oxide	123	0.66	.....	.....
Nitrogen tetroxide	295	0.54	.....	.....
Nitrogen pentoxide	320	0.80	.....	.....

	T_B	τ	τ_L	L_B
Arsenic trioxide	650	0.57	.....	.....
Sulphur dioxide	263	0.76	.....	.....
Phosphorus trichloride	349	0.85	0.85	52
Arsenic trichloride	403	.....	0.56	70
Boron trichloride	291	0.85	0.85	51
Silicon tetrachloride	331	0.85	0.85	40
Tin tetrachloride	387	0.85	0.85	30
Mercuric chloride	576	0.65	.....	.....
Mercurous chloride	656	0.54	.....	.....
Nickel carbonyl	316	0.85	.....	.....
Methane	108	0.9	0.88	134
Ethane	188	0.9	0.88	124
Propane	228	0.9	.....	.....
Butane	274	0.89	.....	.....
Pentane	309	0.88	0.99	75
Isopentane	301	0.85	0.88	85
Hexane	342	0.85	.....	.....
Heptane	371	0.84	0.87	74
Octane	398	0.82	.....	.....
Decane	446	0.76	.....	.....
Ethylene	170	0.78	.....	.....
Acetylene	188	0.83	0.83	153
Methylalcohol	338	0.68	0.68	269
Ethylalcohol	351	0.64	0.64	206
Propylalcohol	370	0.66	0.65	164
Isobutyl alcohol	381	0.66	0.65	137
Isoamyl alcohol	403	0.66	0.66	120
Methyl chloride	249	0.84	0.88	96
Chloroform	334	0.83	0.83	59
Carbon tetrachloride	350	0.85	0.85	46
Ethyl chloride	287	0.84	0.84	92
Trichlorethane	347	0.82	0.82	55
Dichlorethylene	420	0.77	0.77	57
Pentachlorethane	435	0.82	0.82	46
Hexachlorethane	458	0.77	0.77	44

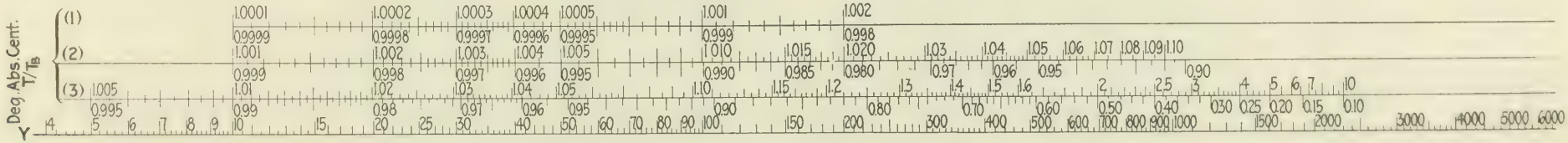
	T_B	τ	τ_L	L_B
Chlorbenzene	405	0.84	0.84	75
Brombenzene	429	0.84	0.84	56.5
Bromnaphthalene	554	0.79	.....	.....
Ethyl bromide	311	0.85	0.85	58.6
Ethylene bromide	405	0.85	0.85	43.8
Bromal	447	0.76	.....	.....
Ethyl iodide	345	0.82	0.82	47
Iodobenzene	462	0.82	0.82	48.2
Fluorbenzene	358	0.85	0.84	77
Cyanogen	252	0.79	0.73	115
Cyanogen chloride	289	0.75	0.74	110
Carbon disulphide	318	0.86	0.86	85
Ethyl ether	308	0.84	0.84	87.5
Acetone	330	0.79	0.79	125
Ethyl acetate	350	0.80	0.80	86
Proplyl acetate	374	0.84	0.84	76
Etnyl butyrate	393	0.78	0.81	71.5
Benzene	353.4	0.825	0.825	95.5
Toluene	384	0.81	0.861	84
o-xylene	415.6	0.8	0.864	79
m-xylene	412	0.8	0.864	78.3
p-xylene	410.5	0.8	0.864	78
Nitrobenzene	481	0.778	0.751	90.5
o-nitrotoluene	493	0.77	0.751	83.3
m-nitrotoluene	497	.....	0.751	84
p-nitrotoluene	512	0.77	0.751	86.5
m-nitroxylene	517	0.77	0.751	78.4
Aniline	457	0.75	0.751	113.9
o-toluidine	472	0.77	0.751	102
m-toluidine	476	0.72	0.751	103.1
p-toluidine	475	0.77	0.751	102.7
m-amidoxylene	491	0.77	0.751	94
Phenol	456	0.70	.....	.....
Naphthalene	491	0.75	.....	.....
Anthracene	624	0.75	.....	.....

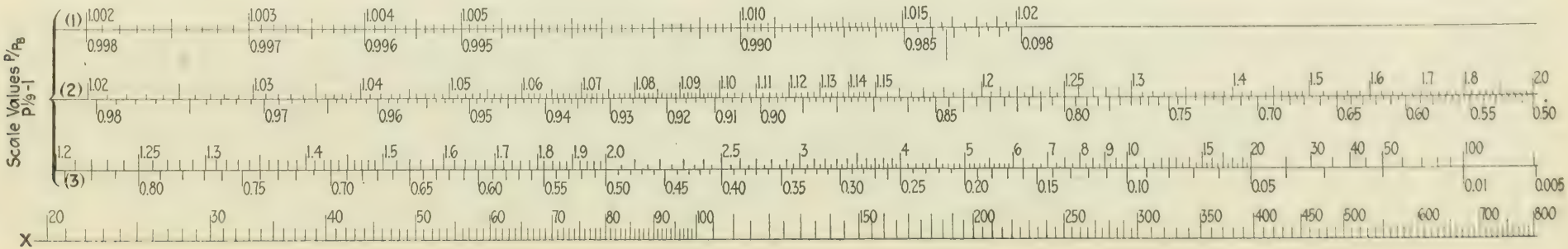


T_B = Boiling Point Abs. C. Deg.
L_B = Latent Heat Evaporation
W = Molecular Weight
P = Pressure in Atmospheres
e = 2.718, Natural Log, Base

Vapor Pressure - Temperature Alignment Chart

Based on Formula $\frac{T}{T_B} = e^{\tau(P^1/_9 - 1)}$





Copper and Magnetite in Copper Smelter Slags—II

Chemical and Microscopic Examination of a Series of Representative Slags, Showing How Copper Losses Occur, the Relation of Magnetite to Copper Loss, the Behavior of Converter Slags in Reverberatory Furnaces and Suggestions for Reducing Copper Slag Losses*

BY CHARLES G. MAIER AND G. D. VAN ARSDALE

IN THE first part an attempt has been made to point out certain relationships between magnetite in slags and copper loss, which have been summarized in the final part of this article to form the basis of a tentative rational theory to account for the mechanism of such co-ordination. Before proceeding to this matter, however, the generality of the conditions as described above should be proved to be prevalent in the usual matte-smelting process.

In Table III are shown the results of the application of the silver nitrate method to various slags from smelters other than those connected with the Phelps Dodge Corporation. The results are more or less self-explanatory, for on examination of the table it does not seem justifiable to conclude that the amount of dissolved copper is constant for all slags. The amount of pellet copper shows considerable variation, indicating varying degrees of efficiency of settling, but it is to be noted that the average deviation from the mean content of pellet copper, however small in amount, is nevertheless about equal to the variation observed in the content of the dissolved copper.

Despite the impossibility of proving constancy of dissolved copper for all slags examined, there is no doubt that a distinct similarity exists among these figures, and it seems fair to state that for all samples examined there remains the general classification as to form and content presented in our previous work; of the total copper present in reverberatory slag, a part, usually slightly less than 50 per cent and with an average magnitude of 0.15 per cent, consists of prills of sulphide, whereas the remaining copper is apparently in the dissolved form as sulphide and averages 0.20 per cent.

The microscopic similarity of all slags examined is even more striking than the similarity of quantitative results gained by the use of the silver nitrate method for dissolved and pellet copper. The visual uniformity of the major structure of the slags will be apparent from an examination of a few photographs appended in Figs. 31 to 38. The observation of all samples examined confirms the generality of the following statements.

Mattes as examined show identical two-phase structures consisting of iron sulphide constituent and copper sulphide constituent.

Reverberatory and blast-furnace slags show inclusions of copper sulphide globules approaching the constitution of white metal and present in amounts as specified in Table III. Attachment of gas bubbles is found in all slags for at least a portion of these globules and the disappearance of the iron sulphide phase or its separation from the copper sulphide globules is common to all samples examined.

On crystallization no oxide or silicate forms of copper have been recognizable, but there is considerable variation in the crystalline structure of the silicate phase. In all cases of reverberatory slags the formation of magnetite crystals on solidification is common and, so far as observed, universal.

TABLE III. DISTRIBUTION OF COPPER CONTENT OF TYPICAL SLAGS

No.	Name of Smelter	Per Cent Total Cu	Per Cent Cu as Pellets	Per Cent Cu as Dissolved	Per Cent Total Cu as Dissolved
1	Copper Queen blast furnace	0.35	0.19	0.16	45.7
2	Copper Queen reverberatory	0.25	0.08	0.17	88.0
3	Morenci blast furnace	0.35	0.23	0.12	34.3
4	Old Dominion blast furnace	0.30	0.15	0.15	50.0
5	Copper Queen reverberatory special	0.31	0.09	0.22	71.0
6	Copper Queen reverberatory converter test	0.28	0.06	0.22	78.6
7	United Verde blast furnace	0.34	0.15	0.19	55.9
8	Arizona Copper Co., reverberatory No. 1.	0.37	0.16	0.21	56.8
9	Arizona Copper Co., Reverberatory No. 2.	0.40	0.20	0.20	50.0
10	Arizona Copper Co., Reberberatory No. 3.	0.40	0.15	0.25	62.5
11	Arizona Copper Co., reverberatory No. 4.	0.32	0.08	0.24	75.0
12	Calumet & Arizona Copper Co. reverberatory	0.23	0.05	0.18	78.2
13	El Paso Smelter, reverberatory No. 1	0.46	0.21	0.25	54.4
14	El Paso Smelter, reverberatory No. 2	0.38	0.13	0.25	64.8
15	A.S. & R. Co., Hayden Plant, reverberatory	0.34	0.23	0.11	32.4
	Average	0.339 ±0.05	0.144 ±0.05	0.195 ±0.04	

Converter slags have sulphide globules similar to white metal usually constituting the major portion of the total copper content, and magnetite crystals formed during the fused state are observed in all cases.

No chemical relationship between copper content and slag constitution can be discerned. In taking up a comparison of slag samples from various smelters it was thought that the ability to distinguish dissolved and suspended copper in slags should be a valuable tool in discovering any such relationship which might exist, but a critical examination of the specific results obtained, as tabulated in Table IV, shows no adequate explanation for observed behavior.

SUMMARY OF FACTS

In spite of the possibility of some repetition, the following summing up of our experimental evidence may be of interest in connection with the theory which we wish to develop concerning the relationship of magnetite and copper in slags.

It has been found that copper matte-smelter slags contain their copper content in two forms usually about equal in amount, one of which consists of sulphide inclusions mechanically retained by the slag, the other being in an apparently dissolved form (at least not microscopically visible) which certain chemical aspects of the slag seem to fix, as also sulphide. But it has been also universally found that the pellet of mechanically held sulphide seldom retains the form of its original matte source, but instead loses its iron constituents (compare Figs. 36 and 37). This separation is accompanied by signs of chemical reaction, two products of

*For Part I, see CHEM. & MET. ENG., vol. 22, No. 24, p. 1101.

TABLE IV. COMPARISONS OF CHEMICAL ANALYSES AND COPPER CONTENTS OF TYPICAL SLAGS

No.	Slag	Per Cent Cu	Per Cent Dissolved Cu	Per Cent Pellet Cu	Per Cent SiO_2	Per Cent Al_2O_3	Per Cent CaO	Per Cent CaO +MgO	Per Cent S	Per Cent FeO	Ratio S/Cu
1	Copper Queen blast furnace	0.35	0.16	0.19	36.0*	11.0*	.....	7.0*	....	38.0*	....
2	Copper Queen reverberatory	0.28	0.22	0.06	40.76	11.43	4.88	7.61	0.41	37.56	1.46
3	Morenci blast furnace	0.30	0.15	0.15	35.0*	10.0*	.....	18.0*	....	34.0*	....
4	Old Dominion blast furnace	0.36	0.13	0.23	37.0*	9.0*	.....	16.0*	....	34.0*	....
5	United Verde Extension	0.34	0.19	0.15	43.86	5.55	12.81	13.53	0.37	34.32	1.09
6	Arizona Copper Co., No. 1	0.37	0.21	0.16	39.98	11.70	3.46	5.89	0.52	39.30	1.40
7	Arizona Copper Co., No. 2	0.40	0.20	0.20	38.80	11.38	3.07	5.31	0.40	42.35	1.00
8	Arizona Copper Co., No. 3	0.40	0.25	0.15	41.35	11.45	6.14	8.65	0.29	34.81	0.83
9	Arizona Copper Co., No. 4	0.32	0.24	0.08	41.69	11.71	6.03	8.33	0.25	36.36	0.78
10	Calumet and Arizona	0.23	0.18	0.05	42.70	6.56	6.52	8.19	0.73	39.96	3.10
11	El Paso, No. 1	0.46	0.25	0.21	41.04	5.88	5.68	7.39	0.40	42.87	0.87
12	El Paso, No. 2	0.38	0.25	0.13	41.75	6.44	5.16	6.41	0.58	44.31	1.50
13	A. S. & R., Hayden	0.34	0.11	0.23	37.22	6.78	15.02	16.63	0.47	38.27	1.38

*Estimated approximate average.

which may be distinguished. The first of these is a gas which must be, if its origin is in matte, sulphur dioxide, and secondarily; in extreme cases of rather unusual occurrence, the appearance of minute globules of metallic copper.

Experiments with the addition of converter slag to reverberatories have shown both chemically and visually through the microscope that there is connection between magnetite (ferric iron) and a portion of the copper loss, i.e., the globule content. The amount of the latter is proportional to the oxidizing strength of the slag usually indicated by the ferric iron and magnetite content.

The dissolved copper content representing the remainder of the copper is unaffected in total amount by the addition of converter slag to reverbertory, and consequently by the slight increase of oxidizing activity. If the dissolved form exists as sulphide, this fact proves that equilibrium is very closely approached.

Theory of Relationship Between Magnetite and Copper Loss in Slags

The facts summarized above lead to the supposition that in considering the process of reverberatory smelting in reference to copper loss, four types of phenomena or fields of action should be considered. These types are indicated graphically in the chart, Fig. 39, and are separated there by dotted lines, although it is not meant that these actions are separable physically or represented by actual spatial zones of the furnace. All of the actions presented probably occur simultaneously to a greater or less degree, but it is not impossible that actual spatial separation in a specially designed furnace might not be theoretically desirable.

The first action in smelting to be considered, from the standpoint of copper loss, is primarily the change of physical state due purely to fusion. The primary formation of matte and slag is essentially and inherently a physical transformation, and any reactions involved are of a metathetical type and do not represent any ultimate change in total slag and matte, nor do they seem to be the source of copper loss. For example, we know that the original roasted calcine fed to the furnace may contain part of its copper content as oxide, but the amount of oxide truly fed to the furnace is not easily determined. A typical sample, as taken for analysis, may contain 10 per cent copper with 3 or 4 per cent acid soluble, but the method of sampling, as compared to the practical handling of calcine where it is conveyed in large quantities directly, and with a minimum cooling, from roaster to reverberatory, does not enable one to state definitely that the hot calcines, as usually fed to the furnace, do contain this amount of oxide. Even if the calcine does contain this amount of oxide copper, however, it does not have effect on the final copper loss, since all the copper not in slag (the copper content of the slag is indicated by our work to be sulphide) is finally found in the matte and the reaction $FeS + Cu_2O = Cu_2S + FeO$ must have occurred if the final condition is to be accounted for. This reaction is obviously the reason for the absence of copper oxide forms in the slag, but does not affect the final copper loss except in so far as it inhibits the formation of oxide forms.

While it is possible that some chemical oxidation does occur during the time in which the change from solid to liquid state is taking place, this action is purely secondary and is not truly an essential part of the matte-smelting process as carried on in the reverberatory. Chemical action, except the roasting mentioned above, is at a minimum in the solid charge. As far as *copper* loss is concerned, chemical reactions are not the source of any loss at this stage of the process, and it it justifiable to assume the first and essential action of smelting in reverberatories to be a purely physical change of state, whose only result on the final copper content is the saturation of the slag phase with sulphides and the entrainment of small amounts of sulphide globules in the slag medium.

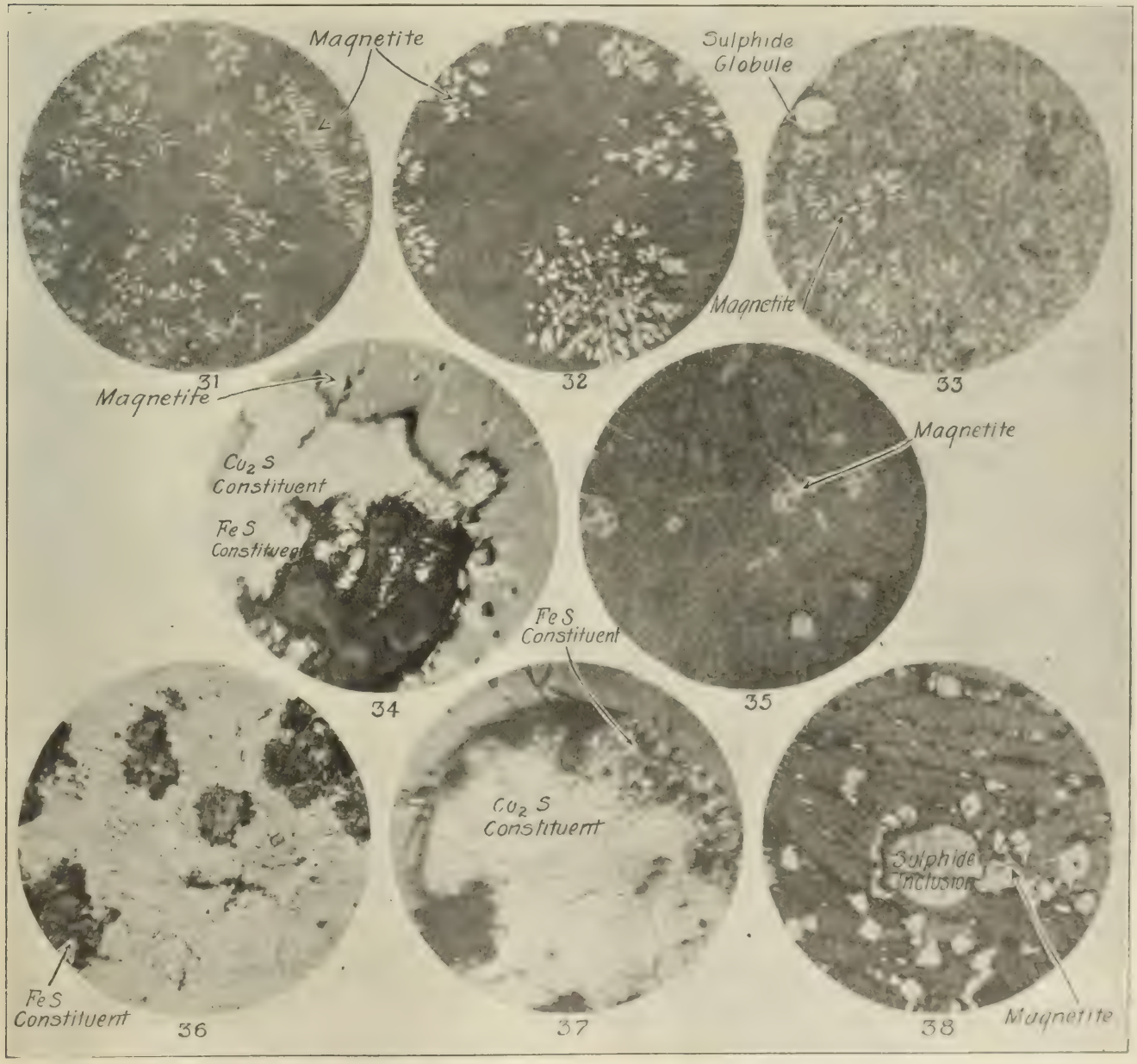
Having once attained the molten condition, aside from the purely mechanical separation in whole or part of the matte and slag components, the chemical activity of the charge is enormously increased by the change of state, and a new condition, marked *B* in the chart, prevails in which chemical equilibrium tends to find its level. The matte, more or less protected by the fused silicates, does not have opportunity for direct oxidation to the same degree as the slag. In the latter the ferrous oxides or silicates are oxidized to ferric iron, thus increasing the content of the latter due to its original presence in the charge. By this means the fusion aids in the formation or crystallization of magnetite. It has been shown that the magnetite has great tendency to settle through the slag as soon as crystals of any appreciable size are formed, and inevitably thus comes in contact with the matte constituting the bottom of the fluid portion. Large crystals of magnetite are not visible in the usual reverberatory sample (cf. Figs. 2, 8 and 14)[2] and their absence can be explained only on the basis of this settling action, for the formation of minute crystals on cooling and solidification shows that the slag is saturated with ferric iron. Moreover, since the total effect of the reverberatory furnace as a chemical apparatus is at least some little increase in oxidation, magnetite crystals must be continually forming in the molten slag. Since crystals formed during the molten condi-

[2]See pp. 1102, 1103 and 1104.

tion are not visible in the final sample, (e.g., Figs. 6 and 12 show[3] only crystals formed in solidification), it must be true that these crystals have been disintegrated as rapidly as they were formed. Fortunately magnetite is wet by fused sulphides (Figs. 29 and 30)[4], and its life at the bottom of the slag in contact with matte is short. Pictures shown above such as Figs. 27 and 28 indicate clearly the progressive character of the ferric iron or magnetite reacting to be fluxed through the agency of the sulphides. The slowness of the fusion in the viscous slag medium prevents the instantaneous reduction of the magnetite in reverberatory slags, and thus permits photographs of the actual mechanism by which equilibrium is attained to be taken in solid specimens. This is consistent with the absence of visible magnetite in the more thoroughly mixed blast-furnace slags. Accidental contact between sulphide globules in suspension and magnetite is rare in reverberatory slag, but more possible in the blast furnace.

Upon contact with the body of the matte below the slag, the magnetite reacts, setting free sulphur dioxide. The gas rises and carries with it the sulphide globules which constitute the second portion of copper loss in the slag. This loss is inherent in the reaction of sulphur elimination and the variation of metal loss in slag under otherwise constant conditions of charge and temperature must be due to changes in this reaction, loss by solution being normally constant. This action is the essence of stage *C* (Fig. 39), where chemical equilibrium of magnetite-sulphide oxidation approaches a condition balanced by the physical action of gravity, mixing, etc. *B* and *C* together are a dynamic condition which becomes cyclical for all usual phases of furnace operation.

[3]See pp. 1102 and 1103.
[4]See p. 1106.



FIGS. 31 TO 38. SLAGS FROM VARIOUS COPPER SMELTERS

Fig. 31. El Paso smelter, reverberatory slag. 110 ×. Fig. 32. Hayden smelter, reverberatory slag. 110 ×. Fig. 33. Calumet and Arizona smelter, reverberatory slag. 110 ×. Fig. 34. Arizona Copper Co. smelter, reverberatory slag. 110 ×. Fig. 35. Same specimen, showing detail of magnetite particles. 700 ×. Fig. 36. United Verde Extension, blast furnace matte. H_2SO_4 etching. 110 ×. Fig. 37. United Verde Extension, blast furnace slag. 110 ×. Fig. 38. United Verde Extension, converter slag. 110 ×.

The last phenomenon, *D*, is the purely mechanical one of settling, and although this may primarily be regarded as a direct and necessary sequence of the change of physical state at *A*, it should, nevertheless, be considered as a separate action because it is so profoundly affected by the intervening and previous chemical and physical equilibria of *B* and *C*. The silicate portion thus acts as a medium for the stabilization of sulphur elimination in which ferric iron formed at its gas contact surface becomes magnetite, settles, reacts with matte to eliminate sulphur as dioxide, and to be itself redissolved and fluxed.

The history of the metal loss in reverberatory slags, as influenced by the four phases of smelting as classified in Fig. 39, should be apparent. The original change of physical state at *A* is the initial cause of two sources of copper loss. The first portion is the direct solubility of a part of the sulphide in the silicate fusion. This part is constant in amount for any normal condition of temperature and composition and is materially unaffected by the subsequent equilibria. As a necessary consequence of the action of melting, entrained sulphide globules are formed. These sulphides should not be normally expected to float in the slag unless affected by some subsequent buoyant effect. As far as density and viscosity are concerned, there is no reason why complete separation of such entrained globules should not be obtained merely through the medium of increasing the time of settling.

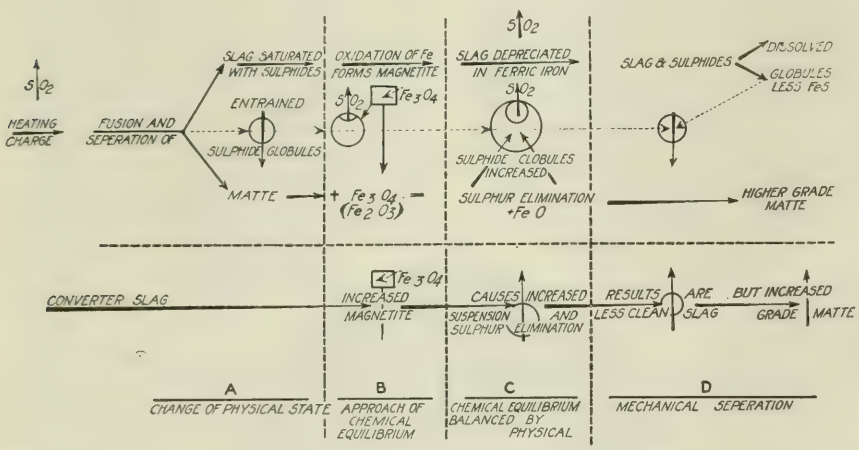


FIG. 39. RELATIONSHIP OF MAGNETITE AND COPPER LOSS IN REVERBERATORY SLAGS

The extent to which contact of magnetite with matte can cause the formation of suspended globules depends obviously upon the rate at which the original magnetite is formed and upon the speed with which it can come in contact with the matte. A limit is reached in state *C*, where the suspension and sulphur elimination are balanced by the physical equilibrium of settling and diffusion, and this represents the final state of the slag as obtained.

The rôle played by converter slag in disturbing slightly the balance of normal conditions, as indicated in the previous paragraph, can now be understood. Its magnetite content increases somewhat the total amount of ferric iron, which is the cause of sulphur elimination in the molten mass, as distinguished from sulphur elimination by roasting action, which is confined to the solid state before fusion. The normal effect of increase in magnetite is an increase in the extent to which sulphur dioxide is produced at the matte surface and consequently results in more suspension of copper globules (sulphide) throughout the slag. At the same time the grade of matte is necessarily increased.

To secure finally the most efficient settling or recovery of sulphides from slag, the modifying effects of iron playing its shuttle game from magnetite crystals to ferrous silicate melts must be considered in its practical aspects.

Certain Practical Aspects of Results

If present and previous work has necessarily been of more theoretical than direct practical application, it has at least indicated rather definitely the answers to some problems which present themselves in considering methods for decreasing the metal loss in copper smelting slags.

In the blast-furnace or reverberatory slags the classification of the losses into two normal classes of dissolved and suspended sulphide globules enables direct prediction of the possible methods for securing decreased loss. Dissolved loss, whether it be due to true or colloidal solution, can only be controlled internally by variation of the temperature or constitution of the melt, or externally by the addition of such reagents as might cause a depression of the solubility by a common constituent (ion?) effect. In a practical way the criteria of satisfactory furnace operation and economy of flux, as well as limitations due to the original constitution of available ores, will tend to render improvement by change of constitution unlikely.

Depression of the solubility by the addition of external agents requires the use of sulphides. Iron is precluded because the slag is already saturated with its sulphide, and further addition could have no effect on the *dissolved* copper portion. Furthermore, the effect of the addition agent would be proportional to the amount added, and consequently no hope of the complete elimination of the dissolved constituent may be entertained, and no practical method whereby a saving of even any considerable amount of the dissolved copper is discernible on this basis.

The elimination of suspended copper globules would seem to have much greater practical possibility, even though the total amount of metal recoverable is limited by the small percentage present in this form. The results outlined above leave no doubt as to the conditions which must prevail to obtain a decrease. Both the initial formation of floating sulphide globules and the continuity of suspension are due to oxidation carried on through the medium of ferric iron and magnetite. Many persons, noting an increase of copper in slag as the grade of matte was increased, have imagined a direct

chemical relationship to exist between the grade of matte and metal loss, but this connection is not truly causative, being in fact a secondary action. Considering the dissolved content, since we know that the constitution of suspended globules approaches that of pure cuprous sulphide, the solubility of copper sulphide in the slag must approach a constant maximum corresponding to equilibrium in accordance with a fixed distribution ratio, one of whose phases approaches a pure material. This means that the grade of matte cannot affect the amount of dissolved copper by any solubility effect. An altogether different condition exists for the globule content. Any process of smelting to give a high-grade matte must necessarily be done under more strongly oxidizing conditions than that producing a low-grade matte, and an increase of suspension is inevitable, because it is just this oxidizing condition which is the source of suspended copper sulphide loss.

In the light of this reasoning, the extent to which the contact of matte and slag is under oxidizing conditions forms the major factor for determining the final copper content of the slag rather than any directly chemical relationship. The necessary conditions under which a saving of suspended copper may be made are clearly a matter of proper non-oxidizing settling, but it must be left to the practical smelter man to design suitable apparatus embodying the above principles for obtaining these conditions in a usable furnace.

Even more definite conclusions are deducible regarding the practical treatment of converter slag. If minimum copper content of slag is desired, the addition of converter slag to normally operated reverberatories is undesirable except under those conditions in which the mixing can be done throughout a zone sufficiently reducing to insure complete reduction of the magnetite. Unless the magnetite is completely fluxed in the presence of excess sulphides, an increased suspension of sulphide globules seems inevitable.

The effect of the addition of converter slag to reverberatories may be practically classified from either of two points of view, regarding the effect on the basis of the per cent saving of copper content of the original converter slag, or with respect to the effect on the original reverberatory slag to which the converter was added. Considering first the saving of copper content of the converter slag, the undesirability of making the addition under any other than completely reducing conditions may be shown by a simple calculation. The original converter slag may normally carry from 3 to 10 per cent of copper, the greater part in the form of suspended globules of white metal with occasionally small amounts of metallic copper. The average dissolved copper content of the converter slag is not nearly so constant as with other slags, but may be assumed to have an average maximum of 0.5 per cent. On addition of the converter slag to the reverberatory, the sulphide globule content of the former might be expected to be amenable to settling and recovery, but it is evident from our work that the recovery of the total globule content is only possible under the strictly reducing conditions mentioned above.

Now assume the normal copper content of reverberatory slags to be 0.40 per cent, of which 0.25 per cent exists as suspended globules and 0.15 per cent as dissolved. Since, as far as microscopic appearance and chemical behavior of the suspended globules in converter slag are concerned, they are exactly similar to those in reverberatory slag, we may assume that the suspension of the original converter globules when present in the mixed slag would certainly not be less than normal but will be greater than normal in proportion to the increase of ferric iron due to the admixture of unfluxed magnetite. A typical case would be represented by the addition of converter slag containing 3 per cent copper, 0.50 per cent of which is dissolved, and with a normal magnetite content of about 25 per cent. If this is now added to the extent of 10 per cent to reverberatory slag with an original 5 per cent magnetite content, the final mixed slag would contain $(5.0 \times 0.9) + (25.0 \times 0.1) = 7.0$ per cent. The suspension of sulphide globules is therefore increased in the ratio

$$(7.0 \div 5.0) \times 0.25 = 0.35 \text{ per cent.}$$

The total amount of the original content of the converter slag which is not recoverable even under the best conditions is therefore the sum of the new suspended copper plus the original dissolved

$$0.50 + 0.35 = 0.85 \text{ per cent} = 28.3 \text{ per cent of total copper.}$$

From the other point of view, with respect to the copper content of the reverberatory slag itself, according to the above calculation, the suspended copper would become 0.35 per cent, giving a total copper content of $0.15 + 0.35 = 0.50$ per cent. This represents an increase of 20 per cent of the total original 0.40 per cent content, whereas the percentage admixture is only 10 per cent. The increased loss due to the addition of the converter slag is greater than the per cent admixture, and the addition must be concluded to be unsatisfactory.

Although the above calculation emphasizes the disadvantages of mixing converter and reverberatory slags so long as reducing conditions do not prevail, it is fortunate that in practice there is always some reducing action at some point in the reverberatory despite the fact that the total effect is one of some oxidation. If it is essential to the routine operations of smelting to add fused converter slag to reverberatories, the practical ideal condition which should be aimed at is obviously to maintain a reducing zone in some part of any given furnace to which admixture is being made.

Better yet will be the results of smelting separately with a pyritic siliceous material, preferably to produce a low-grade matte, in order effectually to reduce the magnetite. Such a process has already been carried out at Anaconda[6].

Finally, the above considerations indicate the possibility that methods of concentration of converter slag other than direct smelting are worth considering, although the practical justification of any method of concentration will be affected by the extent to which the fluxing value of magnetite is usable in smelting by the maintenance of a preponderating reducing atmosphere.

Appendix

The method for the estimation of suspended and dissolved copper in slags by the use of dilute neutral silver nitrate solutions has been given in detail in a previous article and a complete discussion of its justification for this purpose need not be reproduced here. The beautifully definite manner in which it worked in the present instance gives, however, added weight to the consideration of its usefulness as a critical method in the examination of slags.

The determination of ferric iron in slags is a matter

[6] See *Trans.* February, 1920, Meeting of the American Institute of Mining Engineers and CHEM. & MET. ENG., vol. 22, pp. 231 and 317.

of considerable difficulty. Although the total iron is easily determined and an estimation of ferrous iron should complete the solution of the problem, there are two serious difficulties in the way of obtaining accurate results on silicates. These are:

(*a*) The necessity of disintegrating the slag without oxidation.

(*b*) The harmful effects of sulphides in oxidation and reduction reactions involving the state of the iron prevent accurate determinations of ferric iron in their presence.

A number of methods of disintegration have been proposed for determining the ferrous iron in silicates by Hillebrand[6], J. P. Cooke[7] and Doelter[8], based on the use of hydrofluoric and sulphuric acids in an atmosphere of

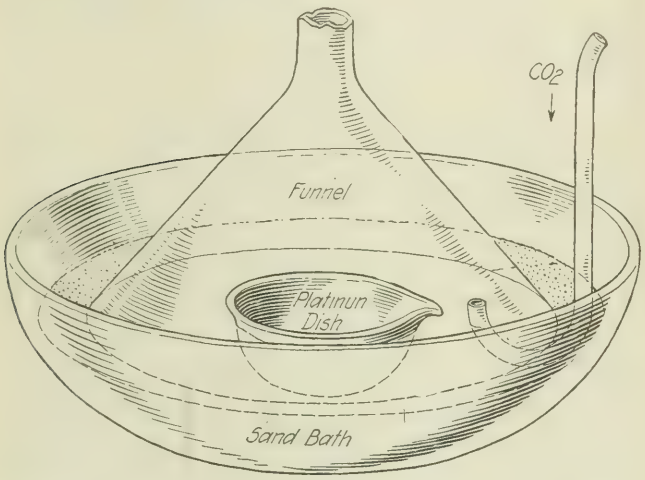


FIG. 40. APPARATUS FOR DISSOLVING SLAG WITHOUT OXIDATION

carbon dioxide. A composite method based on the recommendations of these authorities has been worked out as follows:

From ½ to 1 g. of slag sample ground to 100 mesh in porcelain was weighed out into a 25-c.c. platinum dish, 2 to 3 c.c. concentrated sulphuric acid was added and the whole stirred with a platinum wire. The dish was then immersed in an atmosphere of carbon dioxide over a sand bath, as shown in the illustration Fig. 40. Ten to 12 c.c. of concentrated hydrofluoric acid was added and gentle heat applied for a period of twenty to thirty minutes until, after frequent stirring with a platinum wire through the top of the neckless funnel, complete disintegration had taken place. The heat was then removed and after cooling the contents of the dish were washed into about 300 c.c. of water with warm dilute sulphuric acid.

If one endeavors to titrate for ferrous iron with permanganate in this solution, the presence of hydrofluoric acid remaining undistilled causes a very bad end point because of the reactivity of manganese fluoride toward permanganate. This condition was partially eliminated in the following manner:

Potassium carbonate and pure finely ground quartz in the proportion $4K_2O : SiO_2$ were melted together in a platinum dish to quiet fusion; the silicate thus formed was broken up and dissolved in a minimum of water, and sulphuric acid added until the liquor was quite strongly acid to litmus, thus precipitating gelatinous hydrated silicic acid and forming potassium acid sulphate. An amount of this solution and precipitate corresponding to about 3 g. silica was then added to each determination and the ferrous iron titrated directly with permanganate. Under these circumstances most of the hydrofluoric acid remaining is converted into potassium fluosilicate and the end point is considerably improved.

The determination of ferric iron by this method as the difference between the total and the ferrous iron is perfectly feasible, but the actual amount determined will probably be somewhat less than the true content because of the sulphides present in the slag. For the present work, however, in default of absolute accuracy of results, if the results are comparable they could obviously be made the basis of a theory concerning the relationship of ferric iron to the copper content of slag. The justification of the use of the method depends then on the fact that the total sulphide present in the samples analyzed varies in amount less than a few tenths per cent, whereas several per cent of iron are being determined. Consequently the small practically constant error which is involved, due to the presence of sulphides, has been deemed negligible for present comparative purposes.

[6]Bulletin U. S. Geol. Survey No. 176, 1900.
[7]*Am. J. Sci.*, 2nd series, vol. 44, p. 317, 1867.
[8]*Z. anal. Chem.*, vol. 18, p. 50, 1878.

Sulphuric Acid Industry in Japan

The following table gives some idea of the sulphuric acid industry in Japan:

	Production lb.	Yen
1912	218,460,500	2,118,960
1913	413,613,100	3,328,950
1914	472,905,000	3,004,220
1915	492,026,600	4,702,660
1916	781,425,520	10,844,860
1917	741,039,160	8,916,830
1918	1,269,200,000	14,250,000

Production for 1914, the year the war broke out, shows an increase of 60,000,000 lb. over the previous year but a decrease in value of 324,730 yen. Since then, however, the production has shown an increase, with a slight let-up in 1917. No exact figures are obtainable for 1919, but it is estimated that the production was not less than 1,300,000,000 lb.

EXPORT TRADE

	Kin	Yen
1914	3,386,760	140,348
1915	13,245,641	501,921
1916	25,008,955	1,517,617
1917	6,949,083	503,594
1918	5,862,000	408,450
1919	5,354,092	436,178

As seen from the above table, there was a considerable increase in the export of sulphuric acid in 1915 and 1916, probably due to increased exports to Russia. Since that time, however, the trade has been diminishing until in 1919 it fell to 5,350,000 kin, valued at 436,000 yen.

The principal countries to which Japan exports sulphuric are China, Dutch India, the Straits Settlements and Hongkong. In 1916, 17,000,000 kin of sulphuric acid valued at 1,000,000 yen was exported to Russia, representing 40 per cent in quantity and 60 per cent in value of the total export, but in 1917 the export to Asiatic Russia fell to 29,000 yen and in 1918 to only 200 yen.

Some quantity of sulphuric acid was exported to Sweden, Siam, the United States and Hawaii in 1915, but the export has ceased since 1916. In 1917, 90,000 yen of acid was exported to Egypt and 80,000 yen in 1918.

Legal Notes

By Wellington Gustin

Armour Fertilizer Works Not in Contempt

Judgment has been reversed, in the contempt case instituted by the State Solicitor General of the Atlanta circuit against the Morris Fertilizer Co., and involving the Armour Fertilizer Works, by the Supreme Court of Georgia. Action in this matter seeking to enjoin and abate the fertilizer works of these companies in Fulton County, Georgia, as a nuisance, was begun in December, 1917. In the court proceedings only the Morris Fertilizer Co. was named as defendant, and a temporary order was obtained restraining it "from permitting any poisonous or noxious gases or vapors to escape from or be carried beyond the ground owned by the defendant company, and upon which its plant is located." This order was subsequently modified, in 1918, to read "The defendant is restrained from permitting any gases or vapors to escape from or be carried beyond the ground owned by the defendant company, and upon which its plant is located, so as to constitute a nuisance, etc."

It appears that Armour Fertilizer Works was never joined as a defendant, but subsequent to the court order an agreement was entered into between the Solicitor General for Atlanta and both defendant Morris Fertilizer Co. and Armour Fertilizer Works in which the Armour Fertilizer Works agreed to abide by the terms of the injunction issued against Morris Fertilizer Co. Upon the application of the Solicitor General and by consent of the Morris company the contract, by order of the court, was made a part of the court record in the case. The Armour Fertilizer Works did not join in this application, and did not consent to the court's order.

Both Companies Cited for Contempt

Later the state filed an application for attachment against both the fertilizer companies for contempt of court by violation of the restraining orders, and the Armour Fertilizer Works was adjudicated a party defendant. Both of the companies demurred to the state's petition and their demurrers were overruled in the trial court, and they took the case, by error, to the Supreme Court of Georgia. Here this court held that the Armour company was not a party to the cause, and was not bound by the judgment of record therein, either (1) by voluntary contract, (2) by order of the court, or (3) by estoppel; and this is true, although the Solicitor General for Atlanta contemplated the filing of a separate suit against the company to enjoin its works as a nuisance.

On the application for attachment for contempt, the court said such a proceeding in which the defendant and one not a party to the case are joined as respondents, and in which acts of the defendant and that person are alleged to constitute, jointly and severally, a contempt, is not good because of misjoinder of parties defendant and misjoinder of causes of action.

Regarding the agreement between the parties, the most that can be said is that though the state contemplated filing a separate petition to abate the Armour factory as a nuisance, the contract was made in settlement of a contemplated suit. A controversy is not a suit, and an agreement with reference thereto, though intended as a final settlement thereof, is merely a contract, and not a judgment of the court. The Armour company could not be held to be a party defendant by estoppel, upon the ground that the making of the contract prevented the filing by the state of a separate suit against it, praying that its factory be enjoined and abated as a nuisance.

The judgment was reversed.

Oral Evidence Inadmissible to Transform Sale by Description Into One by Sample

Some important points of information for the trade have been brought out by the Appellate Division of the Supreme Court of New York in the action of the American Aniline Products, Inc., against Mitsui & Co., Ltd.

Aniline Products brought its action to recover on three contracts for the sale to Mitsui & Co., Ltd., of a quantity of dyes, which the exporter refused to accept or pay for. The latter admitted giving the orders, each of which was alike except as to dates, quantity of dyes and dates of shipment, and that the Aniline company accepted them. It was further admitted that the dyes should be packed in barrels of 400 to 500 lb. net each, instead of 100 lb.

Samples of Dyes Submitted

Mitsui & Co. defends on the ground that prior to the date of the orders, as it alleges, the Aniline company submitted to it a certain sample of dye, and offered to sell to it dyes according to such sample, and represented and agreed and warranted that deliveries of dyes under orders thereafter received from it would be equal in dyeing strength, color, quality and all other respects to the sample submitted; that relying upon this it gave the Aniline company its export orders for the dyes referred to in the complaint. Mitsui & Co. further alleged that when the Aniline company notified it of intention to deliver certain dyestuffs under the orders, an examination was made which showed the dyes did not correspond with the sample; that thereupon the dyes were rejected and Mitsui & Co. refused to accept delivery or pay therefor.

Upon examination of the writing and orders involved, it was found that such contained no reference to a sale by sample, nor did they contain any express warranty as to strength, color or quality. The important proposition in the case, therefore, was whether the exporter could show, by evidence outside the writings sued upon by the Aniline company, that the dyes were warranted to correspond in all respects with a sample.

Evidence of Sale by Sample Ruled Out

While oral statements will not be permitted to change or vary the terms of a written agreement, yet this rule of law does not operate to prevent one from showing a prior, independent and collateral agreement, said the court. Now, while the agreement alleged in the exporter's defense to the suit was a prior one, it is neither independent nor collateral, for it touched upon at least one element in the written order and agreement. That element was the quality of the article sold. The writing shows a sale by description, being "Amacid Blue Black KN," and therefore the obligation of the seller was merely to deliver goods to that description of

merchantable quality, ruled the court. In a sale by sample, the bulk must correspond in quality with the sample. To attempt to transform a sale by description into one by sample is to attempt to vary the obligation of the seller as to the quality of the article to be delivered. This cannot be done, said the court. (89 N. E., 365.) Therefore evidence as to a sale by sample was not permitted in evidence, as it would result in varying a written agreement by parol evidence.

However, the court held that upon the trial either party would be at liberty, by word of mouth, to define the term "Amacid Blue Black KN." The rule of law is that when a term of a written contract requires definition in order to make its meaning clear, and such definition is not found in the writing itself, it is always permissible to give that definition by extrinsic evidence. For such evidence does not vary the meaning of the writing, but, on the contrary, discloses the full meaning of the parties to the instrument.

Regulation Upheld for Computing Drawback Due Exporters

Section 22 of the act of Congress effective Aug. 27, 1894 (28 Stat., 509, 551) provides as follows:

"That where imported materials on which duties have been paid are used in the manufacture of articles manufactured or produced in the United States, there shall be allowed on the exportation of such articles a drawback equal in amount to the duties paid on the materials used, less 1 percentum of such duties . . ."

It is further provided in the section that the drawback due thereon shall be paid to the manufacturer, producer or exporter "under such regulations as the Secretary of the Treasury shall prescribe."

Under this section the National Lead Co. brought suit against the United States to recover the difference between the amount of drawback allowed by the Government to the company, as an exporter of linseed oil cake, and the amount to which it claims to be entitled.

The National Lead Co. imported large quantities of linseed upon which it paid a specific duty of 20c. per bushel of 56 lb. This seed, when treated by a simple process, yielded about 20 lb. of linseed oil and about 36 lb. of linseed oil cake to the bushel. The oil was much more valuable than the oil cake, the latter being composed of the solid substance of the seed and a small amount of oil not recovered, which made it valuable as a feed for stock. It is a byproduct and, except for the small amount of oil in it, would be mere waste. The company exported large quantities of oil cake derived from seed which it had imported and made demand for the drawback provided for by the act of Congress.

In rendering its decision on the case the United States Court of Claims found that:

"From Aug. 5, 1861, to the present time the practice of the Treasury Department, where several articles are manufactured from the same imported material, has been to calculate and to pay the drawback by distributing the duty paid on the imported material between such articles in proportion to the value and not in proportion to their weight, as well where the imported material paid a specific as well as where it paid an ad valorem duty. Such calculation and payment had been made under Treasury Department regulations."

The company appealed its case to the Supreme Court of the United States, which has just handed down its decision. The company claimed that the correct construction of the section requires that the drawback should be computed on the basis of the weights of the oil and oil cake derived by the process of manufacture from the seed, instead of on the basis of the values of the two products, as it was computed by the Government. Hence the question presented to the court was whether the department regulation is a valid interpretation of the statute.

The act provides that the drawback allowed shall be "equal in amount to the duties paid on the material used," less 1 percentum. Now, what was the amount of duty paid on the small amount of oil and on the large amount of solid substance, the hull and the fiber, which made up the exported oil cake? Was it substantially two-thirds of the total, determined by weight—on 36 of 56 lb.—or was it about one-fourth of the total as determined by the relative values of the oil and of the oil cake derived from the seed?

Supreme Court Upholds Regulation

The terms of the statute show that the contingency of having one kind of dutiable material, from which two or more kinds of manufactured products might be derived, is not specifically provided for. The statute, thus indefinite if not ambiguous, called for construction by the Treasury Department and the regulation adopted to cover such cases as here presented was commended and upheld by the Supreme Court.

It says that Congress did not intend that two-thirds of the duty should be returned when one-quarter in value of the manufactured product should be exported; or that the exporter should retain 20 lb. of oil, estimated to be worth about 7½c. a lb., derived from each bushel of seed, and recover two-thirds of the duty paid when he exported 36 lb. of seed cake, worth slightly more than 1c. a lb., derived from the same bushel of seed. But such results would follow if the contentions of the exporter were upheld.

This case is important in that it attacks a regulation of the Treasury Department which has had an extensive and long-continued application to imported and exported material other than such as are here involved.

Seller's Representations Amount to Warranty

The Supreme Court of North Carolina has ordered a new trial in the suit of Swift & Co. against I. M. Meekins and others. The plaintiff sued to recover on a note of defendant given for the purchase of fertilizer. Defendant set up a counter-claim for breach of warranty as to the quality of the fertilizer.

It appears that defendant purchased forty tons of fertilizer, analyzing 5-7-0, and ten tons of acid phosphate. Meekins testified that seller's agent, at the time of sale of the fertilizer, stated that it was as good as any of the same analysis sold to be used for cotton and corn, and was as good fertilizer as there was on the market, and that Swift & Co. would sell it cheaper on account of their output from their packing house. The Supreme Court said these statements amounted to a warranty as a matter of law. It is not necessary that the language should be intentionally false or that there should have been any purpose to deceive. The positive representation by a seller that the article sold possesses a certain value and certain qualities amounts to a warranty, and the purchaser may set up the breach of warranty and reduce the sum claimed by the difference between the contract price and the actual value, although there was no deceit in the sale.

Scientific Control of the Filter Station—IV

A Discussion of Methods Used in Discharging Filter Cake From Presses—Points on Handling Difficultly Discharged Materials—Reverse Current Discharge—Use of Air, Steam, Water and Scrapers—Filtrate and Cake Capacity Ratings—The Economy Curve*

By ARTHUR WRIGHT, M.E.

DISCHARGING the cake is in many respects the keynote of efficiency in filter operation. Any type filter that cannot be operated so as to keep the cloths in a free filtering condition for recurring runs is not only inefficient but a makeshift. Let clarification, washing or drying be faulty and discharge satisfactory, the filters can still operate with a certain degree of economy. More filters are operating poorly by reason of incomplete or time-consuming discharge of the cake than for any other reason, and too many of them needlessly so.

The fundamental principle in discharging the cakes from filters using fabric as the medium is that the cake shall cleave away from the cloth. In filter press operation this is indicated by the cakes falling out of the frames as the operators move up the successive frames. In modern type filters it is demonstrated when the reverse current of a discharging agent—compressed air, steam, water, etc.—disengages the cakes from the cloths and allows the solids to fall by gravity or to be removed by a scraper. In sluicing discharge machines the principle is again proved when the water jet is able to sweep the entire cake away from the cloth.

Difficultly Discharged Materials

When handling materials that cannot be effectively discharged, those filters in which the cloth can be most easily removed and replaced by clean cloths are the best the market affords. Fortunately many materials hitherto resisting all methods of effective discharge are today, by reason of our better knowledge of the art, satisfactorily handled. There can be no refutation to the fact that inefficient operation of filters paves the way for substitute methods of clarification—decantation, flotation, centrifugating, etc.—and faulty discharging discredits filter operation most severely.

As was pointed out in the first article of this series, dense filter cloths are not good mediums for best filter operation. We have come to realize that the filter cloth is best designed when used as an auxiliary filter medium, so that we need no longer choose a filter cloth solely for its clarification properties. This fact alone is responsible for a considerable advance in the better discharge from many installations. No explanation is necessary as to the reason for this. It is apparent that dense cloths retain particles caught in its pores much more than thin or open weave cloths.

Open cloths have a further advantage in that they allow the reverse current of the discharging agent to exert a greater force in disengaging the cake from the filter medium than do dense cloths. The latter balloon out with the introduction of the discharging agent and prevent discharge of the solids—in fact, support the cakes and allow but little of the reverse air or steam to act upon the cakes.

The effectiveness of the discharge is often inaccurately indicated by an observation of the surface of the cloth. The rate of flow on the next cycle is the best proof of the thoroughness of the cleaning action. Some operators working on a granular material see the cake fall from the filter cloth the moment the pressure is released and see no need of further cleaning the cloths by reverse currents. To see those filters hung up while the leaves are taken out and hand scrubbed proves the utter inadequacy of the discharge. To leave only a minute film upon the cloth will in time necessitate strenuous methods in order to regain the original porosity. Thorough discharge is required at all times.

Reverse Current Discharge

Some of the most marked advances in filtration are due to the introduction of those continuous filters which employ reverse current discharge. Filters working on sodium carbonate, free-filtering calcium carbonate or gypsum may not require this means of discharge by reason of their extremely granular or free-filtering characteristics, but cement slurries, kaolin and other finely divided materials are inapplicable without this means of discharge. If some of this kind of material is left on the cloth, recurring filtration causes fine particles to wedge into the deposit and a scale-like, impenetrable mass results and most effectively blocks off further filtration.

The advantage in the use of compressed air, steam or water as the discharging agent is dependent upon local conditions. In leaf filters reverse current through the leaves while they are submerged is often more efficacious than the same current through the leaves suspended in the atmosphere. There is a good reason for this, for with the submerged leaves the water has an opportunity of getting underneath the cake and helps release the cake when the air current issues through the cloth.

Some operators are quick to condemn reverse current discharge because it will in some cases clear small areas on the leaves and leave the remainder undischarged. It is true that if the air can escape through a part of the cake it will not issue through the rest of the leaf forcibly enough to release the cake. Such conditions indicate, however, that either too dense a cloth is being used or else that there is some tenacious constituent in the cake which defies discharge. In this respect it is well to point out the analogy between the nap on the surface of a cotton or cellulose filter cloth and the hair used in plaster for wall and ceilings. Each has a binding action and the nap of the filter cloth is a big factor in causing ineffective discharge, so that metallic fabrics are often advantageous just for this point alone.

It cannot be too strongly emphasized that automatic

*For Parts I, II and III, see CHEM. & MET. ENG., vol. 22, Nos. 22, 23 and 24, June 2, 9 and 16, 1920, pp. 1015, 1077 and 1119.

discharge from leaf type filters is due to the combination of the releasing the cake from the cloth and the fall of the material due to gravity. Therefore any impediment that blocks either factor jeopardizes the discharge. Some cakes have a relatively high tensile strength—are leathery in texture—so that the mere bridging over of the cake at the top of the leaves is sufficient to hold those cakes from discharging. In such cases it is good practice to coat over or cover the rim of the leaves and prevent filtration at this point so that no bridging effect is possible. The same is true of any obstruction which tends to hold the cake, such as bulky side aligning lugs in Sweetland filters, unflattened drainage pipes in leaf construction, etc. If, therefore, the reverse current of compressed air is ineffective in releasing the cake from the surface of the cloth, if the cake is of too small a bulk, or is prevented from falling by some obstruction, the discharge will be unsatisfactory.

Use of Air, Steam, Water or Scraper

Determining whether to use compressed air, steam or water, etc., as the agent for discharge, is a matter best decided in light of local conditions. Generally speaking, however, compressed air is the best. Its pressure is easily controlled, it adds no moisture to the discharge cake and its temperature has no deleterious effects on the filter cloth. It does, of course, have a cooling action and when handling hot liquor it may then be that steam can be substituted to better advantage. Steam has its good points, especially in that the cake, always being cooler than the steam, causes a slight condensation at the inner surface of the cake which often lubricates the surface of the filter cloth and facilitates discharge. Water or any liquid is in a sense the best reverse current because it more forcibly pushes the cake from the cloth, but its use is obviously limited. Unless the leaves are submerged, the water will often fail to remove the upper parts of the cake before it issues through the cloth at the bottom of the leaves and never issue through the upper areas.

When the cakes are thin and have not sufficient bulk to fall of their own weight, when released by the compressed air, discharge from leaf filters is impractical without submerging the leaves or without using scraping methods. If the latter must be resorted to, it must be realized that the scraper has the tendency to smear the cake into the pores of the cloth unless the reverse current of air is operating at the same time. This is the basic reason for the efficiency of discharge in continuous vacuum filters and in the automatic discharge plate and frame presses.

Thickness of Cake

Often thin cakes are held to be incapable of discharge by reverse current methods, whereas the trouble lies in the construction of the filter leaves. When the reverse current of compressed air is first turned into the leaves, the effect is to balloon out the filter bags, especially with dense cloths. When the bag is distended, the upper part of the bag supports the cakes from falling, even though the reverse air has efficiently disengaged the cake from the cloth. This is, obviously, a contrary condition for the best discharge of the cake. It is minimized by securing the cloth to the leaves at intervals across the entire area of each leaf or by lateral stitching of the cloths forming pockets into which wooden slat, etc., drainage members are inserted. Then the ballooning effect is decreased sufficiently that the discharge of the cake is just as efficient at the top of the leaf as at the bottom. In continuous vacuum filters the sections are narrow enough and the wire winding is spaced close enough that ballooning of the cloth gives no trouble with these machines.

Very thin cakes are difficult to discharge, but do not offer the difficulties encountered in discharging cakes that are too thick. In leaf filtration cakes are too thick only when adjacent cakes touch each other. Such a condition is diametrically opposite to the theory of operation in this type of filter. It is fundamental that a space remain between adjacent cakes that there may be room for the free fall of the cakes when released from the filter medium. When the entire space between leaves is filled with cake, it is rarely that the cakes can be discharged. Overcharging of a leaf filter is bad operation and indicative of poor control. If it were that the extra time required for discharge were its only disadvantage it would not be so necessary to emphasize this point. But overcharging is productive of warped leaves and they kill any hope of efficient filtration.

Filtrate and Cake Rating

Overcharging is due either to too long a filtering cycle or to too narrow spacing of the filter leaves. Either condition is easily controlled and good filter operation demands the prompt eradication of those conditions. There are liquors which as the precipitate is commonly formed contain too high a percentage of free-filtering material to be easily controlled in leaf type filters. Wherever possible, these materials should be handled in continuous type filters, which are more adaptable to this class of work, but where temperature, acid content, etc., call for leaf filters, the widest practical spacing should be employed, and if the solids still build too freely, then the liquid content of the material should be increased by returning some of the filtrate.

Consideration of overcharging brings out the point too often overlooked, namely, that the rating or duty of a filter can be either in terms of filtrate delivered or in cake built up. With very free-filtering materials the latter view is the safer, and while it must be measured by the quantity of filtrate delivered or by the time of filtering, it is the prime consideration, for seldom is the economical limit of filtration for such materials reached by waiting for the filtrate to decrease in flow to its economical limit. To do so would build up a cake too voluminous and heavy for the best operation both as regards washing and discharging. In design Sweetland type filters are admirably adapted for those solids which easily fall from the leaves, for the lower half of the machine opens away from the leaves which do not have to move the cakes. In practice, however, the cake in the lower half is often a load in excess of the power of the operating cylinder and makes for dangerous banging of the counter-weights against the shell. Also, the cake remaining in the lower half has to be removed by hoeing it out by hand or hosing it out with water.

When filters are working on liquors containing a small percentage of solids they are better known as clarifiers. In this class of work the solids build up to form only a thin coating on the cloth and a discharge by reverse current methods in leaf filters or any discharge in continuous filters is impracticable. The customary method is to sluice the solids off the filter cloth by forcibly spraying water on the surface of the cloth. This is

efficient when the solids have not penetrated the pores of the cloth. Success of such methods is evidenced by the record of the Merrill plate and frame presses in the cyanide industry and Sweetland filters in cane sugar refineries. In both of these filters the sluicing is done by rocking the sluicing pipe or manifold back and forth so as to project the sluicing streams over the entire surface of the cloth. This operation is invariably done without opening the filter and in respect to cleanliness of operation is distinctly advantageous.

Pre-Coating Aids Discharge

With most materials that are handled in clarifiers and which tend to clog the pores of the filter medium it is indispensable to build up an auxiliary filter medium upon the cloth before commencing the clarifying operation. This medium has been described in the article on Clarification as a "pre-coat," and inasmuch as the pre-coat is easily sluiced from the cloth its advantages are obvious. In sluicing discharge there are two points which must not be overlooked. The sluicing streams must be directed to the cloth with sufficient force to remove the solids and the water must not be allowed to collect in the filter so as to submerge a part of the leaves. Both points should be covered in the design of the machine, but where an ordinary filter is being used as a clarifier the nozzles must be spaced and aligned correctly with the limits of the lateral travel fixed. The drainage at the bottom should be unrestricted and if necessary two drainage openings should be used.

The discharge from gravity tank filters has usually been by the laborious methods of hand shoveling. It is simple, however, to rig up automatic means, especially if wet discharge is not objectionable. All that is required is a drainage opening and to forcibly eject the cake with a water hose. It is also possible to discharge the solids mechanically by using a rotating raking device that can be lifted free of the liquor level while filtration and washing take place and that can be lowered into the cake when ready for discharging. The weight of the rakes will be fed sufficient to plow into the solids. The rakes must, of course, be designed to move the mud toward the outlet provided in the tank.

TABLE I.

Time	Elapsed Time	Interval in Min.	Flow in Gal.	Increment in Gal.	Pres. Lb. Sq. In.	Temp. Deg. Fahr.	Dens. Deg. Be.	Remarks
9:00	0	0	0.0	0.0	0	0	0	Filling
9:05	0	0	0.0	0.0	0	0	0	Filtering
9:08	3	3	15.0	15.0	10	182	32	Clear
9:10	5	2	25.0	10.0	12	182	32	
9:15	10	5	46.0	21.0	16	181.5	32	
9:20	15	5	63.5	17.5	20	181	32	
9:22	17	2	71.0	7.5	22	181	32	Pump stopped
10:27	17	0	71.0	0.0	0	..	..	Pump repaired
10:30	20	3	78.0	7.0	25	179	32	
10:35	25	5	90.0	12.0	25	179	32	
10:40	30	5	100.25	10.25	25	178	32	
10:45	35	5	108.75	8.5	25	178	32	
10:50	40	5	114.75	6.0	25	177	32	
10:55	45	5	119.25	4.5	25	177	32	
11:00	50	5	123.25	4.0	25	176	32	
11:05	55	5	127.0	3.75	25	176	32	Filtered
11:10	0	0	0 0	0.0	10	..	..	Washing
11:15	5	5	6.0	6.0	30	176	32	
11:18	8	3	10 5	4.5	30	177	30.5	
11:20	10	2	13.5	3 0	30	177	31	
11:22	10	2	18 0	3.5	30	178	29	
11:24	12	2	20.5	4.5	30	179	22	
11:26	14	2	28.5	6.0	30	180	8	
11:28	16	2	36.5	8.0	30	180	3	
11:30	18	2	45.0	8.5	30	181	0.5	
11:32	20	2	54.0	9.0	30	182	0	Stop
11:34	0	0	0.0	0.0	10	...	..	Drying
11:37	3	3	10 0	10.0	28	...	..	Dried
11:47	10	..	.....	.....	..	...	..	Discharged

COMPUTATIONS

Tare:
- 5 minutes filling.
- 5 minutes draining excess and filling with wash water
- 20 minutes washing.
- 2 minutes draining excess water.
- 3 minutes drying.
- 10 minutes discharging.

45 minutes.

Points on curve:
- 45 minutes tare.
- 5 minutes filtering.

50 minutes cycle; 25 gal. flow divided by 50 minutes equals 0.5 gal. per minute.
- 45 minutes tare.
- 40 minutes filtering.

85 minutes cycle: 114.75 gallons flow divided by 85 minutes equals 1.35 gallons per minute.

The Economy Curve

One of the most illuminating graphs arising from modern filtration developments is that known as the economy curve. Engineers will be struck with the similarity of this with that of the conventional "characteristic" curve of centrifugal pumps. The point of flexure is in both cases the economical limit. In the filtration curve it marks the limit of economical filtering cycle more positively than any other curve. While in practice the amount of liquor handled per shift may be said to be an infallible proof of the best working of the filters, the experimenter has this means of predicting that cycle productive of maximum capacity and it is more for his benefit that the curve is insisted upon in good laboratories.

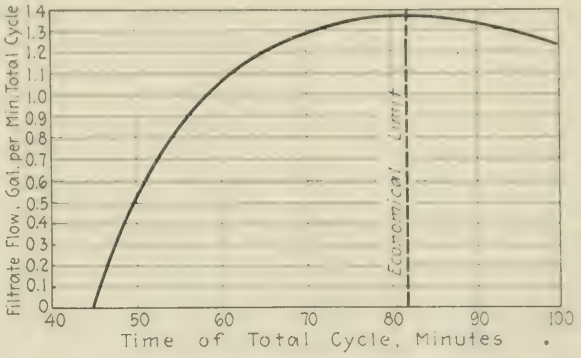


FIG. 7. ECONOMY CURVE

The points on the curve are computations of the rate of flow per minute for each cycle when it is assumed that the tare of the cycle remains constant and that each successive point on the curve is the flow for the cycle if the filtering cycle had ended at that period. The assumption that the tare is constant is based on the fact that the time of filling the filter preparatory to filtering the liquor is a constant, that the time of withdrawing the excess unfiltered liquor and admitting the wash water is almost constant irrespective of the amount of cake deposited, that the withdrawal of the excess wash water takes practically the same time for varying filtering cycles and that the drying, discharging operations and closing up the filter again are practically constants. The time of washing the cakes is a variable with widely differing amounts of cake deposited, but in practice the variation in the length of the washing period is small and for the purpose of this curve can be taken as a constant.

Table I is the form in which it is found most convenient to record the date of a test and from it is computed the points outlining the accompanying curve.

(Part V, General Discussion and Auxiliaries, will be published in a subsequent issue.)

The Potentiometer in Pyrometry

By Charles P. Frey*

DR. GEORGE SIMON OHM published what was originally called "a remarkable mathematical theory" in 1827, and aroused a storm of discussion. It was not until about 1841, when the Copley Medal was awarded to him by the Royal Society of England, that his "theory" was accepted as an axiom, and the importance of his contribution to science fully recognized. Ever since, physicists have labored to establish fundamental units of resistance, current and voltage, and to secure their general adoption.

Fundamental Units

Necessarily, the unit of resistance had to be based upon the physical characteristics of materials; and after much experimenting and discussion the resistance of a column of mercury 106.3 cm. long and 14.4521 g. in mass, having a constant sectional area at 0 deg. C., was adopted and appropriately called the international ohm.

It remains a matter of controversy whether the volt or the ampere can be more easily determined. Since absolute measurements are impossible, the deposition of silver was advocated by many as a medium for current determinations, and the ampere is defined as that current which will deposit 0.001118 g. of silver per second. The electromotive force which will produce such a current, when applied to a conductor having one international ohm resistance, must necessarily be one volt.

The volt, or unit of electromotive force, can now be established with great accuracy by the proper construc-

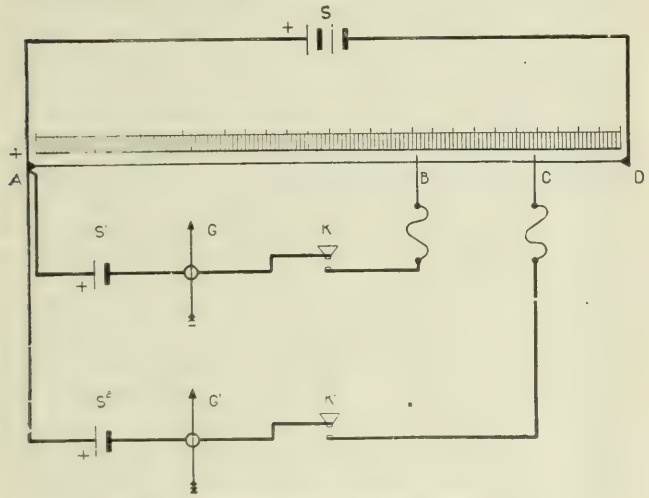


FIG. 1. POTENTIOMETRIC PRINCIPLE

tion of cadmium sulphate cells. The ohm can also be produced in practical form by the substitution of the alloy manganin for mercury.

The Potentiometer

By means of a potentiometer, comparisons of emf. can be made with extraordinary precision. The principle of the potentiometer may be demonstrated as follows, referring to Fig. 1:

A constant current flows from battery S through a resistor $ABCD$, of uniform cross-section. A potential difference is therefore established between the extremes, and between any two points from A to D.

If S^1 is a cell, the known emf. of which is less than that of S, a balance may be obtained when the contactor B connects at a point on the wire found by trial. At that time no current flows through the galvanometer G, with the circuit closed by means of key K. When this is the case, the potential between A and B will be equal to the emf. of the cell S^1. The emf. of the cell S^2 may then be compared with the emf. of S^1 by moving C, and when balanced, $S^2 : S^1 :: AC : AB$, in terms of the emf. of S^1.

The significant feature of this test is the number of unknown values permissible. The current through the

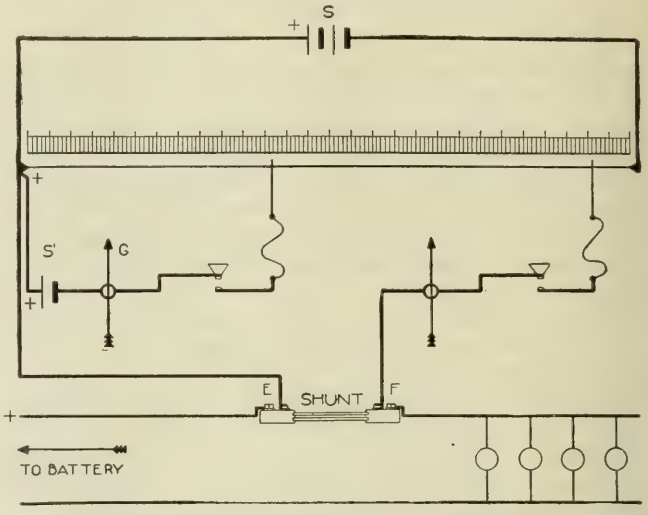


FIG. 2. CURRENT MEASUREMENT BY POTENTIOMETRIC METHOD

feeder circuit including AD, the emf. of S, the resistance of the slide wire and the sensitivity of the galvanometers may all be ignored.

All potentiometers, even the most elaborate and intricate, embody the above principle and depend upon a balance between a known potential and a potential which may be indeterminate. The potentiometer in practical form usually has a calibrated scale which permits direct readings of voltage, or in pyrometry, of temperature equivalents; and by the introduction of proper switches only one galvanometer is required.

In all exact quantitative potentiometer measurements it is necessary that the known emf. has been determined with the utmost exactness and that it is not subject to variations. It is also requisite that the galvanometer is sufficiently sensitive so that when its needle becomes stationary a balance of forces has actually been established.

Current Determinations

The potentiometer may also be used for the measurement of current with great accuracy by the "fall of potential" method or "drop" across the terminals of a shunt.

For instance, if the resistance of the shunt in Fig. 2 is known, the current is determined by finding the drop across EF. This method is necessarily in the nature of laboratory testing and is not direct reading.

By the substitution of a deflecting millivoltmeter in place of the potentiometer, direct indications may be obtained in current measurements, as shown in Fig. 3.

The millivoltmeter scale may be calibrated to indicate amperes, since the current through its movable coil must necessarily be a definite part of the total current undergoing measurement. In this test, the millivoltmeter indications will be a direct index of the drop

*Chief Engineer, the Brown Instrument Co.

across P-P^1, provided the instrument resistance is sufficiently high not to materially reduce the circuit resistance, as a whole, by its own conductivity.

The Movable Coil Galvanometer

Nearly all direct current ammeters, as well as voltmeters, millivoltmeters, galvanometers and pyrometers operating on the movable coil principle, are based on the original investigations of Ampere in 1820.* And it is appropriate to state that all measurements depending upon galvanometers are essentially *current* measurements, although scale readings may be interpreted in volt, ohm, temperature or resistance equivalents.

The degree of accuracy attainable with a deflection galvanometer depends upon the extent of the deflection, also upon the permanence of the magnetic field and the constancy of the controlling forces, such as gravity and the retarding torque of metallic conducting springs or suspension fibers. The temperature coefficients of the conductors are also factors, but errors from such sources can be practically eliminated by the use of properly proportioned materials.

Substitution Checks

In the employment of any measurement apparatus, confidence in the accuracy of its indications is necessary if practical results are desired. Yet if doubt exists, there is always one comparatively easy method by which a check can be made, which is by substitution. Standard weights can be interchanged, thermometers can be read while subjected to the same temperature, two or more millivoltmeters can be connected in multiple, shunts can be checked in series and standard cells can be tested by the opposition method or by replacement.

Potentiometers for Pyrometry

In the selection of a potentiometer best adapted to the requirements of pyrometry, consideration should be given to the fact that since it cannot be adjusted and then read as quickly as the indications of a deflection instrument can be observed, there remains only one reason for its employment, which is on the score of greater accuracy. It also should be designed to be convenient for the measurement of emf.'s which are almost

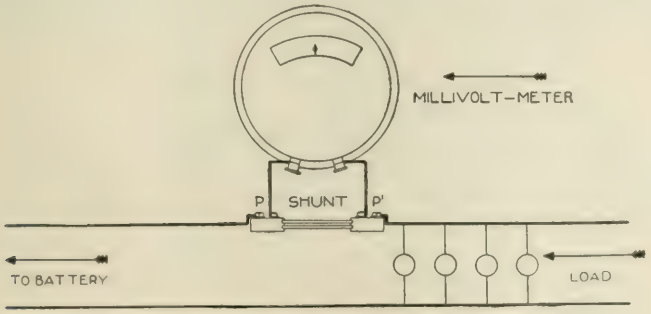


FIG. 3. MILLIVOLTMETER ACTING AS AMMETER

invariably less than 0.05 volt, and have a scale which is not only extremely accurate in its calibration, but which in addition is long enough, or as it is called, sufficiently "open," to permit small differences in potential to be determined with rapidity and precision. If, for instance, such a scale has a length of only about 10 in., and is calibrated to have a range of 0 to 50 millivolts, one millivolt will have a scale length of about 5 mm., or $\frac{1}{5}$ of an inch. Therefore, even if such an instrument is used for measurements near the upper end of the scale and it is possible to read by interpolation to $\frac{1}{10}$ scale division, the extreme limit of accuracy, with no allowance for what is called the personal equation, or error in observation, will be $\frac{1}{2}$ of 1 per cent.

Taking into consideration the fact that a platinum platinum-rhodium standard couple develops only 5.95

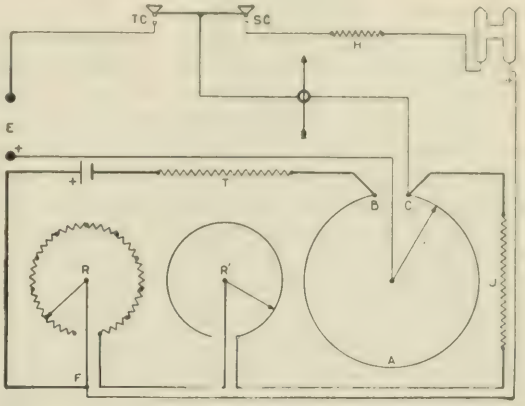


FIG. 4. PORTABLE POTENTIOMETER CIRCUITS

millivolts at a temperature of 1,200 deg. F., it is evident that such an emf. cannot be read with extreme accuracy on a scale which is too short to be sufficiently subdivided.

The scale in the newly developed Brown potentiometer overcomes this objection, since it is 7 ft. 10 in. in length, inscribed spirally upon a drum. The drum wire is wound upon a corresponding insulated cylinder mounted on the same axle and rotating with the scale drum.

The fundamental principle of this instrument may be readily understood by reference to Fig. 4, which illustrates the scheme of an ordinary portable potentiometer. A constant current from the plus side of a small dry cell flows continuously through the rheostats R and R^1, the ballast coil J, the slide wire CAB, and the resistor T, back to the cell. The current through this circuit is regulated by means of the rheostats R and R^1 so that the emf. between C and F will equal the emf. of a selected standard cell. When this is the case the potential drop of the slide wire CAB will have a predetermined value in millivolts between its extremes.

By connecting a source of current at E, its emf. can be determined by balancing it against a suitable part of the emf. of the slide wire. When these cylinders are rotated by means of a knob, an index moves across the scale. The motion of this index is synchronized so that the position of a contactor on the slide wire coincides with a corresponding position of the scale index.

The Standard Cell

Since the accuracy of these potentiometers depends directly upon the emf. of the standard cell, great care has been given to secure satisfactory ones. They conform with the recommendations of the Bureau of Standards and are of the type known as unsaturated.

The Weston normal cell, invented by Edward Weston, containing a saturated solution of cadmium sulphate, was adopted by the Bureau of Standards in 1911 as the standard of emf.; $E = 1.01830$ international volts at 20 deg. C. Saturated cells, if extreme precautions are adopted in their construction, can be produced from different materials and agree within a few parts in 100,000, but owing to the fact that they have a small

*See "The Galvanometer," by E. F. Northrup, CHEM. & MET. ENG., vol. [illegible], p. 941.

temperature coefficient (approximately —0.00004 per deg. C.) they are not preferable for practical measurements, independent of temperature variations.

Another cell, also the invention of Dr. Weston, is identical with the normal standard in ingredients except that the solution used is diluted instead of being saturated. The effect of this dilution is to slightly increase the emf. and to reduce the temperature coefficient to practically zero (—0.00001 per deg. C.). The exact emf. of a properly "aged" cell of this type should lie between 1.0184 and 1.0190 volts, and its voltage will remain constant within 0.01 per cent for years, provided the cell is not short-circuited or otherwise abused.

Since in unsaturated cells the density of the solution affects the emf., this gives manufacturers of precision instruments the advantage of employing cells which are alike in emf. and which may be therefore interchanged. A further advantage lies in the fact that the constant emf. of these cells simplifies the construction of potentiometers, since it obviates the necessity of introducing a thermometer and a device to "set" the instrument to correspond with a definite voltage at a known temperature, which is necessary for precision tests if the usual standard cell is used.

The cell in the Brown potentiometer is packed in a portable case which includes a resistor of about 3,000 ohms, to prevent damage in case of accidental short-circuit. This case can be speedily removed if it is considered desirable to have the cell standardized. Meanwhile, a duplicate cell may be substituted, whose case interchanges with the original, so that only two connecting leads need be secured to binding posts.

A small dry cell is used to furnish current for the main circuit. This cell is called "705 Eveready," and can be purchased in any electrical supply store.

Current Requirements

Nearly all portable potentiometers have a drum wire of low resistance measuring about 20 ohms. Consequently, to obtain sufficient "drop" or potential difference between its extremes, a comparatively large current is necessary. Therefore, the dry cell which furnished this current is constantly falling off in emf., due to polarization, and by use is rapidly exhausted. Furthermore, the current does not remain steady for any length of time and the rheostat requires constant resetting to keep the instrument in balance.

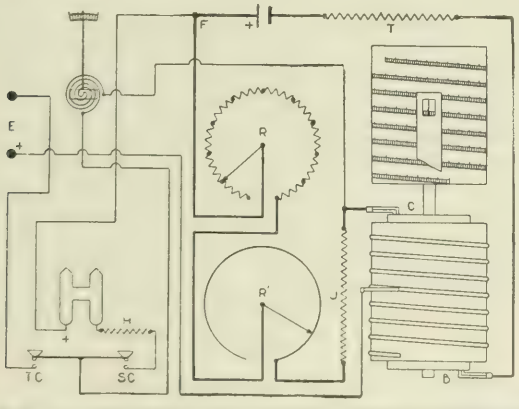


FIG. 5. DIAGRAM OF BROWN POTENTIOMETER

In this new potentiometer (Fig. 5), the drum wire has a resistance of 140 to 150 ohms, and the total instrument resistance for 50 millivolts is approximately 4,175 ohms, including the resistance of the rheostats. This is gradually reduced, by regulating the rheostats, to a minimum of about 3,400 ohms, when the dry cell is exhausted and must be renewed. The emf. of the dry cell is from 1.5 to 1.2 volts, according to its condition, and the current required to operate the potentiometer is never more than 0.00036 amp. or about one-tenth the current required to operate potentiometers of the ordinary portable type. The result is that the dry cell will have a long life (from three to six months, according to condition), which is of course an advantage; but what is of far greater importance is the fact that the current drawn from the dry cell is so small that the cell will not polarize and will give a practically constant current, subject only to temperature changes. Consequently the potentiometer, after being balanced against the standard cell, will remain in balance for hours without readjustment. Hence a large number of tests can be made in succession with the absolute certainty that there will be no errors introduced due to change in the potentiometer current.

Galvanometer

In the construction of any instrument in which the opposition or "zero" method is employed, a sensitive galvanometer is indispensable, in order that it will respond to minute changes in current. The galvanometer has no suspension fibers and the movable coil does not turn with an erratic motion, dance or vibrate. It is positive in its indications as well as aperiodic in action. Its resistance is approximately 150 ohms.

Sensitivity

If an electromotive force of one volt is impressed on a resistor of one megohm (1,000,000 ohms) the flow of current will be one-millionth ampere, or one microampere. This current, when passed through the movable system of the Brown portable galvanometer, will cause a deflection of 2.8 mm. Stated differently, the galvanometer has a guaranteed sensitivity of 2.8 megohms (10^{-6} amp.). These remarkable results are obtained by using tungsten alloy magnets, a concentrated field and a movable system wound with special enamel-insulated aluminum wire. The weight of this movable system is so slight that it is unaffected by mechanical jars in transportation, the pivots remaining sharp under all conditions, with no reduction in sensitivity.

Automatic Compensation, Single Scale

A single scale potentiometer intended exclusively for a certain type of thermocouple is calibrated in temperature degrees, either Centigrade or Fahrenheit or both, and may be automatically compensated for temperature changes in the cold ends of the couple. But such an instrument can be used only in connection with the type of thermocouple for which it has been adjusted and cailbrated.

Philadelphia, Pa.

Vegetable Oil for Italy

Recent inquiries have been coming to Japan for vegetable oil, due to decrease of imports from Holland, and some contracts for export to Italy have already been consummated. A considerable quantity of vegetable oil was shipped by the N. Y. Y. steamer Wakasa Maru, which sailed for Genoa with the Japanese shipping delegates on board. It is said that the N. Y. Y. contemplates in case of regular shipment of oil to Italy, sending its ships to Genoa.

Chart of Viscosities in Different Systems

By H. G. Nevitt

VISCOSITY is variously defined as the degree of fluidity of a liquid, its internal friction or shearing modulus. This property is an important one in many liquids, and the primary one in a lubricant, as it is the most important indication of its fitness for that purpose. Viscosity is commonly measured by an instrument which allows the liquid to flow through an orifice, the degree of viscosity being given by the time taken by a fixed quantity of liquid to flow through.

Obviously in the case of any viscosimeter, where the time of flow or similar direct reading is taken, the viscosity factor is a function of the instrument as well as the liquid. Attempts to get away from this have been made by getting a comparative viscosity, as in the Engler method, where the ratio of the time of flow of the liquid to that of water is taken, or by obtaining the actual shearing force, or absolute viscosity, which is a function of the liquid only.

At the present time there are a number of instruments and systems used, but the following are the most common:

The Saybolt Universal, or time on Saybolt instrument.

The Redwood, or time on the Redwood instrument.

The Engler number or comparative time of flow, with water equal to unity.

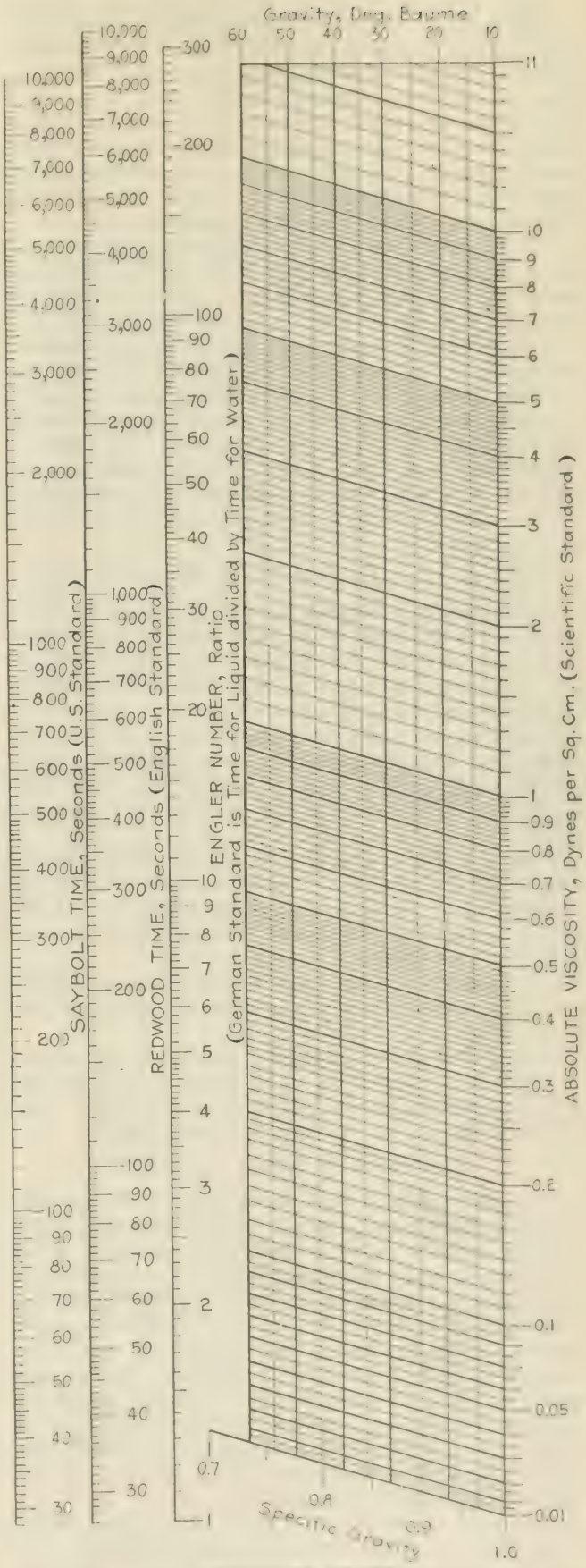
The Absolute Viscosity in c.g.s. units. This involves the specific gravity as well as the time of flow on an instrument, as two liquids of the same time of flow but of different densities have different internal shearing resistances. However, as most liquids being compared generally have about the same specific gravity, this does not cause trouble.

The confusion that may result from the number of systems in use is apparent. This is especially true of the export trade, and when dealing with foreign authorities and data on liquids. In the petroleum industry especially, where viscosity is an important and controlling factor in handling some of the distillation fractions, the difficulties of knowing more than one system or changing over become considerable, if a large number of distillations are being compared. In consequence we are almost forced to some quick method of comparison, and the graphical seems by far superior.

To do this the common method of plotting the various values reduced to equivalent scales, so the value in any other system is read opposite the quantity on the given system, is used. The correction for the specific gravity in reducing to the absolute system also presents no difficulties graphically.

Any basic scale of laying off the values on the primary system may be chosen, but the logarithmic seems best for several reasons. It covers a wide range of viscosities without too small a scale for reading in the common range of values. It also makes the most probable error of reading constant in percentage, rather than in amount. This is also an advantage in that the error of determination is also approximately constant in percentage, so that inconsistencies in reading the chart are avoided. By then plotting the co-ordinate lines for specific gravity to a logarithmic scale also, the lines for variation of absolute viscosity with specific gravity become straight and have a constant slope.

Tampico, Mexico.



VISCOSITY CHART

To obtain equivalent viscosities, read horizontally across the scales. A sheet of paper cut square makes an excellent guide. Example:

An oil of 30 deg. Bé. gravity has a viscosity of 200 on a Saybolt instrument. Read Redwood equivalent as 185, Engler as 5.24 and absolute as 0.328 from the chart, using the 30 deg. Bé. line for the absolute intersection.

The German Works Councils Act

A RECENT issue of the British official *Labor Gazette* contains the following résumé regarding the provisions of the German works councils act:

A works council act (Betriebsrätegesetz) was passed on Jan. 18, 1920, in order to guarantee the general economic interest of workers (manual and non-manual) in relation to their employers and to assist the employers in carrying out the aims of their undertakings.

The term "worker" (Arbeitnehmer) covers all manual and non-manual workers with the exception of members of the employer's family. It does not include persons whose employment is not mainly for profit.

Works councils must be set up in all establishments employing as a rule at least twenty workers. In smaller establishments a works steward must be elected. A special works council for outworkers must be set up when twenty or more are employed. In order to guarantee special economic and social interests, separate councils for manual and non-manual workers must be set up wherever both classes are represented on the works councils.

Council Members Elected by Secret Ballot

Members of the councils are to be elected by direct and secret ballot according to the principles of proportional representation for the year; they shall be eligible for re-election. All workers, male and female, of eighteen years and over, in possession of civil rights have the right to vote. All with the right to vote who are twenty-four years of age and over, who are not learners and who have been at least six months with their employer and three years in the industry, are qualified for election.

Rules are laid down for election procedure, and the Federal Minister of Labor, in agreement with the Federal Council and a committee of the Reichstag consisting of twenty-eight members, is empowered to issue administrative regulations.

If a works council has nine or more members it must elect from its own members a works committee of five persons.

Provision is made for (1) a central works council in addition to, or (2) a joint works council instead of individual works councils when interdependent establishments are owned by the same firms, etc.

Functions of Works Councils

In section 66 it is laid down that it shall be the function of the works council to help the management to secure efficiency; to protect it from unauthorized interference, and, failing agreement in disputes, to appeal to the conciliation committee or to an arbitration board to be agreed on; to fix or modify, in agreement with the employer, the conditions of service; to promote a good understanding between workers and employer and to maintain the workers' right of forming associations to take measures to prevent danger to health and accidents; and to co-operate in the administration of pensions, housing, or other welfare schemes attached to the establishment.

The works council has the right to require the employer to give to the works committee information as to all the transactions of the establishment which affect the contract of service and the activity of the workers (provided no business secrets are endangered or legal regulations contravened), and to show the wages, books, and give other information necessary for carrying out existing collective agreements. The employer must supply a quarterly report on the position and progress of the undertaking and of the industry in general, as well as of the output of the establishment and the expected demand for labor.

Penalties of the Act

Any person who with intent to deceive the workers shall give wrong data or conceal correct data in reports on the financial position is liable to imprisonment not exceeding one year and to a fine not exceeding 10,000 marks, or to either of those penalties. Any person disclosing confidential information given to him as a member of a works representative body is liable to a fine of not more than 1,500 marks or to imprisonment; if convicted of intention to gain financial advantage or to injure the employer, heavier penalties may be imposed.

Should the engagement or dismissal of a considerable number of workers become necessary, the employer must as soon as possible discuss with the works committee or the works council the nature and extent of the necessary changes and the possibility of avoiding hardships.

The functions of the manual and non-manual workers' councils are of a more specialized character. They include, among many others, the laying down of guiding rules for the engagement of workers in their group in the establishments and co-operation in carrying out the regulations as to their discharge.

The engagement of a worker must not be conditional on his political, military, religious, or trade-union views, or on his belonging or not belonging to a political, religious, or occupational union or to a military association. The rules must not prescribe that the engagement shall depend on belonging to a particular nationality.

Appeals Against Discharges

Provision is made for appeal by the councils against the engagement or discharge of workers to the competent conciliation committee or an arbitration board. Discharge without a statement of the reason for it is one of the grounds of appeal.

If the appeal against dismissal is held to be valid, the employer must either offer reinstatement or give compensation for dismissal. The amount of compensation is fixed at the rate of one-twelth of the earnings in the last year for each year of service, but should not in all exceed six-twelfths. Should the worker accept reinstatement, the employer must pay him his wage or salary for the period between dismissal and reinstatement. Should the worker refuse re-employment he is entitled only to wage or salary for the period between the date of his discharge and the date of the conciliation committee's award.

Before giving notice of dismissal to a member of a works representative body, or before transfer of such a worker to another establishment, the employer must obtain the consent of the works representative body.

Membership List of American Chamber of Commerce in Mexico

A printed list of the members of the American Chamber of Commerce of Mexico City has been issued and can no doubt be obtained on application, addressing American Chamber of Commerce of Mexico, at 2A Motolinia 23, Mexico City, Mexico.

Use of Paranitraniline to Standardize Solutions of Sodium Nitrite

By William H. Bell*

THE usual method for the analysis of aromatic amines, such as anthranilic acid, amino G salt, benzidine, dimethylparaphenylenediamine, etc., consists in the diazotization of a definite amount of the aromatic amine by means of a standard solution of sodium nitrite, the end point being ascertained by means of starch-iodide paper. The usual procedure is to use an M/1 (M = molecular weight in grams per liter) solution of sodium nitrite, which is allowed to fall, drop by drop, into a hydrochloric acid solution of the amine. It is customary to dilute the amino solution to about 500 c.c., and to maintain it at a temperature of approximately 15 deg. C., but these factors vary with each individual compound. In some cases, such as aromatic amines containing sulphonic or phenol groups, the amine is first thrown into the sodium salt, the solution cooled, and while stirring vigorously, the compound is precipitated by means of hydrochloric acid. Since the particles come out of solution in fine condition, diazotization is greatly facilitated. Again, in other cases, it is necessary to heat the amino compound with hydrochloric acid, in order to secure solution.

Another factor which varies considerably is the temperature—some compounds must be diazotized as low as 5 deg. C., while others may be safely diazotized as high as 40 deg. C.

In every case, however, the solution is constantly stirred by means of an automatic stirrer, and the sodium nitrite is allowed to drop at such a rate that is used up very quickly. The latter is, of course, ascertained by removing a drop of the solution and testing it with starch-iodide paper.

The Lunge Method

The ordinary procedure in use for the analysis of aqueous solutions of sodium nitrite is based upon the method of Lunge. His method consists in adding a definite volume of sodium nitrite solution to an excess of $KMnO_4$ solution, which has been acidified with sulphuric acid. Sufficient time is allowed for all the nitrite to be oxidized to nitrate, then an excess of KI solution is added. Iodine is liberated and the latter is titrated with sodium thiosulphate, starch being added as indicator.

There is no question as to the accuracy of Lunge's method. However, in the diazotization of aromatic amines, there is a constant source of error, due to the fact that free nitrous acid must be present before an end point is reached. Furthermore, if the sodium nitrite solution had been standardized against an aromatic amine of definite purity, the end point in standardization would contain the same error as is met in the diazotization of unknowns, and the two sources of error, being practically the same, would tend to neutralize each other. The chief source of trouble in applying this method has been in securing an aromatic amine of definite purity. Paranitraniline serves excellently for this purpose, since it can easily be secured in pure form as long yellow needles, of correct melting point, and which I have found by a number of methods to analyze 100 per cent.

*Baldwin Fellow, University of Cincinnati; formerly Chemist, the Ault & Wiborg Co.

Paranitraniline Method

In standardizing an M/1 solution of sodium nitrite, the following procedure is recommended: Dissolve 70 g. of sodium nitrite per liter of distilled water. This will give approximately an M/1 solution. Weigh out 3.4517 g. of paranitraniline, wash into a 600-c.c. beaker, add 10 c.c. conc. HCl, and 100 c.c. water. Heat to effect solution, then add ice and water until temperature is approximately 15 deg. C., and volume of liquid about 350 c.c. Start automatic stirrer, and add sodium nitrite solution, drop by drop, from a burette. If solution is exactly M/1, just 25.0 c.c. of $NaNO_2$ will be required. When 22 or 23 c.c. of solution has been used, it is necessary to test the solution very often for excess nitrous acid. It is best to do this by removing one drop by means of a glass rod and applying it to a piece of starch-iodide paper. When excess nitrous acid is indicated, shut off burette, and test frequently again for several minutes in order to be sure that permanent end point has been reached. Run two other samples of paranitraniline in the same manner, and use the average of the last two results.

$$\frac{25.0}{\text{No. of c.c. } NaNO_2 \text{ used}} = \text{Cor. Fac. for M/1 Solution.}$$

This method has been tested quite thoroughly and has been found quite accurate for the purpose. It is quicker and more convenient than Lunge's method.

Washington, D. C.

Peanuts and Peanut Oil Exports From China

Large quantities of peanuts and peanut oil are produced in the province of Shantung, China, and shipped abroad and to other parts of China. Customs returns show the exportation of the following from Chefoo and Tsingtao to foreign countries and various parts of China:

CHEFOO PRODUCTION IN PICULS

	1914	1915	1916	1917	1918
Peanuts	170,757	243,692	143,557	126,729	78,219
Peanut oil	98	6,834	3,692	2,102	5,326

TSINGTAO PRODUCTION IN PICULS

	Unshelled Peanuts	Shelled Peanuts
1909	336,635	214,000
1910	668,991	
1911	797,058	109,858
1912	829,419	230,987
1913	1,044,000	147,103
1914	964,676	75,573
1915	101,986	57,903
1916	533,601	234,541
1917	410,869	248,387

During the European war, higher freight rates and scarcity of ships caused a decrease in acreage devoted to the cultivation of peanuts, with a corresponding shortage in production and falling off of exports. With the restoration of peace, however, exports have been increasing.

The prices of peanuts and peanut oil are subject to considerable fluctuation. In the spring of 1913, peanuts were quoted at $8.70 (Mexican) per picul at Tsingtao, but just prior to the outbreak of war in 1914 the price fluctuated between $5.50 and $8. At present, however, the price is fluctuating between $4.80 and $9.80.

Peanut oil was quoted at $9.90 per picul at Tsingtao in 1914, but it rose to $19.50 in January, 1918, owing to the keen demand for the oil.

Peanuts and peanut oil are produced in all parts of China, but peanuts produced in Shantung province are well known for their superior quality and are in active demand in both Europe and America.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Indigo and Vegetable Extract Dye Compound.—Indigo paste combines with about eight times its weight of freshly prepared vegetable extract (such as logwood, quebracho or cutch) to form a compound which is readily soluble in soap solution or alizarine oil. This solution dyes yarn or cloth a reddish brown which is developed to the characteristic indigo blue by after-treatment with iron, copper or nickel salts, preferably a solution of copper oxide in ammonium carbonate. Unlike ordinary reduced indigo liquor, the blue color does not develop upon exposure to the atmosphere. JOHN W. FRIES, of Winston-Salem, N. C., has found that oxidized vegetable extract may be reduced by yeast fermentation so that it yields as good results as the freshly prepared extract. The compound may be marketed in powder or paste form. For use it is simply dissolved in 1 per cent soap solution. (1,341,637; June 1, 1920.)

Detonating Fuse.—Detonating fuse or cordeau is ordinarily made by filling a metallic (usually lead) pipe of, say, 1½ in. diameter with molten trinitrotoluene. When the TNT has solidified the diameter of the pipe is reduced by passing through a series of rolls. TNT makes the most satisfactory cordeau, but unless the TNT is very pure, the cordeau deteriorates with age. WILLARD C. COPE, of Woodbury, N. J., has found that the addition of tetryl (2.4.6-trinitrophenyl-methyl-nitramine) increases the velocity of detonation of the cordeau and also prevents deterioration so that an inferior grade of TNT may be used. The proportion of tetryl may vary from 2 to 75 per cent. (1,341,705; assigned to E. I. du Pont de Nemours & Co.; June 1, 1920.)

Caustic Mixtures.—Owing to the necessity of shipping caustic soda in airtight iron drums, JOHN ARMSTRONG, of London, England, proposes to ship a mixture of dry slaked lime and sodium carbonate, which will give a solution of sodium hydroxide when stirred with water, calcium carbonate being precipitated. The mixture is permanent in reasonably dry air and may be put up in paper containers. (1,342,148; one-half assigned to Patent Corporation, Ltd., of Liverpool; June 1, 1920.)

Sulphuric Acid Chambers of Acid-Proof Masonry.—The reactions in sulphuric acid chambers generate large amounts of heat which in lead chambers must be dissipated by radiation. Since the radiating capacity of the chamber is practically a fixed quantity, a rather definite limit of production is set beyond which the chambers fail to function properly. It has long been recognized that the reaction velocity in the chamber process could be increased by a vigorous mixing of the gases, causing them to impinge upon surfaces wet with acid. However, forms of construction hitherto proposed have involved the use of lead so that increased construction and maintenance costs overbalanced the advantages due to increased reaction velocity. ELDON L. LARISON, of Anaconda, Mont., constructs the chamber of acid-proof masonry. The heat of reaction is removed by continuous circulation of sulphuric acid over the tower packing. The concentration of the acid is so regulated as to avoid the absorption of material quantities of nitrogen compounds. By employing for every 2 lb. S in the form of SO_2 an amount of nitrogen compound equivalent to from 1 to 2 lb. $NaNO_3$, it has been found that the usual chamber reactions are accelerated about thirteen times. In lead chambers the ratio is 4 lbs. to 1 lb. $NaNO_3$ equivalent. (1,342,024; June 1, 1920.)

Process of Treating Copper-Bearing Sands.—In the leaching of copper-bearing sands with solutions containing ammonia, difficulty has been encountered in removing the occluded or adsorbed ammonia from the leached material. The loss of solvent has been a source of expense and a cause of low recovery of copper. The ammonia cannot be completely removed by washing with water. A better recovery may be obtained by passing steam through the bed of leached sands and condensing the effluent vapors. The latter method is expensive and entails the use of heavy apparatus to withstand pressure and the apparatus must be made tight to avoid loss.

C. H. BENEDICT and H. C. KENNY of Lake Linden, Mich., avoid the drawbacks attendant with the use of steam under pressure by admitting the steam at atmospheric pressure above the bed of sand and causing it to flow downwardly through the bed by maintaining a partial vacuum beneath the bed. There is some condensation of the steam; this is withdrawn and used as a wash in the treatment of fresh batches of sand. The application of steam is continued with the condensation of effluent vapors until the ammonia content in the condensate falls to a predetermined minimum. The application of steam is then discontinued and hot water distributed uniformly over the upper surface of the bed, the partial vacuum being maintained. The water vaporizes at the diminished pressure as it percolates through the heated sand and the resulting steam entrains the last recoverable trace of adsorbed ammonia. The utilization of the residual heat in the sand avoids the heat losses which obtain where highly heated sands are run directly to waste. (1,335,474; March 30, 1920.)

Process of Recovering Cobalt.—The process consists in roasting the ore in the presence of sulphuric acid, extracting the soluble sulphates with water, precipitating the impurities, such as iron, arsenic and copper, with calcium carbonate, removing the precipitate by filtration, precipitating the cobalt in the filtrate with lime in amount sufficient to form a basic insoluble sulphate. The cobalt is recovered by electrolysis, of a sulphuric acid solution, with insoluble anodes, the electrolyte being maintained at less than 1 per cent acidity by neutralizing the liberated sulphuric acid with the basic sulphate obtained as described. In case copper is not completely precipitated when the solution is treated with calcium carbonate, it may be separated from solution by precipitation on cobalt or removed in a special cell using low voltage. Nickel if present will follow the cobalt through the various steps of the process and, if desirable, can be separated by any of the usual methods. (1,336,765; MARVIN J. UDY of Kokomo, Ind.; assigned to Haynes Stellite Co.; April 13, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent office, Southampton Buildings, Chancery Lane, London, England.

Antimony Pigments.—An antimony pigment suitable for vulcanization is produced by decomposing a mixture of an antimony salt with alkali waste liquor by means of an excess of sulphuric or hydrochloric acid. Any proportion of the alkali waste liquor may be replaced by the product obtained by boiling lime with sulphur. (Br. Pat. 138,137—1919. E. F. MORRIS, Roby, near Liverpool, March 31, 1920.)

Synthetic Tanning Products.—Formaldehyde condensation products are obtained by condensing formaldehyde (or substances yielding it) with mixtures of naphthylamine sulphonic acids and aromatic monohydroxy compounds containing acid salt-forming groups, at 60 to 80 deg. C., in the presence of a little sulphuric acid. The resulting solutions may be used directly for tanning, after neutralizing by alkali the free sulphuric acid present. Products of increased tanning value are obtained by neutralizing the free sulphuric acid in the solutions by hydroxides of metals whose salts have tanning properties, as chromium, aluminum or iron, with or without neutralizing the sulpho groups by alkali. (Br. Pat. 138,796—1919. A. G. BLOXAM, DURAND & HUGUENIN, Basel, Switzerland, April 14, 1920.)

Cellulose for Paper Making.—In the preparation of cellulose for paper making from fibrous plants such as maize, alfalfa, dwarf palm, papyrus, etc., the stalks and leaves are cut up, crushed and washed, and then treated by steam at 2 to 3 kg. pressure for one hour in a digester, condensation water being drained away and taking with it parenchymatous cellulose and soluble matters such as gums and pectates. The cellulose fibers swell up and the cement is partly dissolved. The drain cock is then closed and 13 per cent caustic soda is introduced and circulated by a Koerting injector, or by using a digester of the vomiting type, or other means, the operation being conducted for 3 hr. at 2 to 3 kg. pressure. The product is washed, broken in a beating engine or small mill, and bleached, and may be used for half-pulp paper, such as packing paper. Semi-chemical pulp may be obtained by substituting slaked fat lime for the caustic soda, and, by partial bleaching of the half pulp so produced, a pulp suitable for newspaper is obtained. Alkali materials may be recovered by evaporation and re-causticized by the methods usually employed in soda pulp mills. (Br. Pat. 138,911—1919. SOC. ANON. A. OLIER, Clermont-Ferrand, France, April 21, 1920.)

Phenol-Aldehyde Condensation Products.—Soluble condensation products are first obtained from phenols and aldehydes by heating with catalysts such as sodium salicylate or ammonium sulphocyanide, and are then converted into insoluble products by heating with catalysts such as sodium cyanide or ammonium chloride. An example is given of the treatment of phenol and formaldehyde. The products may be used in the manufacture of varnishes, enamels, plastic compositions, insulating materials, combs, phonograph disks and cylinders, etc. They may be mixed with cellulose esters, sugars, albumens, triacetin, tartaric esters, eugenol, camphor, coloring matters, etc. (Br. Pat. 139,147—1919. L. JALOUSTRE, Z. KHEIFETZ and M. WARCHAVSKY, Paris, April 21, 1920.)

Oxyaldehydes.—Oxyaldehydes and their ethers are produced by the interaction of a phenol or its ether, formaldehyde, and a nitroso compound. The preparation of vanillin by treating guaiacol and formaldehyde with p-nitrosodimethylaniline is described. Anisol aldehyde, pyrocatechin aldehyde and salicylic aldehyde are also referred to. (Br. Pat. 139,153—1919. A. WEISS, Lyons, France, April 21, 1920.)

Sulphur Dioxide From Slag.—Sulphur dioxide sufficiently concentrated for the production of a sulphuric acid is obtained by oxidizing the sulphides in liquid blast-furnace slag by passing a limited amount of air or oxygenated air over or through the slag, or both, or by adding an oxidizing agent such as calcium or magnesium sulphate to the slag, or by both adding such an agent and treating with air. The oxidizing agent may be pre-heated and may be used in molten condition. For this purpose, calcium sulphate may be fused with a small proportion of a flux such as sodium chloride or calcium fluoride. The treatment of the slag is such as not to cause solidification. For instance, the air may be blown through the slag, and the hot air arising therefrom may be passed over the slag as it runs along a covered channel in counter-current. The liberation of the sulphur dioxide may be facilitated by stirring or by blowing in heated air, but the quantity of air should not in any case be such as to yield a product containing less than 4 per cent of sulphur dioxide by volume. The slag may be treated in a slag-pan provided with a hood, dip-pipe and gas outlet, or in one of several covered slag sumps disposed in the slag run. The treated slag is suitable for the manufacture of slag cement, slag wool, etc. (Br. Pat. 139,172 and 139,173—1919. L. H. DIEHL, Berlin, April 21, 1920.)

Cellulose Acetates.—Cellulose acetate is formed by adding a halogen, such as chlorine or bromine, to a mixture of cellulose, acetic acid and acetic anhydride. A halogen acetic acid is formed and acts in its nascent state as a condensing agent. When the action is completed (after about 2 hr. at 70 deg. C.), further esterification is brought about by the addition of a strong acid such as sulphuric or chlorsulphonic acid. The solution may be used for directly making films, artificial silk, horsehair, etc., or the ester may be precipitated. The halogen has also a hydrolytic action upon the cellulose and this action may be varied by varying the temperature (up to 80 deg. C.), the amount of halogen or the length of time of the action. A further hydrolysis may be effected by adding dilute acetic or other acid, formaldehyde or hydrogen peroxide. Esters are obtained which yield solutions of low viscosity in acetone, chloroform, or in mixtures of acetone and alcohol, or of acetone, alcohol and benzol. (Br. Pat. 139,232. J. O. ZDANOWITCH, London, April 28, 1920.)

Chlorination and Sulphonation.—The sulphonation or chlorination of aromatic compounds, such as benzene, toluene or phenol, is effected by atomizing the aromatic compound and sulphuric acid or liquid chlorine into a chamber, from which the mixture passes to a second chamber provided with heating or cooling coils; the product is drawn off from the lowest chamber. The production of benzene monosulphonic acid and chlorbenzene is described. In the case of chlorination, the second chamber contains a catalyst, such as aluminum chloride or ferric chloride. (Br. Pat. 140,007—1919. H. N. MORRIS, Manchester, May 5, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Hearing on Minerals Separation-Miami Contempt Proceedings

At Wilmington, Del., on June 15, a motion to dismiss the petition of Minerals Separation, Ltd., seeking to punish Miami Copper Co. for contempt of court, was heard. The petition also asked an extention of injunction to cover the present operations of that company.

The Miami company held that such a petition for contempt and extension of injunction was not warranted by the facts. It took the ground that such action, under the circumstances, was not the proper procedure. Such action by the court before the Miami company's witnesses had also testified before the Master, it was claimed, would be unfair to the defendant, since the processes enumerated in the petition were the very ones to which so large a part of the testimony already given before the Master referred. Judge Bourquin's decision in the Butte & Superior contempt proceedings (CHEM. & MET. ENG., June 16, 1920, pp. 1099 and 1131) was cited, Miami claiming its case analagous.

Minerals Separation eventually admitted that Miami should have an opportunity to cross-examine Minerals Separation witnesses. Much of the arguments of Minerals Separation counsel was devoted to emphasizing the violence of agitation in various steps of Miami process. Miami counsel, however, made their contention strictly one of procedure.

Miami Petition to Reopen Case Denied

The United States Circuit Court of Appeals of Philadelphia has declined to reopen the case of Minerals Separation, Ltd., vs. the Miami Copper Co. on petition of the latter to admit newly discovered evidence. The order of the court in this matter was filed June 18. While it declines to reopen the case, the court states that it expresses no opinion as to the relevancy and competency of the subject matter of the Miami petition on questions arising in the accounting before the Master.

Large Pulp and Paper Combination Formed

A big combination of pulp and paper manufacturers of Canada has been formed by the merger of the Riordon company of Montreal and the Edwards, the Bronson, and the Gilmour & Hughson companies of Ottawa. This merger, which is a $60,000,000 affair, will control greater pulp wood and timber limits than any other single management in the Dominion.

It will control 12,000 square miles of timber lands in the Ottawa River Valley, containing about 25,000,000 cords of pulp wood, 1,200,000,000 ft. of standing pine and other woods, in addition to water facilities for generating 150,000 hp. The tract is said to be the largest known remaining source of pulp wood and pine in Canada. The pulp and paper output of the new corporation as estimated will be 150,000 tons, while 125,000,000 ft. of pine will also be cut.

Crown-Willamette Installs New Sulphurous Acid System

The Crown-Willamette Paper Co., operating large mills at Camas, Wash., and West Lynn, Ore., and also, under the name of Pacific Mills, Ltd., another mill at Ocean Falls, B. C., has installed the Jennsen tower system for the production of sulphurous acid at the Camas plant. This is the first use of the new system in paper mills on the Pacific Coast. The feature of the Jennsen system consists of high concrete towers which are filled with raw limestone, calcined dolomite being used in this case. Through this rock sulphur dioxide is passed in solution. Under the older and more expensive process, bubbles of sulphur dioxide were passed through a vat containing milk of lime. Efficiency and economy of operation and a greater uniformity of product are advantages of the Jennsen system. If the new process proves up to expectations, it will be installed in all three plants operated by the company.

Another innovation recently inaugurated by the Crown-Willamette Paper Co. is the bringing of sulphur by water instead of by rail from the Gulf of Mexico to Portland, Ore., for distribution to the two plants near that city. The sulphur, as well as the lime rock, is handled entirely in bulk. The rock is to be brought from Puget Sound to Portland by a fleet of sea-going barges.

This same paper company has just purchased 17,500 acres of timber land in Necanicum County, Ore., which cruises a total of 650,000,000 ft. of standing timber. Spruce and hemlock comprise 88 per cent of this timber. The supply is sufficient to keep the mills running for twenty years.

Committee Urges Development of Alaska's Pulp Wood

In a special report to the Secretary of the Interior the Alaska Advisory Committee urges that an intensive campaign be made for the development of Alaska pulp wood. The committee is charged with the duty of searching out ways to better conditions in Alaska and particularly to stimulate industries so as to provide tonnage for the new Alaska railroad.

The committee points out that an ultimate possible annual production of 2,000,000 cords of pulp wood may be obtained from Alaska timber and recommends that the Government launch an intensive campaign for its development. Attention is called to the fact that the water-power resources of Alaska can be used to advantage in this development.

The report declares that 60 per cent of the population of the territory in the past has been directly or indirectly employed by the gold mining industry. To the decline in gold mining is laid the principal blame for Alaska's loss in population and the discouragement of her residents. Thus the maximum prosperity of the territory must await a revival of gold mining.

Water-Power Bill Signed by the President

After twelve years of consideration, Congress at last has adopted a water-power policy and has prescribed exact conditions under which the nation's white coal may be used. The final step, so far as Congress is concerned, was taken May 28 when the Senate, by a vote of 45 to 21, approved the conference report on the water-power bill. The bill was signed by the President prior to June 11 under a formal opinion by the Attorney-General that the adjournment of Congress does not deprive him of the ten days allowed by the Constitution for the favorable consideration of a measure.

While much of the delay in securing this legislation has been due to the difficulty of determining in advance a policy in a matter which has so many ramifications and intricacies, the main conflict has been between those who were emphasizing what they conceived to be necessary in the public protection, as against those who were struggling to secure a law of sufficient liberality to attract capital. In the enactment of some of the so-called conservation measures, the conservation idea was so emphasized that capital could not be interested, with resultant stifling of development.

Believed Capital Will Be Attracted

The water-power bill, just signed, contains many restrictions, but it is believed that capital can be attracted to water-power development under its provisions. It is realized that modifications are certain to be made in the light of experience, and capital apparently is hopeful that it will have an opportunity to make a fair rate of return on investment. On the other hand, in conservation circles, the opinion seems to prevail that the bill is unnecessarily liberal and that the last of the great national resources is being disposed of without proper protection of the interests of the general public.

Much Power Gone to Waste

During the long wrangle over the water-power policy, it is admitted that the country has suffered very large losses through allowing water power to go to waste. Senator Wesley L. Jones, of Washington, the chairman of the Senate Committee on Commerce, under whose jurisdiction the bill comes, estimates that the delay in fixing fair and reasonable terms for the use of water power resulted in the United States being found at the beginning of the World War with 5,000,000 hp. of developed hydro-electric energy, instead of 20,000,000 hp. which it should have had. Caught in the pinch of war, Senator Jones points out, the nation was soon short of coal, short of oil and short of power. Half a billion dollars had to be expended within two years in the erection of steam power plants, just at a time when the capital, labor and material were most needed for other purposes in the prosecution of the war.

Estimates as to the potential water power in the United States vary greatly, but the calculations of the United States Geological Survey place the minimum potential water power of the country at about 35,000,000 hp. and the assumed maximum at something over 65,000,000 hp. This estimate does not take into consideration the increases in horsepower which it will be possible to obtain by providing for storage of water.

Commission to Administer the Act

The act is to be administered by a Federal Power Commission which is to be composed of the Secretaries of War, Interior and Agriculture. The direct administration of the law, however, falls upon an executive secretary. The commission is charged with forty-five specific functions or duties. It has administrative control over all power sites on the navigable waters and on the public lands and reservations of the United States. It is to have to do with the location, design, construction, maintenance and operation of power projects upon such sites. Under certain conditions it must regulate financial operations and fix rates for service, to say nothing of making physical valuations of properties. In addition, the commission is charged with general investigations covering a wide field.

Specific Functions of the Commission

Among the specific functions of the commission are the following:

To issue licenses for power projects and transmission lines on navigable waters, public lands and reservations of the United States.

To investigate and approve all contracts for power made by a licensee which will extend beyond the termination of the license.

To prescribe rules for, and to fix annual license charges and to determine the relation of such charges to prices to consumers.

To hold hearings when desirable or necessary in connection with any application for a permit or license.

To see that projects are best adapted to a comprehensive scheme of improvement and utilization.

To require that project works be properly maintained and kept in efficient operating condition.

To keep in touch with conditions of the power market tributary to every development in order to require extensions as rapidly as conditions warrant.

To prescribe a system of accounting for licenses.

To prescribe rules for the establishment and maintenance of depreciation reserves.

To devise principles for the proper apportionment of surplus earnings to amortization reserves.

To regulate under certain conditions the amount and character of securities which may be issued for the financing of power projects.

To make valuation of all projects brought under license which have been constructed in whole or in part, prior to the application for license.

To determine the net investment and severance damages in the event that properties of the licensee are taken over by the United States at the termination of a licensed period.

Commission Also to Collect Data

In addition, the Commission is charged with the collection and reporting of data concerning:

The utilization of the water-power resources of any region to be developed.

The water-power industry and its relation to other industries and to interstate and foreign commerce.

The location, capacity, development costs and relation to water-power sites.

Whether the power from Government dams can be used advantageously by the United States for its public purposes and what is the fair value of such power.

To determine whether lands of the United States reserved as power sites may be open to entry subject to a reservation of the power rights of the United States.

Deterioration of structures and equipment for the purpose of establishing rates of depreciation and the amount of annual depreciation reserves.

Special Investigations to Be Made

In addition there are a number of special investigations which the Commission must make. One of these is to estimate the cost and economic value of generating hydro-electric power at Great Falls, on the Potomac River, near Washington. The opening up of the nation's water powers is expected to be of special stimulus to the chemical industry.

New Jersey Chemical Society Holds Meeting at Rutgers College

The June meeting of the New Jersey Chemical Society was held at Rutgers College, New Brunswick, by invitation of the Chemical Department, on the afternoon and evening of June 5, and, in spite of the heavy rain, a fair number of out of town members were present. The storm prevented inspection of the college farm, as well as the buildings and grounds, as had been planned, and the afternoon session was devoted to the series of motion pictures contributed by the Goodyear Tire & Rubber Co. of Akron, Ohio.

These showed the entire history, from the collection of the rubber latex, on the company's plantations in Sumatra, through each step in the manufacture, to the final inspection of automobile tires. It was an exhibit of the greatest educational value and intensely interesting.

After dinner had been served in the college dining hall, the evening meeting was begun by an address by Dr. Jacob G. Lipman on the uses of sulphur in agriculture. After showing that the sulphur required by some crops was not present in some soils, Dr. Lipman described his own discovery of oxidizing bacteria on sulphur and finely ground phosphate rock in stable manure, which makes both the sulphur and phosphoric acid available.

A lecture was given by Dr. D. A. Lyon, of the Bureau of Mines, Washington, D. C., on the hydrometallurgy of copper illustrated by motion pictures of the extensive leaching and electro-deposition works at Ajo, Ariz. The processes employed have been so perfected that less than 2 per cent of copper makes the ore worth working, and the pictures gave a clear presentation of the operation of the project.

Awards Recommended by Minerals Relief Commission

A total of $1,238,451.12 has been recommended by the War Minerals Relief Commission for awards to claimants who produced chrome, manganese, tungsten and pyrites in response to the Government's war-time request or demand. This represents 32.6 per cent of the amount asked by the claimants. The total claimed in the cases in which these awards were made was $3,798,756.09. These figures include all claims in which recommendations have been made up to and including the week ended June 12.

Results of Government Nitrate Sales

Not more than 100 tons of the Government's nitrate of soda has been sold under the special statute enacted shortly before the close of the last session of Congress. The act authorized the sale of 100,000 tons of the Government's reserve of nitrate.

The nitrate is being offered at $88.90 a ton. At many points regular dealers in nitrate are making sales at lower figures. It is believed, however, at the War Department that the law at least had the effect of stabilizing the nitrate market.

All orders that have been placed are for ton lots. It is believed by Major J. H. Hunter, the officer in charge of the distribution, that the volume of buying will increase decidedly as the fact becomes more widely known that the War Department is conducting this sale of the material. At several of the points where the nitrate is in storage the Government price is lower than the price in the open market. It is not anticipated, however, that more than 20,000 tons will be sold under the act, which expires Oct. 20.

It is admitted that a larger volume of the nitrate would have been sold had it become available earlier in the year, but owing to the late season it could have been utilized to practically the same advantage had it been purchased when first available. For that reason some are of the opinion that the scarcity of nitrate is nothing like as great as was represented in Congress.

Procter & Gamble to Build Soap Plant in California

An option on about thirty acres of land in the San Francisco Bay district has been taken by representatives of the Procter & Gamble Co. upon which to build a new soap plant. At the beginning about 500 will be employed, but it is expected that double that number will be required shortly.

Personal

ELMER D. BALL, of the Iowa Agricultural College, has been appointed Assistant Secretary of Agriculture. For more than twenty years Mr. Ball has been engaged in investigation and research on agricultural problems or teaching in agricultural colleges.

WALTER M. BERRY, chemist in charge of the gas engineering section of the Bureau of Standards, has just started on a trip through the far West in connection with the Bureau work on gas quality standards and the activities of state public service commissions.

EDWARD CALDWELL, treasurer of McGraw-Hill Co., Inc., and treasurer and director of the McGraw-Hill Book Co., was tendered a dinner by his business associates in commemoration of his thirty years of service with these companies. Mr. Caldwell's first connection with technical journalism was as assistant editor of *Electrical World* in June, 1890. Among other activities he developed the book department of the McGraw Publishing Co. and was later instrumental in effecting the consolidation with the book department of the Hill Publishing Co., known as the McGraw-Hill Book Co. Among his early activities was that of business manager of *Electrochemical Industry*, the forerunner of CHEMICAL & METALLURGICAL ENGINEERING.

EUGENE B. CLARK has been made president of the American Ore Reclamation Co. and of the American Sintering Co., to fill the vacancy caused by the death of James Gayley.

SIDNEY CORNELL, chemical and industrial engineer, has moved his office from 1 West 34th St. to 80 Maiden Lane, New York City. He is spending the summer at Ogunquit, Me.

Dr. F. G. COTTRELL'S nomination as director of the Bureau of Mines was confirmed by the Senate shortly before the adjournment of Congress.

Dr. FREDERIC DANNERTH, who was retained by the C. Kenyon Co. of Brooklyn, N. Y., as consulting chemist, has recently declined the invitation to become head of the new laboratories. The new development department was planned and organized by him and this work was recently completed.

Dr. HENRY S. DRINKER announced his retirement from the presidency of Lehigh University, Bethlehem, Pa., on June 15, 1920. Dr. Drinker was graduated from Lehigh University in 1871, in which year he was one of the founders of the American Institute of Mining Engineers. Since that time he has been devoted to the service of the university, serving as secretary of the alumni, president of the alumni, alumnus trustee, trustee and president.

HENRY B. FABER received the honorary degree of Doctor of Science at Emory University, Atlanta, Ga., on June 10. Dr. Faber is a consulting chemical engineer in New York City, a member of the advisory board of the Chemical Exposition and until recently was actively connected with the Industrial Filtration Co.

EDGAR S. GENSTEIN, formerly engineer of tests, U. S. Naval Ordnance Plant, Charleston, W. Va., is now metallurgist for the Treadwell Engineering Co., Easton, Pa.

E. P. MATHEWSON has been appointed consulting metallurgist to the Granby Consolidated Mining, Smelting & Power Co.

STANLEY P. ROCKWELL has resigned his position as vice-president of Weeks-Hoffman Co., Syracuse, N. Y., to become metallurgist at Whitney Mfg. Co., Hartford, Conn., the change to take place July 1, 1920.

WILLIAM YOUNG WESTERVELT, consulting mining engineer, announces the removal of his office to the Fifth Avenue Guaranty Building, 522 Fifth Ave., New York City.

Obituary

OSCAR H. EBERT, treasurer of the Baugh & Sons Co. and the Baugh Chemical Co., with offices and plants at Philadelphia, Baltimore and Norfolk, died suddenly at his home in Baltimore on Wednesday, June 2, from an attack of acute indigestion, which brought on heart failure. He was ill only one day, and his death came as a great shock to his many friends in the fertilizer industry. Mr. Ebert was fifty-eight years old, and had been connected with the Baugh company more than forty-one years.

WHITFIELD P. PRESSINGER, of New York, vice president Chicago Pneumatic Tool Co., died June 10 as a result of complications following an operation. Mr. Pressinger was actively engaged in the pneumatic tool and allied machinery industry for many years. He was general manager of the Clayton Air Compressor Co. for seven years and became widely known through numerous activities in the American Society of Mechanical Engineers and the Compressed Air Society. He was born in New York City in 1871. In addition to the foregoing societies he was a member of the Sons of the Revolution, 7th N. Y. Regiment Veterans, F. and A. M., and the following clubs of New York City: Engineers, Lawyers, New York Athletic, New York Railroad, Columbia Yacht, and the Machinery Club.

HENRY E. SURFACE, a chemist of national authority on paper and valuation work, was killed in the disastrous wreck Wednesday, June 9, on the N. Y. Central Railroad, at Schenectady, N. Y. He is survived by a widow, Mary Hubbard Surface, and a son, Henry, Jr.

Current Market Reports

The Non-Ferrous Metal Market

New York, June 21, 1920.—A sharp drop in the London copper market caused a depression in this city. Large sellers quote 19c. for June-July deliveries, as before, but in outside market 17.75c. will buy spot copper, 18c. July-August. The tin market is a shade stronger than last week.

	Cents per Lb.
Copper, electrolytic	18.50
Aluminum, 98 to 99 per cent.	34.00
Antimony, wholesale lots	8.00
Nickel, ordinary	45.00
Nickel, electrolytic	45.00
Tin, Straits, spot	46.25
Lead, New York, spot	8.00
Lead, E. St. Louis, spot	7.75
Zinc, spot, New York	7.87½
Zinc, spot, E. St. Louis	7.50

OTHER METALS

Silver (June 17)	oz.	59.67
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.70@2.90
Cobalt	lb.	1.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.65@1.85
Platinum	oz.	75@77
Iridium	oz.	300@400
Palladium	oz.	75@80
Mercury	75 lb.	70@75

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	34.00
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	25.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	43.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	24.00@24.50
Aluminum, sheet scrap	24.00@24.50
Copper, heavy machinery comp.	15.00@15.50
Copper, heavy and wire	14.25@14.75
Copper, light and bottoms	12.50@13.00
Copper, heavy cut and crucible	15.00@15.50
Brass, heavy	9.00@10.00
Brass, light	7.50@8.00
No. 1 clean brass turnings	9.25@9.75
No. 1 comp. turnings	13.00@13.50
Lead, tea	5.00@5.50
Lead, heavy	7.00@7.25
Zinc, scrap	5.00@5.25

The Iron and Steel Market

Pittsburgh, June 18, 1920.

The course of the iron and steel markets has been quite uneventful in the past week. Buying of pig iron continues at a minimum, although there are occasional transactions. In steel there is free buying from the Steel Corporation, but limited business on the part of the independents, the explanation of the divergence being of course the wide difference in prices.

There is absolutely no snap in the market. Buyers take hold for only absolutely known requirements. They seem quite indisposed to consider any business except what it is certain they must place, and show signs of being on the lookout for a good opportunity to relax their efforts and await a more convenient season for activity. Almost throughout the industries there is a growing feeling that it is altogether too difficult to do business, costs being so high and performance on all hands so indifferent. Many observers insist the country needs "the rest cure" and will not be able to do good work until this corrective influence to the present ills has been applied. There is even, perhaps, a disposition on the part of some producers to apply the remedy, possibly in homœopathic doses, in the not distant future.

TRANSPORTATION CONDITIONS IMPROVING SLOWLY

Transportation conditions continue to improve, but very slowly indeed. Early in the week there was a backset in the matter of car supplies to some mills, due to the inauguration of the lake ore and lake coal pools, but this is only temperary, it is claimed, incident to starting the new system, which is expected to result in better service in moving coal to Lake Erie and bringing ore back, in proportion to the number of cars in the service.

In occasional instances steel mills are now shipping as much steel as they produce, but the general average is not as favorable as that, and outside the tin-plate industry there has been no noticeable reduction in the stocks of steel accumulated at any of the mills.

In tin plate excellent results have followed the preference accorded to box car supplies to tin mills, at the instance of the Interstate Commerce Commission. The tin-plate stocks at mills, fully 2,500,000 boxes, equal to the production of about one billion 2-lb. cans, or about one-seventh of the normal requirements of the fruit and vegetable packers, have been reduced to about 1,500,000 boxes, and the current make, at between two-thirds and three-fourths of capacity, has been shipped besides.

Production continues to increase by both blast furnaces

and steel works, and this despite the continued shortage of both coal and coke. The rates of production in both pig iron and steel are now nearly if not altogether up to the rates of last March, the highest since October, 1918, about 40,000,000 tons a year in pig iron and 45,000,000 tons in steel ingots.

Prices in general show no material change. Pig iron is firmly maintained by the furnaces, which experience no difficulty in securing full prices for such prompt deliveries as are called for, while there is little inquiry for second half to tempt price concessions even if sellers were so disposed. There are reports of a few consumers requesting postponements in deliveries, perhaps a reaction from the heavier shipments the furnaces are able to make as car supplies improve.

Prompt deliveries of steel products continue to show a declining tendency, but prompt deliveries have at no time comprised any large part of the turnover. The larger independent mills, able to make shipments in from two to four months, are firm in their price views, and naturally so since the business on books needs to be protected. It is recognized that in the easier general conditions that now obtain requests for postponements or cancellations are a possibility. As to the Steel Corporation, it pursues the even tenor of its way, with its Industrial Board prices, far below the prices of independents, tonnages being allotted from time to time to regular customers for shipment in the indefinite future, and following the shipment of tonnage already on books.

Labor Contest in Prospect

The uninteresting perennial, the sheet and tin plate wage scale settlement between the Amalgamated Association and the sheet and tin mills, about 40 per cent of the total number which sign tonnage wage scales annually with the association, has this year developed news, and a contest of such proportions as circumstances would permit is in prospect. The men had their usual demands for wage advances, and repeated the demand of a year ago for a 6-hr. instead of the thoroughly established 8-hr. shift, and from these demands there would probably have been the usual complete or nearly complete recession, but an entirely novel demand was made, that there should be inserted in the "preamble" to the scale a proviso that the manufacturers signing the scale book—the various tonnage wage scales, for iron mills, sheet and jobbing mills and tin mills are all printed in the one book—should thereby agree to allow the Amalgamated Association a free hand in organizing any other departments the various companies might have. This novel demand seems to have resulted from expectations on the part of the Amalgamated Association officials that the American Federation of Labor might undertake seriously to organize the iron and steel industry, and a feeling that the Amalgamated Association, while small now, is the "logical" body for doing any organizing if there is organizing going to be done. The manufacturers, of course, could not agree, and when it was proposed, at last Monday's session of the conference at Atlantic City, that an adjournment be had to the last week in June, the existing scales expiring June 30, the workers rejoined that if there were going to be an adjournment it would be to the first week in September, as the workmen desired a vacation and the manufacturers seemed to need time for reflection. Adjournment thereupon occurred promptly. Approximately 60 per cent of the sheet and tin mills, about a thousand all told, are non-union, including all those of the Steel Corporation, about 40 per cent of the total. The prospect is that the Amalgamated Association will be eliminated. Except in the sheet, tin plate and iron mill industries it has not been a factor since the Homestead strike of 1892.

The Chemical and Allied Industrial Markets

New York, June 18, 1920.

Developments in the chemical market during the past week have been few, with a slight falling off in demand as the most noticeable feature. As has been the case for some time back, more attention is displayed in locating certain of the more active items than in the actual price that is being asked. Among the *acids* which have been generally scarce for some time fair-sized offerings of *sulphuric*, 60 deg., at \$14@\$19 per ton, in tank cars, have been made, and there is also 1,200 tons of 66-deg. available for prompt shipment from Nitro, W. Va., quoted at \$23@\$26 per ton, sellers' tanks. *Acetic acid*, glacial, is easier with \$16.50 per cwt. as the prevailing quotation on a quantity of three carloads of this material. *Muriatic* is well sustained at \$3.50 per cwt. as the average quotation, while, on the other hand, producers are finding it difficult to meet their contracts for *oxalic*, crystals, for which as high as 65c. per lb. is being asked, but owing to the small stocks on hand it is difficult to determine whether this is an actual sale price or a nominal quotation. It is reported that there is a considerable supply of *anhydrous ammonia* in Philadelphia, but owing to the scarcity of cylinders the producers have been unable to make deliveries. This material is being offered, to those who can furnish cylinders, at 35@45c. per lb. for prompt shipment. The present scarcity of *barium chloride*, brought about by two causes, first the switching of many users from *blanc fixe* to this item during the war and secondly the destruction of the plant belonging to the largest factor in this market, has placed it in a nominal position. There is no immediate relief in sight and \$150@\$180 per ton will continue as the listing for some time. The *formaldehyde* situation seems to be somewhat easier and although production is nowhere near normal, because of the short supplies of *alcohol*, nevertheless an offering of a 50-bbl. lot at 52c. was heard during the week.

Coal-Tar Products

This market is reported on the decline, but as yet no evidence in price changes can be observed. Now that the break is supposed to have occurred, buyers are anxiously waiting to see how far prices will drop. The export business is in as bad condition as it has ever been previously, the war excepted, and with Japan not only out of the buying position but offering resale material below the domestic market, the present waiting position of the buyer seems to be justified. Against this, however, there is the shortage of crude materials and poor transportation facilities to weigh before definitely deciding a big slump is due. *Alpha naphthylamine* dropped to 55@60c., against 65@70c. of the previous week, but even at the new level there has been very little activity. With the principal producer completely sold up on *naphthalene*, there is very little material to be had of any grade except in small resale lots, which are commanding 17@18c. for *flake* and 16@17c. for *balls*. *Paradichlorbenzol* came down slightly and is now listed at \$1.50@\$1.55 per lb., against \$1.65 previously quoted.

Waxes

Interest in this market continues to center on the *paraffine* grades, which have come up throughout the list. No contracts for large quantities are being placed and the prices quoted are those prevailing on the small resale lots which are jumping around the trade.

Miscellaneous Materials

Barytes, quoted f.o.b. Kings Creek, advanced approximately \$2 a ton on both the ground white and off-color product, moving upward from \$20@\$22 and \$16@\$18 respectively as per last week's quotation to \$22@\$25 and \$18@\$20. *Feldspar*, ground, in car lots, f.o.b. Baltimore, showed an advance from \$18 to \$22 per gross ton.

Inquiries for *graphite*, especially the 90 per cent grade of flake, at prices ranging from 8½c. to 9c. per lb., f.o.b. Ashland, Ala., continue strong. It is reported that during the week a shipment of one 60,000-lb. car of 85 per cent guaranteed *carbon*, Alabama flake, was shipped at 11c. delivered. Accumulated stocks are being cleaned up rapidly through the heavy demand for both the lubricating and the 90 per cent crucible grades, and indications are that prices will show a rise if the domestic material continues in use.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots		Less Carlots	
Acetic anhydride	lb.			$0 65	$0 75
Acetone	lb.	$0 15	$0 20	.21	.22
Acid, acetic, 28 per cent	cwt.	3 50	3 75	4 00	4 50
Acetic, 56 per cent	cwt.	6 00	7 50	8 00	9 00
Acetic, glacial, 99½ per cent., carboy	cwt.	15 50	16 00	16 50	17 50
Boric, crystals	lb.	.15	.15½	.15	.16½
Boric, powder	lb.	.15	.15½	.15	.16
Citric	lb.	1 05	1 12	1.17	1 18
Hydrochloric (nominal)	cwt.	2 00	3 00	3.50 –	4 00
Hydrofluoric, 52 per cent	lb.	.13½	.14	14½–	15
Lactic, 44 per cent tech	lb.	.11	.11½	12 –	16
Lactic, 22 per cent tech	lb.	.04	.05½	.06 –	07
Molybdic, C. P.	lb.	4.00	4 50	4.50 –	5 00
Muriatic, 20 deg. (see hydrochloric).					
Nitric, 40 deg.	lb.	.06 –	.7	07½	08½
Nitric, 42 deg.	lb.	.07	.8	.8	09½
Oxalic, crystals	lb.	.55	.57	.60 –	65
Phosphoric, Ortho, 50 per cent solution	lb.	.14 –	.23	24 –	25
Picric	lb.	.28 –	.35	.40 –	.50
Pyrogallic, resublimed	lb.	2.25 –	2.55	2.60 –	2 65
Sulphuric, 60 deg., tank cars	ton	14.00 –	19.00		
Sulphuric, 60 deg., drums	ton				
Sulphuric, 66 deg., tank cars	ton	23.00 –	24.00	25.00 –	26 00
Sulphuric, 66 deg., drums	ton	35 00 –	40.00	45.00 –	50.00
Sulphuric, 66 deg., carboys	ton	36 00 –	40 00	50.00	55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –	30.00	37.00 –	42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –	30 00	38 00	42 00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 –	35 00	40 00	
Tannic, U. S. P.	lb.	1.45 –	1 50	1.55	1 60
Tannic (tech.)	lb.			.00 –	80
Tartaric, crystals	lb.			80	85
Tungstic, per lb. of WO	lb.			1 20	1 40
Alcohol, Ethyl (nominal)	gal.	5.10 –	5.50	6.00	7 00
Alcohol, Methyl, 95°	gal.			2.50 –	2 70
Alcohol, Methyl, pure	gal.			3 50	3.55
Alcohol, denatured, 188 proof (nominal)	gal.			1.10 –	1 15
Alcohol, denatured, 190 proof (nominal)	gal.			1.05 –	1 10
Alum, ammonia lump	lb.	.04½–	.05	.05½–	06
Alum, potash lump	lb.	.07½–	.08¼	.09 –	.09½
Alum, chrome lump	lb.	.15½–	.18	19 –	20
Aluminum sulphate, commercial (nominal)	lb.	.02 –	.03	.03½–	04½
Aluminum sulphate, iron free	lb.	.03½–	.04	.04½	04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½–	.10¼	.11 –	12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 –	.35	.35 –	.40
Ammonium carbonate, powder	lb.	.16 –	.16½	.17 –	.17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 –	.16½	.17 –	.18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½–	.13½	.13½–	.14½
Ammonium nitrate	lb.	.08½–	.09½	10 –	.11
Ammonium sulphate	lb.	.07 –	.07¼	.08½–	
Amylacetate	gal.			5.00 –	
Amylacetate tech	gal.			4.75 –	5.25
Arsenic, oxide, lumps (white arsenic)	lb.	.15½–	.16	16½–	17
Arsenic, sulphide, powdered (red arsenic)	lb.	20 –	.21	22 –	23
Barium chloride	ton	150.00–	160 00	170.00–	200.00
Barium dioxide (peroxide)	lb.	.21 –	.23	.24 –	.25
Barium nitrate	lb.	.09½–	.11	.11 –	.12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½–	.05	.05½–	.06
Bleaching powder (see calcium hypochlorite)					
Blue vitriol (see copper sulphate)					
Borax (see sodium borate)					
Brimstone (see sulphur, roll)					
Bromine	lb.	.70 –	.90	1.00 –	1.05
Calcium acetate	cwt.	3.50 –	3.55		
Calcium carbide	lb.	.04½–	.04½	.04¾–	.05¾
Calcium chloride, fused, lump	ton	23.00 –	25.00	30.00 –	40.00
Calcium chloride, granulated	lb.	.01½–	.01¾	.02 –	.02½
Calcium hypochlorite(bleaching powder)	cwt.	4 00 –	4 25	4 50 –	6.50
Calcium peroxide	lb.			1 50 –	1.70
Calcium phosphate, monobasic	lb.			75 –	.80
Calcium sulphate, pure	lb.			.25 –	.30
Carbon bisulphide	lb.	.08 –	.09	10 –	.11
Carbon tetrachloride, drums	lb.	.11 –	.11½	.12 –	.15½
Carbonyl chloride (phosgene)	lb.			.80 –	1.05
Caustic potash (see potassium hydroxide)					
Caustic soda (see sodium hydroxide)					
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 –	.09½	.10 –	.10½
Chloroform	lb.	.30 –	.35	.36 –	.38
Cobalt oxide	lb.			2.00 –	2.05
Copperas (see iron sulphate)					
Copper carbonate, green precipitate	lb.	.27 –	.28	.29 –	31
Copper cyanide	lb.	.08 –	.09	.65 –	.70
Copper sulphate, crystals				.09 –	.09¼
Cream of tartar (see potassium bitartrate)					
Epsom salt (see magnesium sulphate)					
Ethyl Acetate Com. 85%	gal.	1.35 –		1 40 –	
Ethy Acetate pure (acetic ether 98% to 100%)				1 75	
Formaldehyde, 40 per cent (nominal)	lb	.36 –	40	.57 –	.65
Fusel oil, ref	gal.			5.25 –	6 00
Fusel oil, crude (nominal)	gal.				
Glauber's salt (see sodium sulphate)					
Glycerine	lb.	4.30 –	4.35	.26½–	28½
Iodine, resublimed	lb.			4.40 –	4 45
Iron oxide, red	lb.			.03 –	.20
Iron sulphate (copperas)	cwt.			2.90 –	3 10
Lead acetate, normal	lb.		.12	13½–	16
Lead arsenate (paste)	lb.	.11 –	.1	13 –	17
Lead nitrate, crystals	lb.			90 –	1.00
Litharge	lb.	.14 –	.15	15½–	.16
Lithium carbonate	lb.			1.50 –	
Magnesium carbonate, technical	lb.	.12 –	.14	.15 –	16
Magnesium sulphate, U. S. P.	100 lb.	3.00 –	3.55	4.00 –	4 50
Magnesium sulphate, commercial	100 lb.			3 25 –	3.60
Nickel salt, double	lb.			.14 –	16
Nickel salt, single	lb.			.16 –	18
Phosgene (see carbonyl chloride)					
Phosphorus, red	lb.	.50 –	.55	.60 –	65
Phosphorus, yellow	lb.			.35 –	37
Potassium bichromate	lb.	.35 –	.37	.45 –	.46
Potassium bitartrate (cream of Tartar)	lb.	.52 –	.56	57 –	58
Potassium bromide, granular	lb.	.80 –	.85	90 –	95
Potassium carbonate, U. S. P.	lb.			85 –	88
Potassium carbonate, crude	lb.	.21 –	.25	.26 –	28
Potassium chlorate, crystals	lb.	$0 15	$0 16	.20 –	.21
Potassium hydroxide (caustic potash)	lb.	.28	.29	.31 –	.35
Potassium iodide	lb.			3 –	3 66
Potassium nitrate	lb.	.15	.17	.19 –	.21
Potassium permanganate	lb.	.75	.80	.87 –	.95
Potassium prussiate, red	lb.	.1	1 00	1 –	
Potassium prussiate, yellow	lb.	.2	.3	.55 –	30
Potassium sulphate (powdered)	ton	225	240 00		
Rochelle salts (see sodium potas tartrate)					
Salammoniac (see ammonium chloride)					
Sal soda (see sodium carbonate)					
Salt cake	ton	28 00	32 00		
Silver cyanide (nominal)	oz.			1 25	
Silver nitrate (nominal)	oz.			.74	76
Soda ash, light	100 lb.			3 50	3 60
Soda ash, dense	100 lb.			3 55 –	3 65
Sodium acetate	lb.	.08	.09	.07½	12
Sodium bicarbonate	100 lb.	2 25	2 60	2 75	3 50
Sodium bichromate	lb.	.30	.35	34	.4
Sodium bisulphate (nitre cake)	ton	7 00	7 50	8 –	10 00
Sodium bisulphite Powered	lb.	.06	.07½	.07	10
Sodium borate (borax)	lb.	.09	.1	11 –	12
Sodium carbonate (sal soda)	100 lb.	1 60	1 80	1 80	2.00
Sodium chlorate	lb	.10	.16	.10	.11
Sodium cyanide, 96-98 per cent.	lb.	.24	.25	.26	27
Sodium fluoride	lb.	.18		.19	26
Sodium hydroxide (caustic soda)	100 lb.	4 25	6 00	6 25	6 50
Sodium hyposulphite	lb			.3	.04
Sodium molybdate	lb.	2 50		3 –	
Sodium nitrate	100 lb.	3.00	3 25	3 75	4 00
Sodium nitrite	lb.	.19	.19	.20	.21
Sodium peroxide, powdered	lb.	.32	.35	.35 –	.40
Sodium phosphate, dibasic	lb.	.03	.04½	.04½	.05
Sodium potassium tartrate (Rochelle salts)	lb.			.39	.40
Sodium prussiate, yellow	lb.	.23 –	.27	.31 –	.32
Sodium silicate, solution (40 deg.)	lb.	.01¼	.01½	.02	.02¼
Sodium silicate, solution (60 deg.)	lb.	.03¼	.03	.04 –	.05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1 60	1.70	1 75	2 50
Sodiumsulphide, crystal, 60–62per centcone	lb.	.09 –	.10	.10½	.11
Sodium sulphite, crystals	lb.	.03½–		.04 –	.06
Strontium nitrate, powdered	lb.	.17½–	.18½	.19 –	.20
Sulphur chloride	lb.	.05½–		.06 –	
Sulphur, crude	ton	22.00 –			
Sulphur dioxide, liquid, cylinders	lb.	.09 –		.10 –	.12
Sulphur (sublimed), flour	100 lb.	3 35 –		3.40 –	3.65
Sulphur, roll (brimstone)	100 lb.	3 20 –		3.30 –	3.40
Tin bichloride (stannous)	lb.	.42½–		.46 –	.50
Tin oxide	lb.	.60 –	.63	.65 –	
Zinc carbonate, precipitate	lb.	.16	.18	.19 –	.20
Zinc chloride, gran.	lb.	.13	.13½	.13½–	.17
Zinc cyanide	lb.	.49		.50 –	.60
Zinc dust	lb.	.12½		.13 –	.15
Zinc oxide, U. S. P.	lb.	.18 –	.19	.20 –	.21
Zinc sulphate	lb.	.03½–	.03¾	.04 –	.06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities.

Alpha naphthol, crude	lb.	$1.40 —	$1.50
Alpha naphthol, refined	lb.	1 60 —	1 70
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, drums extra	lb.	.35 —	.40
Aniline salts	lb.	.40 —	.50
Anthracene, 80% in drums (100 lb.)	lb.	.90 —	1 00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.35 —	1.40
Benzidine, sulphate	lb.	1 15 —	1 25
Benzoic acid, U.S.P.	lb.	.90 —	1.00
Benzoate of soda, U.S.P.	lb.	.80 —	.90
Benzol, pure, water-white, in drums (100 lb.)	gal	.27 —	.40
Benzol, 90%, in drums (100 lb.)	gal	.25 —	31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	3 50 —	4.00
Beta naphthol, sublimed (nominal)	lb.	80 —	.90
Beta naphthol, tech (nominal)	lb.	65 —	85
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	18 —	19
Ortho-cresol, in drums (100 lb.)	lb	23 —	25
Cresylic acid, 97-99%, straw color, in drums	gal	1 10 —	1 20
Cresylic acid, 95-97%, dark, in drums	gal	1.00 —	1 05
Cresylic acid, 50%, first quality, drums	gal	65 —	75
Dichlorbenzol	lb.	08 —	10
Diethylaniline	lb.	1 50 —	1 60
Dimethylaniline	lb.	1.35 —	1 55
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb	30 —	35
Dinitronaphthaline	lb.	45 —	55
Dinitrophenol	lb.	40 —	45
Dinitrotoluol	lb.	40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal	38 —	40
Diphenylamine (nominal)	lb.	80 —	85
H-acid (nominal)	lb.	2 25 —	2 50
Metaphenylenediamine	lb.	1 15 —	1 30
Monochlorbenzol	lb.	18 —	20
Monoethylaniline	lb.	2.00 —	2 40
Naphthaline crushed, in bbls. (250 lb.)	lb.	17 —	
Naphthaline, flake	lb.	17 —	18
Naphthaline, balls	lb.	16 —	18
Naphthionic acid, crude	lb.	75 —	85
Nitrobenzol	lb.	14 —	15
Nitro-naphthaline	lb.	40 —	50
Nitro-toluol	lb.	18 —	25
Ortho-amidophenol	lb.	3 25 —	4 25
Ortho-dichlor-benzol	lb.	15 —	20
Ortho-nitro-phenol	lb	80 —	1 25
Ortho-nitro-toluol	lb.	25 —	40
Ortho-toluidine	lb.	35 —	45
Para-amidophenol, base	lb.	2 50 —	3 00
Para-amidophenol, HCl	lb.	2.50 —	3 00
Para-dichlor-benzol	lb	08 —	12
Paranitraniline	lb.	1 50 —	1 55
Para-nitro-toluol	lb.	1 35 —	1 50
Paraphenylenediamine	lb.	2 60 —	3 00
Paratoluidine	lb.	2 00 —	2 50
Phthalic anhydride	lb.	65 —	75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	12 —	20
Pyridin	gal.	2 00 —	3 50
Resorcin, technical	lb.	4 25 —	4 50
Resorcin, pure	lb	6 25 —	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0 50	—	$0.52
Salicylic acid, U. S. P.	lb.	.50	—	.60
Silol	lb.	.90	—	1 00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal	.28	—	...
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal	.35	—	...
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb	$0 36	—	$0 39
Beeswax, refined, light	lb.	39	—	40
Beeswax, white pure	lb.	63	—	68
Carnauba, No. 1. (nominal)	lb.	1 00	—	1 05
Carnauba, No. 2, regular (nominal)	lb.	85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.43	—	44
Japan	lb	.21	—	22
Montan, crude	lb.	23	—	25
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.09½	—	10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½	—	.12¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.14½	—	.15
Paraffine waxes, refined, 133-135 m.p.	lb.	.16½	—	.17
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb	.26	—	.27
Stearic acid, triple pressed	lb.	.27	—	.28

NOTE—Quotations on paraffine waxes are nominal

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1 80
Pine oil, pure, dest. dist.	gal	1 60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal	48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal	35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal	85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal	36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1 75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots

Rosin B-D, bbl.	280 lb.	$17 50	—	$18 00
Rosin E-I	280 lb.	18 50	—	19 75
Rosin K-N	280 lb.	20 00	—	21 00
Rosin W. G.-W. W.	280 lb.	21 25	—	23 00
Wood rosin, bbl	280 lb	17 00	—	17 00
Spirits of turpentine	gal	1 85	—	
Wood turpentine, steam dist.	gal.	1 70	—	1 80
Wood turpentine, dest. dist.	gal.	1 40	—	1 50
Pine tar pitch, bbl.	200 lb		—	8 50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15 00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	87	—	.89
Rosin oil, second run	gal.	89	—	.92
Rosin oil, third run	gal.	1 04	—	1 05
Rosin oil, fourth run	gal.	1 12	—	1.12

Solvents

74-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.37½	—	$0.38
Upriver coarse	lb.	.28½	—	.29½
Upriver caucho ball	lb.	.30	—	.30½
Plantation—First latex crepe	lb.	.38	—	.39
Ribbed smoked sheets	lb.	.38½	—	.39
Brown crepe, thin, clean	lb.	.37	—	.38
Amber crepe No. 1	lb.	.....	—	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.22
China wood oil, in bbls.	lb.	.22½	—	.23½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½	—	.19½
Corn oil, crude, in bbls.	lb.	.17½	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.16½	—	.16¾
Cottonseed oil, summer yellow	lb.	19	—	.19½
Cottonseed oil, winter yellow	lb.	21	—	22
Linseed oil, raw, car lots, domestic	gal.	1 57	—	1 67
Linseed oil, raw, tank cars (domestic)	gal.	1 52	—	1 62
Linseed oil, boiled, car lots (domestic)	gal.	1.60	—	1.70
Olive oil, commercial	gal.	3 10	—	3 25
Palm, Lagos	lb.	.12	—	.13½
Palm, bright red	lb.	.13	—	.13½
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	13	—	.15
Peanut oil, refined, in bbls.	lb	.22	—	.24
Rapeseed oil, refined, in bbls.	gal	1.70	—	1 72
Rapeseed oil, blown, in bbls.	gal	1.80	—	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½	—	.13½

FISH

Winter pressed Menhaden	gal	$1 17	—	$1 18
Yellow bleached Menhaden	gal.	1.20	—	1 22
White bleached Menhaden	gal.	1.23	—	1 24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$22.00	—	$25.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	18.00	—	20.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off-color, f.o.b. Cartersville	net ton	16.00	—	19 00
Barytes, crude, 88%@94% ba., Cartersville	net ton	12.00	—	...
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00
Casein	lb.	.15	—	.18
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8 00	—	12 00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40 00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar (nominal) f.o.b. N. Y. State	net ton	16.00	—	20.00
Feldspar, crude, f.o.b. Maryland and North Carolina, points	net ton	7.50	—	8 00
Feldspar, ground, f.o.b. Baltimore	net ton	22.00	—	25.00
Feldspar, ground, f.o.b. North Carolina	net ton	16.00	—	20.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25 00	—	...
Fuller's earth, powdered, f.o.b. Fla.	net ton	18 00	—	...
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala	lb.	....	—	.01
Graphite (dust facing grade 50%) Ashland, Ala	lb.	....	—	.02
Graphite, crucible, 80% carbon Ashland, Ala	lb	....	—	.05
Graphite, crucible, 90% carbon Ashland, Ala.	lb.	....	—	10
Graphite, crucible, 85% carbon	lb.	....	—	.08
Graphite, crucible, 88% carbon	lb.	....	—	09½
Graphite, crucible, 90% carbon	lb.	....	—	.10½
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	...
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	....	—	10 00
Quartz (acid tower) 1½ to 2 in., f.o.b. Baltimore	net ton	....	—	14 00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	....	—	17 00
Quartz, lump, f.o.b. North Carolina	net ton	5 00	—	7.50
Shellac, orange, fine	nominal lb	1 40	—	...
Shellac, orange, superfine	lb.	1 50	—	...
Shellac, A. C. garnet	lb.	1.10	—	1.15
Shellac, T.N.	lb.	1.15	—	1 25
Soapstone	ton	15.00	—	25 00
Talc, paper-making grades, f.o.b. Vermont	ton	9.50	—	14 00
Talc, roofing grades, f.o.b. Vermont	ton	8 00	—	9 00
Talc, rubber grades, f.o.b. Vermont	ton	9 00	—	15 00
Talc, powdered, Southern, f.o.b. cars	ton	12 00	—	15 00
Talc, talcum powder grade, California	ton	20 00	—	35.00
Talc, imported	ton	60.00	—	70.00

Refractories

Following prices are f.o.b. Works:

Chrome brick, 9 in. straights and sizes	net ton $80-90 at Baltimore
Chrome brick	net ton 75-80 at Chester, Penn.
Chrome cement	net ton 45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000 45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000 40-45 at Clearfield, Penn.
Fire clay, f.o.b. Baltimore	net ton 5—7
Magnesite, dead burned	net ton 50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton 85 90 at Chester, Penn.
Magnesite brick, 9 in. straights	net ton 90 at Baltimore
Magnesite brick, 9 in. sizes and shapes larger than 9 in.	Regular extras
Silica brick	1,000 50-55 at Mt. Union, Penn.
Silica brick, 9 in. and 9 in. sizes	1,000 55, Chicago District

Ferro-Alloys

All Prices f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.17	—	.18
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon	lb.	.18	—	.19
Ferro-manganese, 70-80% Mn.	gross ton	200 00	—	250.00
Spiegeleisen, 16-20% Mn.	gross ton	72 50	—	75 00
Ferro-molybdenum, per lb. of Mo.	lb.	2 25	—	2 75
Ferro-silicon, 10-15%	gross ton	60 00	—	65 00
Ferro-silicon, 50%	gross ton	80 00	—	90 00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	90	—	1.10
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7 00	—	...
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All Prices f. o. b. Mines

Chrome ore, 40%, min., Cr_2O_3 f.o.b. Atlantic Seaboard	unit	$0.70	—	$0.85
Coke, foundry, f.o.b. ovens	net ton	16.00	—	16.50
Coke, furnace, f.o.b. ovens	net ton	15.00	—	15.50
*Petroleum coke, refinery, Atlantic seaboard	net ton	....	—	24.00
Fluor spar, gravel, f.o.b. mines	net ton	22.50	—	25.00
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50	—	....
Manganese ore, 45% Mn and over	unit	.80	—	85
Manganese ore, chemical (MnO_2)	gross ton	75.00	—	85.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.85	—	....
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	....
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore per lb. of V contained	lb.	1.00	—	3.00
Pyrites, foreign, lump, per unit of S contained	unit	.16½	—	....
Pyrites, foreign, fine, per unit of S contained	unit	.16⅜	—	....
Pyrites, domestic, fine, per unit of S contained	unit	.16	—	.17½
Ilmenite, 52% TiO_2, per lb. ore	lb.	.02	—	....
Rutile, 95% TiO_2 per lb. ore	lb.	.20	—	.25
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	2.75	—	3.00
Zircon, washed, iron free	lb.	.10	—	.....
Monazite, per unit of ThO_2	unit	42.00	—	.....

*Nominal

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

STEGE—The Stauffer Chemical Co. is building a modern sulphuric acid plant here. The plant will have a daily capacity of 10 tons of concentrated acid. Estimated cost, $1,000,000.

Colorado

JOHNSTOWN—The Great Western Sugar Co., Sugar Bldg., Denver, has purchased a site here and is having plans prepared for the construction of a factory on same. Estimated cost, $2,000,000.

Connecticut

NEW LONDON—The United States Electric Co., 108 State St., has awarded the contract for the construction of a 75x101-ft. foundry for the manufacture of electric riveter and heater, at 21 Trumbull St., to A. T. Jackson & Co., 108 State St. Estimated cost, $50,000.

Idaho

JEROME—The Bd. of Trustees for the Independent School Dist. 33, will soon award the contract for the construction of a high school. Chemical and physical laboratories will be installed in same. Oliver Hill, clk.

Illinois

ASHLAND—School Dist. 212 has awarded the contract for the construction of a 1-story, 105x180-ft. high school, to C. H. Schenk, 2068 South 5th St., Springfield, at $110,000. Experimental laboratory equipment will be installed in same.

MONTICELLO—The Bd. Educ. is having plans prepared for the construction of a 2-story, 110x192-ft. high school here. A small chemical laboratory will be installed in same. Estimated cost, $200,000. J. C. Llewellyn, 38 South Dearborn St., Chicago, archt.

WAGGONER—The Community High School Bd. plans to construct a high school here. A small chemical laboratory will be installed in same. Estimated cost, $60,000. J. N. Coleman, 6257 St. Laurence St., Chicago, archt.

Indiana

SHELBYVILLE—The stockholders of the Citizens Gas Co. have voted in favor of the construction of an artificial gas plant here.

Iowa

DES MOINES—The Des Moines Fdry. & Machine Co., 314 Flynn Bldg., has awarded the contract for the construction of a 1-story, 130x220-ft. foundry and machine shop on 16th St. and Wabash Ave., to F. D. Chase, Inc., 17 Battery Pl., New York City. Estimated cost, $350,000.

Kansas

NORTON—The city has awarded the contract for the construction of an addition to the sewage treatment plant, powerhouse, dam, etc., to Green & Rickey.

Kentucky

STURGIS—The Bd. Educ. has awarded the contract for the construction of a high school here, to J. N. Boston & Son, Marion, Ky. A chemical laboratory will be installed in same. Estimated cost, $45,000.

Maine

BIDDEFORD—The Saco-Lowell Shop, 77 Franklin St., Boston, has awarded the contract for the construction of a 1-story, 160x200-ft. foundry, to the Aberthaw Constr. Co., 27 School St., Boston, at $250,000.

Maryland

BALTIMORE—The LaMotte Chemical Products Co., 13 West Saratoga St., plans to construct two 1-story laboratories. The company is in the market for earthenware, filters, crystallization vats, vacuum pumps, laboratory and general equipment. F. J. LaMotte, pres. and mgr.

BALTIMORE—The Prest-O-Lite Co., Inc., 30 East 42nd St., New York City, will soon award the contract for a 1-story, 25x50-ft. acetylene plant in connection with the 8 proposed acetylene buildings here. Estimated cost, $75,000.

FREDERICK—The Frederick County School Comrs. have awarded the contract for the construction of a 2-story high school addition, to L. C. Culler, Knights of Pythias Bldg. Plans include a chemical laboratory, machine shop, etc.

SPARROW'S POINT (Baltimore P. O.)—The Bethlehem Steel Corp. plans to increase its unit here. New blast furnaces will be installed and the capacity of the present tin plate plant will be doubled by the addition of 24 mills. Eugene G. Grace, pres.

Massachusetts

GARDNER—The Amer. Fibre Corp. has awarded the contract for the construction of a 1-story fiber manufacturing plant on Coleman St., to N. E. Frissul, at $75,000.

Michigan

BAY CITY—The Wildman Rubber Co., Book Bldg., Detroit, is having plans prepared for the construction of a 1- and 3-story rubber manufacturing building. Estimated cost, $2,000,000. Osborn Eng. Co., 2848 Prospect Ave., Cleveland, O., archt. and engr.

GRAND RAPIDS—The Oliver Machinery Co., 1025 Coldbrook St., N. E., will build a 1-story foundry addition on Coldbrook St. Foundry equipment will be installed in same. Estimated cost, $50,000. Work will be done by day labor.

New Jersey

NEWARK—Max Hertz, 68 Oliver St., has awarded the contract for the construction of a 1-story factory addition for the manufacture of leather at 74 Oliver St., to J. W. Ferguson Co., United Bank Bldg., Paterson. Estimated cost, $20,000.

TRENTON—The Bergeuman Rubber Corp., East State St., is in the market for $60,000 worth of machinery for plant now being constructed. Herbert Coleman, pres.

TRENTON—The John E. Thropp Sons Co., Fair St., has awarded the contract for the construction of a 1-story, 150x160-ft. foundry on Fair St., to the Austin Co., Bulletin Bldg., Philadelphia, Pa. Estimated cost, $36,000.

New York

BROOKLYN—Henry Holder, archt. and engr., 242 Franklin Ave., plans to construct a 1-story, 100x250-ft. foundry. Estimated cost, $250,000. Owner's name withheld.

BUFFALO—The Jacob Dold Packing Co., 745 William St., had plans prepared for the construction of a tank house and a fertilizer building. Estimated cost, $250,000.

TONAWANDA—The Bd. of Pub. Works has commissioned Chester & Fleming, consult. engrs., Union Bank Bldg., Pittsburgh, Pa., to make a report on the sewerage and sewage disposal systems for the city.

Ohio

RAVENNA—The Natl. Furnace Stove Co. is having plans prepared for the construction of a 1-story, 80x220-ft. office and foundry building. Estimated cost, $125,000. M. Minsman, mgr. D. C. Smith, 4500 Euclid Ave., Cleveland, archt. and engr.

Pennsylvania

BLAIRSVILLE—The Western State Hospital for the Insane plans to construct a sewage disposal plant, concrete hospital buildings, etc. at Torrance, near here.

PHILADELPHIA—The Keystone Leather Co., 9th and Westmoreland sts., plans to build a 1-story, 45x50-ft. factory addition on 19th and Ontario Sts. Estimated cost, $10,000.

WILKES BARRE—The Wilkes-Barre Berlois Tin Co., Pennsylvania Ave., plans to build a 2-story, 75x75-ft. tin factory. Estimated cost, $40,000.

South Carolina

CAYCE—The Seminole Fertilizer & Oil Co., Jacksonville, Florida, has purchased site here and had plans prepared for the construction of a fertilizer and mixing plant here. Noted May 12.

Texas

ALPINE—E. F. Berkeley, mayor will soon award the contract for furnishing material and labor including a sedimentation tank, etc., for the construction of a sewer system for the city.

Virginia

MARTINSVILLE—S. G. Whittle, Jr. will receive bids until July 15 for the construction of a 2-story high school here. A chemical laboratory will be installed in same. W. C. Northup, Winston-Salem, N. C., archt.

RICHMOND—The Gould Fire Prevention Products Co., 215 Travelers Bldg., is in the market for full equipment for manufacturing oil, lead and zinc paints.

Washington

VALLEY—The Amer. Mining Production Co. is building a kiln, etc., for the treatment of magnesite. Estimated cost, $50,000. Howard F. Wierum, engr.

Wisconsin

APPLETON—St. Elizabeth Hospital plans to build a 4-story hospital. A chemical laboratory will be installed in same. Estimated cost, $500,000. Address Franciscan Sisters.

BEAVER DAM—The F. Kassman Mfg. Co. plans to build a 1-story, 60x120-ft. molding foundry addition on Main St.

CORNELL—The Cornell Wood Products Co. has awarded the contract for the construction of a 2-story, 44x320-ft. paper making plant here, to W. E. Uhle, Stevens Point. Estimated cost, $1,000,000.

PORT WASHINGTON—The Turner Mfg. Co. is having plans prepared for the construction of a 1-story foundry here. Estimated cost, $50,000. F. D. Chase, Inc., 645 North Michigan Ave., Chicago, engr.

RACINE—S. C. Johnson & Son, 1012 Sixteenth St., rejected bids for the construction of a 4-story, 60x160-ft. warehouse and varnish plant. Work will be readvertised. Noted June 9.

WAUKESHA—F. C. Blair & Son, 240 B'way, plans to build a 1-story foundry.

Wyoming

SHOSHONI—The Wyoming Chemical Products Co., Duluth, Minn., plans to build a plant including several buildings for the manufacture of alum and epsom salts from the natural deposits near Shoshone Siding along the Chicago, Burlington & Quincy R.R. Estimated cost, $200,000. The company is in the market for 3 triple effect evaporators, drying equipment, etc. W. G. Wey, engr.

Ontario

BRANTFORD—S. C. Johnson & Son, Racine, Wis., is having plans prepared for the construction of a factory to manufacture floor waxes, varnishes, etc.

TORONTO—The Bd. Educ., College St., plans to construct a 3-story technical school including chemical laboratory equipment, etc. Estimated cost, $400,000. Address Dr. McKay, Central Technical School, College St.

TORONTO—The Canada Creosoting Co., 1006 Canadian Pacific R.R. Bldg., plans to construct a plant and is in the market for creosoting cylinders etc. Estimated cost, $150,000.

Quebec

MONTREAL—The Natl. Drug Co., St. Laurence St., will soon receive bids for the construction of a plant in the St. Henry Dist. Estimated cost, $275,000.

MONTREAL — The Phillips Electrical Co., Craig St., West, has awarded the contract for the construction of a 2-story, 40x60-ft. factory for the manufacture of electrical goods, on Henri Julien St., to Nicholson Co., St. Catharine St., West, at $22,000.

ST. ANNE DE MONTS—The Great Eastern Pulp & Paper Co., London, Great Britain, plans to build a pulp and paper plant here.

SHAWINIGAN FALLS—The Northern Aluminum Co. will soon receive bids for the construction of an office building and is in the market for laboratory equipment.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its twelfth semi-annual meeting as follows: June 28 and 29 will be spent in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its one hundred and twenty-second meeting Aug. 20 to Sept. 3, at Lake Superior.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its annual meeting at the New Monterey Hotel, Asbury Park, N. J., June 22 to 25.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE FOREST PRODUCTS LABORATORY will hold its decennial celebration at Madison, Wis., July 22 and 23, 1920.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its mid-summer meeting at Boston, July 15 and 16.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE NATIONAL FERTILIZER ASSOCIATION will hold its twenty-seventh annual convention at the Greenbrier, White Sulphur Springs, W. Va., the week of June 21.

THE ILLINOIS MINING INSTITUTE will meet in Chicago, June 23 to 26.

THE STEEL BARREL MANUFACTURERS' ASSOCIATION will meet in Chicago, June 24.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its fall meeting at Saratoga Springs, N. Y., Sept. 1, 2 and 3.

Industrial Notes

THE ELECTRIC FURNACE CONSTRUCTION Co., Philadelphia, Pa., announces that George P. Mills, formerly electrical sales engineer of the General Electric Co., Philadelphia, has joined the staff, to take charge of and specially develop electrical industrial heating furnaces.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING Co. at the annual meeting of stockholders, held at East Pittsburgh, Pa., June 9, re-elected the following directors for three years: Guy E. Tripp, chairman of the board of directors of the Westinghouse Electric & Manufacturing Co., New York City; Joseph Marsh, president of the Standard Underground Cable Co., Pittsburgh, Pa.; H. H. Westinghouse, chairman of the board, Westinghouse Air Brake Co., New York City; Albert H. Wiggin, chairman of the board of the Chase National Bank of New York. George W. Davison, president of the Central Union Trust Co. of New York City, who was selected by the board of directors to succeed James N. Wallace, deceased, was elected by the stockholders for the term expiring June, 1921. The election was decided by the largest number of votes (personal or proxy) ever cast in the history of the company. This company also announces that G. B. Rosenblatt, who specializes in the commercial and technical activities in the West with respect to metal mining and smelting, coal mining and oil, and electrometallurgical and electrochemical industries, has moved his headquarters from the Salt Lake City office to the San Francisco office.

HAMILTON & HANSELL, INC., of New York City, has moved its offices to 15-21 Park Row, New York City. N. V. Hansell is president, H. A. DeFries vice-president, and J. Herlenius treasurer-secretary.

THE CHEMICAL CONSTRUCTION Co., New York City, has moved its New York office from 30 East 42nd St. to 51 East 42nd St.

THE MERRILL Co., San Francisco, Cal., announces that it is now prepared to deliver standard sizes of the Merco Nordstrom Plug Valve from the plant of the Swenson Evaporator Co. at Angola, Ind., which is now manufacturing these products for the Merrill Co. Inquiries regarding the valve and orders for the valve can be handled by the Chicago office, and Eastern consumers will save considerable in freight as well as in time of delivery, if orders are placed there.

THE RESEARCH CORP., New York City, has just opened up an office in Chicago at 76 West Monroe St. H. M. Pier, at present commercial representative, will be Chicago district representative.

WILLIAM C. REDFIELD, formerly Secretary of Commerce of the United States and now president of the American-Russian Chamber of Commerce, spoke before the civic industrial committee, Chicago, recently on business conditions in Russia.

THE INDUSTRIAL TRACK CONSTRUCTION Co. of St. Louis has established a branch office in Memphis, Tenn., headquarters in the Randolph Bldg. This company specializes on industrial track layouts. H. A. Nims is general manager.

THE LAKEWOOD ENGINEERING Co., Cleveland, O., has established branch offices in the Central Bank Bldg., at Memphis, Tenn. C. F. McArdle will be in charge of the territory.

S. F. BOWZER & Co., INC., of Fort Wayne, Ind., has appointed A. B. Carriger district manager, Falls Bldg., Memphis, Tenn.

WILLIAM D. EDWARDS, of Chicago, has established a consulting engineering office at 116 South Front St., Memphis, Tenn. The mechanical features of industrial drying and dehydrating plants in the fertilizer business and allied industries will be dealt with.

THE LOWE BROS Co., paint and varnish manufacturer of Dayton, Ohio, has established a branch sales office at Shelby and Nettleton Sts., Memphis, Tenn.

DR. OTTO K. ZWINGENBERGER has moved his offices from 13 Park Row to 38 Park Row, New York City.

THE INTERNATIONAL OXYGEN Co., of Newark, N. J., announces that Eugene Schoen, general manager, has sailed for Europe to make an inspection of the company's branches in London and Paris, and to extend the business of the company in France, England, Belgium, Germany, Switzerland, Sweden and Denmark, where reconstruction following the war has stimulated the demand for oxygen and hydrogen-generating apparatus.

THE BUR-MAC CORP., 1 Liberty St., New York, has been organized as a dealer in industrial chemicals, particularly used in textile, paper, tanning, soap and chemical manufacturing. Swen Ringborg is president, M. E. McGovern vice-president, and W. R. Burrows treasurer.

THE MERRILL Co. has retained the services of W. H. Campbell as auditor of the Chicago office. Mr. Campbell was recently connected with the Government food administration.

THE AMERICAN BLUE PRINT PAPER Co., 455 Plymouth Court, Chicago, has developed the Baker process for making duplicate waterproof tracings. The lines of the Baker prints are photographed on chemically prepared surfaces — tracing cloth, paper or other pliable material. The duplicate tracings are covered with waterproofing and the lines are actually produced in the waterproof coating. Corrections on the duplicates are made quickly because the lines erase very easily. This process is very convenient where a full drawing would necessarily have to be retraced on account of changing just a small portion or detail. A duplicate Baker print can be made having any desired portion left out, after which the change in details can be inserted, thus producing a new tracing with minimum cost.

THE WESTERN FOUNDRY Co., Chicago, has purchased a 3-acre plant at the corner of Wentworth Ave. and 16th St., Chicago Heights, to be used as an addition to its manufacturing operations.

THE ILLINOIS TOOL Co. of Chicago has secured a new building at the northwest corner of Erie and St. Claire Sts., for use as a general sales room, office and manufacturing plant to produce a large variety of tools.

THE WATERBURY Co. of New York, manufacturer and dealer in wire and manilla rope, has opened a Chicago branch at 609 North LaSalle St.

THE LAMBERTSON JAPANNING WORKS will occupy a 1-story building at 4010 North Claremont Ave., Chicago.

THE COLOMBIAN COMMERCIAL CORP., LTD., Earl Harding, president, 54 Dey St., New York City, has been organized to develop trade with Colombia from an international viewpoint. It offers its services to manufacturers of North America in developing a market for merchandise in Colombia and importing raw materials therefrom. Manufacturers interested in this country can secure a complimentary copy of the *Colombian Review* on application to the corporation.

THE AFFILIATION of Westinghouse, Church, Kerr & Co. and Dwight P. Robinson & Co., Inc., which was announced some time ago, is to be known until the completion of the merger as the Westinghouse, Church, Kerr & Co., Inc. Offices have been moved from 37 Wall St. to 125 East 46th St., New York City.

THE EASTON CAR & CONSTRUCTION Co. has removed its general offices from 30 Church St. to larger quarters in 50 Church St., New York City.

THE AMERICAN METALLURGICAL CORP., Philadelphia, announces the closing of a contract with the Thermoid Rubber Co., Trenton, N. J., for the installation of electric oven equipment to take care of the production of a special processed product to be placed on the market by this company. The installation involves a number of new principles specially pertaining to solvent recovery and automatic control of heat temperatures.

THE E. I. DU PONT DE NEMOURS POWDER Co. has declared the regular quarterly dividend of 1¾ per cent on the common and 1¾ per cent on the preferred stock, payable Aug. 2 to stock of record July 20.

E. I. DU PONT DE NEMOURS & Co. declared quarterly dividends of 4½ per cent on the common, payable $2 in cash and $2.50 in common stock and 1¾ per cent on debenture. Common is payable June 15 to stock of record of May 29 and debenture July 20 to stock of record July 10.

THE U. S. INDUSTRIAL ALCOHOL Co. has declared a dividend of $2 a share for the second quarter of the year 1920 on the common capital stock of the company, payable June 15, 1920, to stockholders of record June 1, 1920.

THE UNION CARBIDE & CARBON CORP. has declared a quarterly dividend of $1.50 payable July 1 to stock of record June 10. Previously it paid $1.25 quarterly.

THE CENTRAL LEATHER Co. has declared a regular quarterly dividend of 1¾ per cent on the preferred stock, payable July 1 to stock of record June 10.

H. C. PARMELEE
Editor
ELLWOOD HENDRICK
Consulting Editor
ERNEST E. THUM
Associate Editor
WALLACE SAVAGE
ALAN G. WIKOFF
Assistant Editors

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of
ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

J. W. CHAPMAN
Western Editor
CHESTER H. JONES
CHARLES A. SCHOLEY
Industrial Editors
J. S. NEGRU
Mechanical Editor

Volume 22 — New York, June 30, 1920 — *Number* 26

Index to the Current Volume

FOLLOWING the custom established by this journal beginning with vol. 1, there is bound in this issue the current index. A special effort has been made to produce an index that would be exceptionally useful. It has not been compiled in a hasty or careless manner, but according to a well-defined plan worked out by the editorial staff, with a special view to the reader's interests.

It seems appropriate at this time to say a word in regard to the proposed 20-volume index to CHEMICAL & METALLURGICAL ENGINEERING regarding which we circularized our subscribers last fall. The response was so favorable that we planned to prepare the index, but have been deterred in so doing on account of the shortage of paper and the greatly increased mechanical cost of production. These conditions were not foreseen when the index was proposed, but they necessitate abandoning the project for the time being.

A Question of Professional Ethics

CODES of ethics have been drawn from time to time and proposed for adoption by various bodies of professional men. In their essence such codes must be broad and general, leaving to the individual the nicety of interpretation in particular cases. When the test comes we discover not so much the efficiency or deficiency of the code as the integrity of the man; and after all that is the crux of the whole matter whether we have codes or not. Of course codes are helpful even to men of good intentions, just as padlocks are discouraging to those of evil design, and it is just as well for men of high ideals to formulate a statement of what they believe to be good conduct for themselves and others. So we have no quarrel with codes, though we admire ethical conduct the more where no code is written.

A recent case in point is the action of THEODORE J. HOOVER in offering to submit in evidence in the flotation litigation between Minerals Separation, Ltd., and the Miami Copper Co. a document which came into his possession when he was general manager of Minerals Separation in 1907. The document in question is a copy of "The Theory of Concentration Processes Involving Surface Tension," by HENRY L. SULMAN and HUGH F. K. PICARD, consulting metallurgists to Minerals Separation then and now. When written, it purported to be a full and complete treatise on the subject, embodying the authors' ideas on the science and technology of the flotation process, and it is the same document to which we referred in our issue of March 3, 1920, when we commented on the discrepancy between the ideas held by Minerals Separation in 1907 and those advanced by Mr. SULMAN in his gold-medal paper before the Institution of Mining and Metallurgy in 1920. The document was given by Mr. SULMAN to Mr. HOOVER in 1907, and subsequently remained in his possession for more than twelve years without request for its return. In the meantime Mr. HOOVER severed his connection with Minerals Separation and has not been in its employ since 1910.

Such was the status when in 1919 Mr. HOOVER had occasion to delve into the record of the case of Minerals Separation, Ltd. vs. Miami Copper Co. From his affidavit on the subject we learn that as a consequence of his investigation he was convinced "that the present contentions of the complainant therein as to the scope of United States Patent No. 835,120 are so entirely opposed to the statement of two of the patentees as contained in the treatise, above referred to, as to amount, in my opinion, to an attempt to perpetrate a fraud on the court and to impose an unwarranted and unjustifiable burden upon the mining industry of the country."

With regard to the state of the art prior to the date of application for Patent No. 835,120, Mr. HOOVER says that the ideas of SULMAN and PICARD as given in the treatise are "wholly inconsistent with the position for which their assignee, Minerals Separation, Ltd., is now contending in this case."

With this as a background, we may ponder the delicate position in which Mr. HOOVER found himself. As a former employee, at one time under contract with Minerals Separation, he legitimately came into possession of documentary evidence of the avowed opinions of that company's metallurgists as to the scientific basis of the flotation process. Twelve years later, as a private engineer and professor of mining and metallurgy in Stanford University, he finds his former employers engaged in litigation, basing their contentions as to the prior state of the art on statements wholly inconsistent with those given in the treatise mentioned. What was Mr. HOOVER to do? Had he any duty at all in the matter? If so, what was it and to whom? Was his possession of the treatise a matter of confidence which he was bound to keep inviolate? Had he any obligation to Minerals Separation under his former contract of employment? Was it his duty to speak or keep silent on the subject?

We can imagine the soul-searching effort to find the proper answer to these and other questions, because the decision when made would be fraught with important consequences. If Mr. HOOVER remained silent and allowed Minerals Separation ultimately "to perpetrate a fraud on the court and to impose an unwarranted and unjustifiable burden upon the mining industry of the country," he might be considered accessory before the fact. On the other hand if he opposed the claims of

his former employers they might brand him as treacherous and disloyal, and seek to discredit him in various ways. The path of duty finally led Mr. HOOVER to an exposure of the facts as set forth in his affidavit. But the determining motive to which we want to direct attention is that he was moved to break silence, as he testifies, "particularly as I believe that the rights of the public are also involved."

Evidently Mr. HOOVER'S sense of duty to the public transcended all other considerations, and few will question the soundness of his decision. For ourselves we are glad to see so important a question resolved as a matter of ethics free from technicality.

Just a Little Strike

ON THE 18th of this month the switchmen and yard employees of the railways in Baltimore expressed by a strike their impatience over what they regarded as dilatoriness on the part of the authorities charged with the problem of finding a satisfactory readjustment of their wage scale; that is, a scale that the railways could meet on the one hand, and which would be acceptable to them on the other. The strike, as some labor leaders are constantly telling us, is their only weapon and their only means of expression. Since neither sword nor gun nor any other weapon is necessary to register impatience, the present walk-out must be regarded as an expression of opinion rather than as a blow, so far as its intent is concerned. The gentlemen were annoyed and this is the way in which they tell it. At present writing the strike has extended through the Philadelphia district and reached Jersey City.

Now let us see what this expression of opinion costs. Baltimore is headquarters for the manufacture of tin cans in the Eastern district. The factories are there. The corn and tomato crops of Delaware, Maryland and New Jersey are ripening. There is no reserve tin plate in existence. It cannot be made unless the steel is transported into the works and the cans transported away to the canneries. Nevertheless the crops are ripening, and no cans are being made or delivered in this region. Therefore most of the corn and tomato crop in the states mentioned will have to rot if the strike continues. There's no market for this immense amount of perishable goods now. They are needed for our winter food supply. Of course it may be said that tomatoes are 90 per cent water, and that we can get water from the pump, but tomatoes contain vitamines and they make other foods edible which otherwise are not. Canned corn and tomatoes are necessaries.

There's an immense crop of sweet corn in Maine, and this also is chiefly dependent upon Baltimore cans. A few cans may come in from Rochester, N. Y., if the strike does not extend out there, but only a small fraction of those needed. And a very few may be drawn from Portland, but not enough to count. The farmers—poor Rubes!—didn't know the yardman mind or the switchman conscience. They planted up to the limit, and now the joke is on them. Then next winter the joke will be on us. There is some danger, however, that the great American sense of humor will fail us all by the time cold weather comes around.

Out in Newcastle, Pa., there are two tin-plate mills and a Carnegie steel plant. They were shut down from April 10 to June 7 for lack of coal. And the plate mills couldn't get steel; all because of transportation difficulties due to strikes. These strikes also were expressions of opinion. The immediate result was that five to six thousand men were thrown out of work. They have sold their Liberty bonds, used credit to the limit at the groceries, and are in arrears for rent. It takes a lot to support a family for two months at present prices. Now the mills have started up and the men are working, but the situation is delicate. Freight moves very slowly and at any fresh disturbance they must close down again.

The connection between steel mills and tin-plate mills and can factories and canneries is a kind of frayed-out shoestring. Transportation is needed and there is hardly any transportation of freight. It is too late now to make up all the cans needed. In Indiana there are 5,500 acres planted in tomatoes that face nearly a total loss. Wisconsin has 60,000 acres planted in peas. The seed cost $9 a bushel and it takes three and one-half bushels to the acre. That means an investment of nearly $2,000,000 by Wisconsin farmers for seed alone. If they are able to can half the crop owing to some early deliveries of cans, they will be lucky. The rest is in the lap of fate as may be determined by the meditations and opinions of the railroad employees.

Sardines are beginning to run along the Maine coast, but there are no cans at hand. And there's no use in catching them if they can't be packed. Fish do not keep well if exposed to the air.

In other words, the gentlemen engaged in switching cars are annoyed. They register their annoyance by their "only weapon," the strike, and this in turn causes the rich products of our blessed land to rot in the fields, it bankrupts farmers, and dooms hundreds of thousands of our people to hunger and millions to distress. If any king of the past two hundred years were to have inflicted such a punishment as a mark of his disapproval he would have been dethroned. People will not stand that sort of thing from kings. But we seem to endure it with complacency from yardmen and switch-tenders. Perhaps their hearts bleed for the suffering in prospect.

The Stable Market For Chilean Nitrate

VARIOUS sources of information, notable among which are the United States Department of Agriculture and the Chilean Nitrate Committee, show that the demand for Chilean saltpeter in the world market has been the criterion of the nitrogen requirements for explosives and fertilizers for a number of years past. This is not an amazing fact when we consider that the industry dates back to the discovery of caliche by the early Indian tribes of Tarapaca, that sodium nitrate was known in the time of PHILIP V and that actual production of saltpeter began in Huantajaya during the early part of the eighteenth century. Tradition has it that when the Indians revealed their discovery to the priest he announced that the explosive soil was not the abode of an evil spirit but a gift of Providence for increasing the productiveness of the earth. Thus it was simultaneously found to be both an explosive and a fertilizer.

Wise, in truth, are the present-day dealers in this old-established commodity who philosophically accept the advent of new processes for securing nitrogen compounds. In spite of the upheaval of the market due to

the war the business is even now showing signs of future stability. The development of better methods for supplying the wants of mankind should always be welcomed if for no other reason than the consequent addition to individual wealth.

Experience with the marked industrial improvements of the past hundred years has taught us that such processes of growth are more often evolutionary than revolutionary. This is easily accounted for in that economic laws essentially function to keep pace with the new achievements and with small disturbance to industrial welfare. Nitrogen-fixation plants will supply the consumer with new compounds of nitrogen, but the demand is growing at such a rate as to still require an increasing output of the product from the deserts of Chile.

The most fundamental change which will likely take place in the Chilean nitrate industry is the forced application of modern methods to mining and leaching operations. Competition which necessitates improvements over aboriginal processes is wholesome indeed.

Organizing the Steel Workers

FAR from the failure of the iron and steel strike of last autumn having settled the matter of whether or not the iron and steel industry should be "organized," the present situation is that there is competition in the matter of endeavoring to do the job. The work of organizing that led to the recent strike was conducted more or less under the auspices of the American Federation of Labor. There is an organization about forty years old, called the Amalgamated Association, for several years "affiliated" with the Federation, which aspires to do all the organizing there is to be done in the industry, and wanted the Federation to leave the matter to it, but the Federation at the annual convention in Montreal turned down the proposition and laid plans for a fresh campaign of its own. The old committee, which survived after the Fitzpatrick and Foster resignations, following the failure of the strike, is to be disbanded and an entirely new committee formed, profiting by the mistakes the last time.

The Amalgamated Association has been losing ground more or less continuously, except during the late war, since its Homestead strike of 1892, and of late has controlled practically nothing except 30 or 40 per cent of the hot-mill labor at the sheet and tin-plate mills, the tin-house labor at the same tin-plate mills, and most of the iron mills from Pittsburgh west. One advantage it had to offer to those signing its scales was that the matter was over for a year, and the management had to deal with a mill committee instead of with individuals. The scale agreement prevented a strike as long as its terms were complied with. Last fall the Amalgamated Association was commended for keeping its men at work, under its signed scales. Instead of being encouraged to continue the system the Amalgamated Association proposed to the sheet and tin-plate manufacturers hitherto signing the scale that for the new year, beginning July 1, the men for whom the scale was signed should have the right to go on strike if the Amalgamated Association should at any time organize other departments operated by the company signing the scale, and the scale then presented should not be accepted by the management. Under Amalgamated Association rules ten men can form a union and get a charter. Thus the hot-mill men could get the picklers in, then the hot-mill men plus the picklers could get the cold-rollers in, then the hot-mill men plus the picklers plus cold-rollers could get the annealers in, and so on. The Republic Iron & Steel Co. bought a ten-mill sheet plant last year for the hot-mill labor of which the Amalgamated Association scale has hitherto been signed. According to the plan proposed, this could be used as a lever gradually to get the company's plate mills, pipe mills, bessemer converters, open-hearth furnaces and blast furnaces into the union class, bit by bit, otherwise down would go the Deforest sheet mills.

Needless to say the proposal was rejected and the scale conference adjourned, leaving it that the Amalgamated Association will after June 30 make all the trouble it can. So will the American Federation of Labor, and the two organizations will not work together, the point being that the officials of each organization wish to retain their positions. This may represent a new form of competition, but it is no new thing for labor organizations to compete with each other, as witness innumerable cases of construction jobs being held up because there was a plurality of unions desirous of doing the same piece of work.

Nothing has been said thus far as to what either organization wants for the men it is desired to unionize. That may be announced later if the leaders have the necessary leisure. The fact is baldly apparent that the main thing is to "organize" for the sake of organizing.

Something— But Not Enough

THE Sterling-Lehlbach bill, which provides for the retirement of Government employees, has just become effective, and those in the service above 62, 65 or 70 years of age, according to the branch of the service, are to be retired on a pay which is pitifully small, especially for those who have occupied responsible positions. After thirty years of service, retirement is on the basis of 60 per cent of the salary, but a maximum of $720 per year limits the retirement pay. Those who have been fifteen years in the service retire on a 30 per cent basis, but here again the maximum retirement pay is limited to $360 per year.

It is certainly gratifying to know that Congress has at last recognized the principle of retirement provision for superannuated civilian employees. However, it is not pleasant to consider the situation of a technical expert who has been in the service for thirty years and who under the new law is required to surrender 2½ per cent of his basic salary, being provided with the munificent reward of $60 per month when he retires for old age. The professional men of the country cannot look with satisfaction upon such an arrangement.

It is up to us, therefore, to get busy and see that a more nearly adequate arrangement is made for the retirement of specialists. Particularly for those in technical and other professional lines the retirement should be upon a basis comparable with the dignity of the position which they have occupied. This is only one of the efforts which is essential in order to restore the Federal services to that position of self-respect and reliability which can reasonably be demanded if proper care is taken of the individuals' interests, both during and after public service.

Readers' Views and Comments

Putrefaction and Decomposition

To the Editor of Chemical & Metallurgical Engineering

SIR:—Dr. George L. Hagadore of Chicago has contributed an illuminating article to *The Undertakers Journal* on Putrefaction and Decomposition, which is so replete with chemical and biological news that I offer some notes taken from it as a worthy supplement to Prof. Moadinger's masterly contribution to corpse chemistry which I abstracted and which you were good enough to print some time ago.*

"Decomposition," says Dr. Hagadore, "is the separation of the component principles of the body, which are organic, nitrogenic or proteid compounds . . . . The separation takes place by chemical analysis under conditions causing fermentation." Of cells he says that "like all organic structures they have a limited period of life, their continued decay and death necessitating reproduction, which takes place in higher animal life by fission." "Blood," he continues, "is another unstable tissue," and he says it is the first tissue of the body to decompose.

"The body has fifteen chemical elements, all of which are combined in characteristic proportions (by the law of chemism) to form compounds, the proximate principles of which are about one hundred, which are divided into four classes, viz., inorganic, organic, non-nitrogenized, organic-nitrogenized and the principle of waste. Chemical elements, with the exception of the gaseous oxygen O_{16}, hydrogen H_1, and nitrogen N_{14}, do not exist alone in the body, but form compounds. The proximate principles O_{16}, H_1 and N_{14} are gases possessing great atomic heat, while C_{12} has the greatest atomic cohesion. O_{16} will combine with all the elements except fluorine, FO_8." The function of O_{16} "appears to be the oxidation of albuminous, oleaginous and saccharine compounds to their ultimate forms of urea, carbonic acid, etc."

Later on the author states that "according to the Law of Chemism, atoms are not satisfied to remain in complex compounds, readily giving up the unsatisfied atoms from molecules in the compound, which is termed analysis, or chemical decomposition of the body."

The sequelæ of decay are described in rather minute detail and the phenomena are explained by the statement that "the gases that chemists and pathologists describe are purely new chemical compounds caused by the chemicals in the body readily giving up the unsatisfied atoms in the molecules and the atoms combining with the O_{16} gas, the H_1 gas and the N_{14} gas."

Here we have a remarkable example of the reach of technology beyond the advancement of pure science. Let us consider a few of the high lights of Dr. Hagadore's great research. We are told, for instance, that decomposition takes place by chemical analysis; that blood is a tissue, and of proximate principles, which will be a new concept to most of your readers, I believe. The reproduction of life in the *higher* animals by fission is a new biological idea. The principles of waste to some minds will probably involve C_2H_5OH, but the inert H_1 molecule will probably strike most readers as a novelty. It is not surprising, however, that such a super-ozone as O_{16} will oxidize the oleaginous and saccharine compounds of the body, whether it be dead or alive.

MARTIN SEYT.

*See CHEM. & MET. ENG., vol. 22, No. 11, March 17, 1920, p. 484.

Air Furnace vs. Cupola Semi-Steel

To the Editor of Chemical & Metallurigcal Engineering

SIR:—I have recently had occasion to refer to my remarks at the A.I.M.E. meeting, Feb. 16 to 19, New York City, reported on page 391 of the March 3 issue of CHEMICAL & METALLURGICAL ENGINEERING, as follows:

"Attention was called to the exceptional wearing qualities of some semi-steels by R. F. Harrington, who thought that real information was needed as to whether cupola or air-furnace semi-steel was superior for abrasion-resistant parts such as locomotive cross-head shoes. Mechanics generally prefer cupola semi-steel, even if physical tests appear quite similar. For determining this essentially practical point, a good testing machine should be designed."

The writer appreciates fully the difficulty often encountered in reporting absolutely correctly the statements of different speakers on such occasions. It does seem, however, in this particular case that some of my remarks were entirely contrary to the statements reported as above, as can be seen from the extracts from a copy of stenographic notes submitted by the Secretary of the A.I.M.E. for my record:

"This so-called semi-steel . . . has always been of rather great interest to the speaker from the standpoint of its wear-resisting properties. We hear a great deal about the high tensile strength, transverse load and the increased deflection that is obtained through the use of steel, as compared to metal which has been made without the use of steel. This is particularly true in the case of the frictional parts of the locomotive, where much material of both kinds as mentioned above is used. . . . I have often wondered how the wear-resisting qualities of these two metals would compare, viz., metal made through the use of steel and one through the use of the open-hearth or air furnace type of melting unit. . . . In the railroad world . . . are many able men who believe that the addition of steel materially reduces the wearing quality of a metal as compared to a metal of the same analysis obtained through the reduction of carbon by other means. I believe that . . . some endeavor ought to be made to test out the relative wear-resisting qualities . . ."

Boston, Mass. R. F. HARRINGTON.

Increased Production of Sugar in Belgium

The Belgian production of sugar, which in 1918 was 70,000 tons and in 1919 113,000 tons, will easily reach 160,000 tons this year and will cover the interior needs of Belgium without obliging it to have recourse to foreign stocks. If the production attains 200,000 tons, as it did several years ago, there is a possibility of a surplus for export.

American Society for Testing Materials

Review of the Technical Papers Presented Before the Meeting at Asbury Park, N. J., June 22 to 25, Especially Relating to Molybdenum Steel, Transverse Fissures in Rails and to Testing Machines

EDITORIAL CORRESPONDENCE

AMERICAN Society for Testing Materials held its twenty-third annual meeting at Asbury Park, June 22-25, 1920, which was quite well attended by men interested in different substances together comprising engineering materials either from a producer's or a consumer's standpoint. As formerly, the main activities were confined to committee meetings, only the finished result of which was exhibited in open meetings. Nearly a hundred changes or additions were made to the standard and tentative specifications, most of them being matters of detail.

One action almost promised a year ago, was left undone—the restoration of phosphorus and sulphur limits in steel. Many 1918 specifications were raised 0.01 per cent to admit the necessary war tonnage—half of them replaced last year on materials of special purity or composition, and the remaining specifications (comprising the largest part of the tonnage) left with high limits for twelve months more. Now comes the time to replace the lower limits, but the committee finds that the conditions existing a year ago still remain, consequently consideration will again be deferred for a year. No question was raised as to the possibility of "conditions"—principally high-sulphur coal—ever being better, lacking an insistent spur; meanwhile a joint committee[1] has embarked upon a pretentious investigation as to the effect of sulphur and phosphorus on tonnage steels. Before scientific results can be obtained from this investigation—if they ever are obtained acceptable to both producers and consumers—the psychological factor may have intervened, and the purchaser become so satisfied with higher sulphur and phosphorus shapes that he wonders at his former insistent demand for the lower limits. "Anyway, if the steel mills cannot produce the stuff you want, . . .?"

CORROSION OF SHEET METAL

Another important committee report was on the present condition of a great number of 16- and 22-gage corrugated sheets exposed to atmospheric conditions for several years. Three different sets were exposed, one at Annapolis, where deterioration has proved slow; at Fort Sheridan, where the conditions are more severe, and at Pittsburgh, where the sheets are failing badly. The May, 1920, inspection of the 41-months' old sheets at Pittsburgh showed that out of 146 sheets of copper-bearing steel and iron (including puddled and ingot iron, open-hearth and bessemer steel) all with copper content above 0.15 per cent, ranging from 0.18 to 0.62, forty-two have failed, or 28 per cent. Out of eighty-four non-copper-bearing sheets, containing copper less than 0.15, ranging down to 0.01 per cent, eighty-one have failed, or 97 per cent. Atmospheric conditions at Pittsburgh and Fort Sheridan therefore appear to be resisted better by corrugated sheets containing appreciable amounts of copper. Coupons reserved from all these exposed sheets will now be exposed in salt, mine, and tap water, to check the result of the atmospheric-exposure results. Exposure of galvanized and other protected sheets probably cannot be undertaken on account of the difficulty in guaranteeing unchanged location for the long term of years which would be required.

SHATTERED ZONES IN RAILS

In discussing James E. Howard's paper "On the Shattered Zones in Certain Steel Rails, With Notes on the Interior Origin of Transverse Fissures," M. H. Wickhorst reviewed the gradual increase in our knowledge regarding simple transverse fissures. As these failures appeared (they were first described by Mr. Howard in 1911) the rails containing them were studied from many angles. Chemical analysis gave no clue to the trouble. Microscopically, the rails appeared all right. Tension tests cut from transversely-fissured rails gave consistent results in flange, web, or outside of head, yet the same tests from the interior of the head showed low ductility.

Transverse fissures, properly so called, were always characterized by a flat break, square across the rail. All these breaks showed a "detail fracture" consisting of a roughly oval area giving a bright silvery appearance, at the center of which was a granular spot—the so-called nucleus, apparently the point of initial growth. Suspicion that the interior of the rail head and base contained shattered metal became a certainty with Waring and Hofammann's[2] discovery of "worm holes"—deep gouges produced by the action of hot HCl on polished sections. Rawdon and Epstein[3] very elegantly proved that such deep-etching marks represented in fact pre-existing cracks in the metal, a conclusion which has been substantiated by other investigators in their efforts to locate them prior to acid treatment.

Literally thousands of minute fissures exist in the deep seated interiors of heavy, hard rails, unaccompanied by non-metallic inclusions, and following both the grain boundaries and crystalline cleavages. Rawdon believes intracrystalline directions predominate.) Howard, however, shows that they do not extend closer than $\frac{1}{2}$ to $\frac{5}{8}$ in. to the hot-sawed ends of the rail, so that the shattered zones are entirely surrounded by sound metal, a circumstance which leads both Howard and Wickhorst to ascribe their origin to a time subsequent to hot-sawing. Another possibility—not mentioned at the meeting—appears worthy of discussion, and that is that pre-existing cracks might be cured in cooling surface regions exposed by the saw. Doubtless the mechanical working effects caused by hot-sawing are not comparable to the rolling stresses induced below the lateral

[1] CHEM. & MET. ENG., vol. 22, pp. 297, 609, 952.

[2] "Deep Etching of Rails and Forgings," *Proceedings* A.S.T.M., 1919, p. 182.

[3] Bureau of Standards Technologic Paper No. 154; CHEM. & MET. ENG., vol. 22, p. 505, March 17, 1920.

surface. Summation of this evidence, together with collateral experiments on internal stresses in rails and steel tires, convinces Howard that such defects in the shattered zone are cooling or shrinkage cracks.

Relation Between Shattered Metal and Transverse Fissures

All agree that transverse-fissured rails should be avoided, but lacking definite information as to their nature and cause, not much progress can be expected toward their systematic elimination. Deep etching cracks seemed the first real clue. While Robert Job agreed with Howard that no connection has yet been established between shattered zones and transverse fissures, G. F. Comstock takes rather sharp issue with them and contends that at least one transverse crack may reasonably be assumed to pre-exist at the nucleus of a transverse fissure, even though none are found elsewhere in the piece.

In different stages of development transverse fissures are found in all sizes of rails. Among 663 fissures occurring on one railroad, 535 occurred on the gage side of the head, 128 over the web, and none on the outside of the head. Transverse fissures have been found 1½ in. from the end of a rail, a location where internal strains were certainly the dominant ones. Well advanced transverse fissures have been found barely an inch apart, a development which could not take place as a result of bending stresses, even though one is inclined to disagree with the author that the most recent track measurements show fiber stresses inadequate to account for the rupture of rails by bending alone. Howard's suggestion that shattered interiors may even suppress fissuring in service by allowing the diffusion and therefore relief of internal strains transmitted from the cold-rolled running surface is questioned by Rawdon, who said, "It would seem logical to infer that if several *incipient* transverse fissures form in close proximity to each other, the 'diffusive action' referred to should be sufficient to prevent further development so that *well-developed* transverse fissures ought never to occur in close proximity to one another." On the other hand, a sound rail possessing moderate ductility should be safer against internal fissuring; unfortunately modern traffic conditions need a strong rail, to withstand the track loads, and a hard rail, to prevent undue distortion —a combination in carbon steels which unfortunately demands large cross-section, high carbon and low ductility. Apparently traffic conditions and "margin of safety" in carbon rails are an almost impossible combination of requirements.

Molybdenum Steels

G. W. Sargent presented an interesting paper giving the results of experience with molybdenum as an alloying element, dating back to 1899. At that time he, as well as several other investigators, was handicapped by the fact that the alloying elements available were quite variable in quality. Saladin[4], Guillet[5] and Cohade[6] have described the properties of a number of molybdenum steels made at Creusot, which researches showed high Mo steels to possess a special constituent which makes the steels brittle and hard, and even develop transverse weakness.

Swinden[7] prepared several low-molybdenum quaternary alloys showing high strength and good ductility, resembling nickel and chromium : nickel steels. Adoption by the consumers has been slow, however, owing to the comparatively high cost of molybdenum and the uncertainty in quantity and quality of the supply. Investigations within the last few years show the metal to be comparatively wide-spread and plentiful, and at present ample producing capacity is available for any expected demand. Electric-furnace ferromolybdenum and chemically prepared calcium molybdate may also be obtained in quantity.

Manufacture

Sargent says that molybdenum alloys present no difficulties in any modern steel-making process. Calcium molybdate is not to be used in the crucible process, and in general, low-molybdenum ferros are to be preferred on account of their lower melting point and ready diffusion. A typical basic open-hearth heat from a campaign producing about 6,000 tons is cited showing a charge at 10 a.m. of 99,100 lb. clean scrap, 30,100 lb. cold pig and 73,100 hot metal, with some spiegel iron, nickel scrap and nickel metal. Additions in order are as follows: Carbon, three of limestone, four or ore totaling 11,000 lb., nickel, and four of ferro-silicon, this last at 11.16 p.m. Then quickly followed 1,000 lb. 16 per cent spiegel; 1,504 lb. 50 per cent ferromolybdenum, 3,150 lb. 66 per cent ferrochrome, and 1,500 lb. ferromanganese, and the heat, tapped at 11.56 p.m., teemed into 20 x 24 ingots with a recovery of 93 per cent. Analyses follow:

	Carbon	Mn	Cr	Mo	Si
Preliminary from laboratory.....	0.15	0.24	....	.....	....
Added.....	0.19	0.61	1.02	0.347	....
Total....	0.34	0.85	1.02	0.347	....
Final.....	0.30	0.64	0.77	0.350	0.12
Wanted,	0.25 to 0.35	0.50 to 0.80	0.80 to 1.00	0.25 to 0.50	0.25

Yields for several heats averaged: Ingots, 87 per cent of melting; billets, 80 per cent; bars, 94.4 per cent of billets; total yield, 66 per cent of metal charged into furnace. Analyses from two 40-in. corrugated ingots made at the Bethlehem Steel Co. showed no excessive segregation of any element.

The author presented several diagrams similar to Fig. 1 comparing the physical properties of popular alloy steels with and without ½ to ¾ per cent Mo. Annealing these oil-quenched steels at progressively higher temperatures decreases the ultimate strength and elastic limit—which, by the way, are quite close together, and increases the reduction in area and elongation. These diagrams show consistently a high reduction in area with a relatively low elongation. Quenching from as high as 2,000 deg. F. does not impair the physical properties nor cause the grain growth characteristic of overheated steel.

Physical Properties

Structurally, a quenched steel low in molybdenum (C 0.32, Cr 0.90, Mo 0.40) is martensitic. Drawing at 900 to 1,000 deg. F. reverts this into fine short pearlite filaments, and at 1,400 deg. F. the ferrite colesces into rounded masses, when the steel is well annealed and machines easily. A higher molybdenum steel (C 0.39, Cr 1.05, V 0.17, Mo 0.87) is finely pearlitic on oil quenching from 1,600 deg. F., and remains unchanged until drawn at 1,400 deg. F., upon exceeding which it is annealed. Swinden's researches indicate that molyb-

[4] *Iron and Steel Magazine*, 1904.
[5] *Revue de Metallurgie*, 1904.
[6] *Jour. Iron & Steel Inst.*
[7] *Carnegie Research Memoirs*, vols. 3 and 4; CHEM. & MET. ENG., vol. 22, p. 259, Feb. 11, 1920.

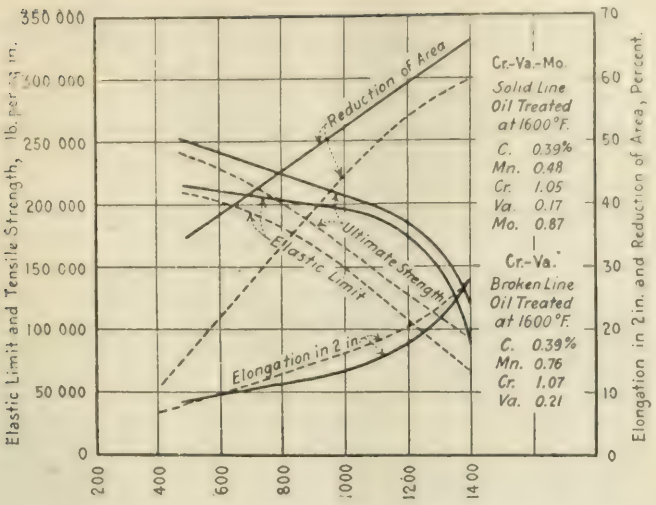


FIG. 1. COMPARISON OF CHROME-VANADIUM-MOLYBDENUM AND CHROME-VANADIUM STEELS, 1⅛ IN. ROUND BARS HEAT-TREATED IN FULL SIZE, THEN MACHINED TO 0.505 IN. DIAMETER

denum enters and toughens ferrite as solid solution when no Cr nor an excess of Mn is present. Otherwise it forms double carbides in addition, imparting additional hardness and strength. Thermal studies indicate that beyond 800 deg. C. (1,475 deg. F.) some compound is found in the austenite which upon cooling first dissociates at normal Ar, with precipitation of Fe_3C, later breaking up into a Mo:Fe compound at about 500 deg. C. (930 deg. F.), which further dissociates, giving a Mo:Fe solid solution only upon repeated reheatings. Hence the flatness of the physical properties vs. annealing temperature curves, and the persistence of the fine pearlitic microstructure.

Replying to questions, Mr. Sargent said that one of his torsion tests on low-molybdenum steels gave thirteen twists in an eighteen-in. length before breaking. Testing billets transversely to the direction of rolling gave no more evidence of transverse weakness than disclosed in carbon steels. Molybdenum added to gray cast iron in the ladle up to 4 per cent increased its tensile strength from 32,500 to 38,400, with a concomitant increase in Brinell hardness of 235 to 311. The graphite flakes were notably straighter edged and sharper. These results were substantiated by similar ones on semi-steel.

Non-Ferrous Alloys

Sub-Committee IX reported progress in its effort to systematize in some manner the names of ferro-alloys. Some idea of their task may be had from a glance at the list of usable alloys, twelve pages in length, among which there are perhaps 500 alloys known by name. How descriptive or apropos are these names may be inferred from the common "German-silver," neither German nor silver, or the designation of commercial aluminum mixtures by number (there are two No. 31's on the market at present). The committee recommends "nickelene" for Ni: Zn: Cu alloys, perhaps a doubtful improvement. However, no small advance would be made if a Zn: Cu alloy would always be some kind of a brass and not a "bronze" in order to denote some superexcellence imparted by a small percentage of a third element. A like committee of the British Institute of Metals believes that systematic names should have preference. The American committee recommends that commercial names which have become established by long usage, such as brass, bronze and cupro-nickel should be retained, differentiating by color, preferably. Thus a Zn 40 per cent Cu 60 per cent would be called a yellow-red brass. If it contained some tin it would be a tin yellow-red brass. Systematically the latter would be a tin-zinc-copper alloy, the first metal representing the smallest proportion, which must have at least 1 per cent present to be worthy of mention.

Effect of Tin on Brasses

William Campbell presented "A Note on the Constitution of Certain Tin-Bearing Brasses," in which he clearly explained the rather puzzling fact that a relatively slight variation in tin often causes the most profound physical changes in the alloys. Microscopically, some naval brass castings were found to resemble Muntz metal, in that they consisted of a mixture of alpha and beta constituents; some of them appeared like bronzes (alpha and eutectoid), while a third class consisted of alpha, beta and eutectoid. All of them were cast to the following specifications: Cu 60 to 65 per cent, Sn 0.5 to 1.5 per cent, iron 0.5 per cent maximum, Pb 1.0 per cent maximum, Al 0.5 per cent, Zn remainder.

He therefore studied the region of the ternary diagram shown in Fig. 2, both as cast and after annealing for two hours at 650 deg. C., and furnace cooled, finding results very similar to those of Hudson and Jones.* The alpha-beta-eutectoid complex is found in an approximately rectangular area, from which it is immediately

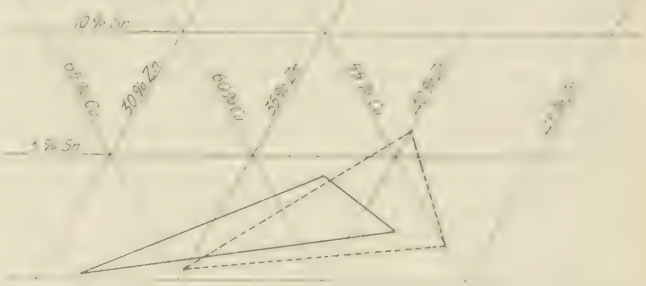


FIG. 2. PART OF Sn : Zn : Cu : TERNARY DIAGRAM, SHOWING STRUCTURE ANALOGOUS TO GUN METAL

seen that as the copper content of the cast alloy increases from 56.5 per cent, the amount of tin which will cause the alloy to change from the ductile "naval brass" type to the less desirable "gunmetal" type decreases from 2 per cent to less than 0.5 per cent with 67 per cent of copper. Consequently in proportioning such alloys it should always be clearly understood that the amount of tin should be inversely proportional to the copper. Corresponding facts for the annealed state are shown by the dotted triangle in the figure.

Testing Machines

A number of papers describing testing machines of various kinds were read, one attracting the most attention being perhaps that by A. S. Cushman on "A New Method of Testing Galvanized Coatings." This is merely a portable device for measuring the amount of hydrogen evolved when dissolving a given area of coating in concentrated HCl. A short length of 2½-in. tubing, properly convoluted on its bottom edge to fit the shape to be tested, is puttied down on the desired spot, closed with a stopper, connected to a gas burette and the entire system filled with water. Then by means of proper

*Journal, Institute of Metals, vol. 14, p. 98

thistle tube, an undetermined quantity of HCl -$SbCl_3$ solution is introduced into the test ring, the evolving hydrogen being collected in the burette. Action is very rapid for about 30 seconds, slowing down to almost zero as the bare iron is exposed. The system is again washed out with water to insure all the hydrogen entering the burette, the volume noted, and by using a proper factor, the coating calculated in any units desired.

Hiding Power of Paints

"An Instrument for Measuring the Hiding Power of Paints" was described by R. L. Hallett. It consists merely of a long microscopic tube with plane ground glass for objective and small hole for ocular. If under this ground glass is placed a card having a contrasting stripe painted across it, the line of demarcation becomes more and more indistinct as the objective is withdrawn; finally a distance is reached where by diffusion the field appears uniformly illuminated. This vertical distance is measured and is found to be proportional to the contrast existing on the card under view.

The ground glass was prepared by polishing back an overground piece until a white card with a black stripe would become merged under view at an objective distance of about 15 cm. Calibration is required for each instrument, and is done by viewing various grays, ranging from best white to darkest obtainable black, each tone having previously been analyzed for white and black by a Howland color photometer. In this way a logarithmic curve was established, using objective distance as ordinate and per cent of hiding power as abscissa.

This instrument evidently can be used for any spreading rate, and for any color over any background. Its chief difference from the cryptometer[10] is that the latter measures 100 per cent hiding in liquid paint, while the new device measures to within 5 per cent any percentage of hiding less than 100 in a dried coat applied to any desired surface at any desired rate.

Colorimeter for White Paints

A. H. Pfund notes that heretofore it has been extremely difficult to evaluate various so-called white paints because their departure from white is so very slight, and in developing a "New Colorimeter for White Pigments" makes use of optical principles for intensifying these differences to measurable quantities. He defines a white surface as one which reflects white light non-selectively. While truly white light is as difficult of attainment as a truly white pigment, for practical purposes so-called white pigments may be compared by comparing the way they reflect blue, green and red light. If a certain paint reflects the three equally well, it is white; if blue is reflected less completely, the paint is not white, but reflects selectively, and in this case has a yellow tint—a condition common to all commercial "white" pigments. Sublimed magnesium oxide has a reflecting power of 87 per cent (the standard of brightness) and is practically white. Lithopone in glycerine, however, reflects red 77 per cent, green 75 per cent and blue 71 per cent. It evidently is not so bright as MgO, and in comparison will also appear yellow-tinted. On the other hand, Titanox reflects red 77 per cent, green 71 per cent and blue 64 per cent. It is even less bright than lithopone, and appears yellow to MgO, yet lithopone appears bluish when alongside.

[10]Journal of the Franklin Institute, Nov., 1919.

Such numerical results define each paint uniquely, and make purchasing independent of standard samples. The instrument is reproducible at any point and dependent only upon physical constants. It is evidently useful in studying aging phenomena, the relation between hiding power and brightness, the effect of minute additions of colored pigments, and so on.

Briefly, the instrument intensifies selective reflection by multiple reflection of diffused electric light between parallel surfaces covered with the paint in question. Emerging beams are compared with the source by an ordinary photometer cube, viewed through screens of colored glass or solutions and a brightness match established and measured.

Plastometer

An improved plastometer which should be applicable to the investigation of many problems connected with paints, clays, greases, lards, soaps, lubricants and the like was described by Henry Green. As described a year ago in the *Proceedings*, the material under study is forced through a long capillary by air pressure, the rate of flow then being plotted against the pressure, or, more preferably, against the shear so induced. Rate of flow is measured by measuring the air displaced in the receiving vessel through a very delicate gas flowmeter.

Maxwell in his "Theory of Heat" points out that if any stress, no matter how small, be applied to a true liquid, a permanent deformation ensues. Flow-shear curves for liquids plotted by the plastometer agree with theory, since they are straight lines passing through the origin, the viscosity being a function of the slope. Plastic solids, on the other hand, require a certain definite unit force before flow (or deformation) occurs. Graphically, this means that the flow-shear curve should cut the X axis at a definite value ("yield value") equal to the shear required for incipient movement. Actually, at low pressures the curves for paint pastes (for instance) bend so as to approach the origin, apparently acting like viscous liquids at low pressures and as plastic solids at higher.

Microscopical observation of such capillary movement shows that at rest the vehicle wets the walls of the tube, the pigment touching the walls at but very few points and existing as interlocking floccules of relatively large mass. Slight pressure causes this interlocked mass to move *en bloc* so that shear is confined to the truly liquid vehicle. As the pressure increases, however, the pigment deflocculates, and movement is "telescopic," *i.e.*, the inner portions move much faster than the outer ones —true "fluid" motion. In this state lubrication is not complete and surplus force is required to overcome the largely increased friction between the moving particles.

From these results it appears that "plasticity" is a term of composite significance. Two substances may have the same yield value and yet one have a higher mobility (or fluidity, which is an analogous term) giving higher rates of flow for given pressures. On the other hand the mobility of a pair of substances may be the same, yet the more plastic would have the lower yield value.

True matching of plasticity is consequently a most difficult operation, involving substantial agreement of two pairs of factors, each to each, and can be successfully done only by painstaking studies by the plastometer or some instrument measuring the factors equally well.

Legal Notes

By Wellington Gustin

Egyptian Lacquer Manufacturing Co. vs. Chemical Company of America

The Egyptian Lacquer Manufacturing Co. of Rahway, N. J., instituted suit for damages against the Chemical Company of America for pollution of water furnished it by the city of Rahway. The Chemical company attacked the complaint as failing to establish a right of action. This complaint set out that the city of Rahway is authorized by law to take such portion of the water of the Rahway River as may be required to furnish the inhabitants of the city with wholesome water for domestic and other uses; that the Egyptian company has a factory in the city for the manufacture of chemical products requiring a large quantity of water which was furnished it by the city; that the Chemical Company of America, having a factory at or near the river, emptied therein refuse from its factory above the intake of the city which so polluted the water furnished by the city that the complainant was injured in its use, and business was prevented from being carried on.

Is the Complaint a Cause of Action?

In passing on the law involved to determine whether the complaint disclosed a cause of action, the Supreme Court of New Jersey said it was clear from the complaint that although the city and the Chemical company are riparian owners, the Egyptian company is not, and further that there exists no contractural relation between the complainant and the Chemical company, or between the city and the Chemical company, as to the supply of water. This, said the court, presents the question whether, granting the right of the city to maintain an action against the Chemical company because of the pollution, the Egyptian company has such right, not being a riparian owner.

This is not a case of an indictment for creating or maintaining a public nuisance, or for the violation of any statute against the pollution of a running stream, but a suit for damages resulting from a special injury based upon the non-performance of a duty which the plaintiff claims was due to it from the Chemical company, and the claim is not sustained by the complaint, as the court found.

Dismissal of the Complaint

It says: "We may assume in this case that a liability existed in favor of the city as a lower riparian owner for the pollution of the stream by a higher riparian owner; but there the obligation ceased, for the right of action would not pass to a non-riparian owner merely because the latter had contracted with the city for the furnishing of the water, for his right depends upon his contract with the city, which might provide for the very character of water which was supplied. The liability of the defendant, if any, rests upon his violation of the legal right of a lower riparian owner, unless it had contracted with the plaintiff." But there was no claim of contract between the Chemical company and either the Egyptian company or the city. And if such a contract existed between the Chemical company and the city the court was of the opinion it could not inure to the benefit of the Egyptian company, as user of the city's water. Neither did the complaint show as a matter of law that the Chemical company as a riparian owner owed any general duty to the public or a special one to the complainant. The complaint was dismissed.

Agreement to Order as Soon as "a Car or Two" Has Been Used Held Valid

The Lakeside Forge Co., of Erie, Pa., has won in the Pennsylvania Supreme Court on its judgment against the Freedom Oil Works. An action for breach of sales contract for a year's supply of fuel oil had been entered into by correspondence between the parties. Defendant agreed to furnish oil and plaintiff accepted the offer, stating that it had a "car or two" coming from another source and would commence on the order "as soon as this is used up." This was on Aug. 16.

The Forge company by letter on Nov. 15 called upon the refinery for a car of the fuel oil, and two days later received a reply, refusing to deliver it, alleging that plaintiff's delay had operated as a cancellation of the contract. As a matter of fact plaintiff had seven cars of fuel oil coming on a former contract when this contract was made and this was the oil it used from August to November. The statement that it had a car or two coming was made honestly but without investigation.

The parties had further correspondence and telephone conversations, but the refinery refused to perform the contract, and plaintiff was forced to supply its requirements for the balance of the contract year from other sources of supply, at the prevailing market price. Then the present suit was brought to recover from the defendant refinery the difference between the price paid in the open market and the contract price. The trial court gave a judgment for this difference and the refining company appealed.

"A Car or Two" an Indefinite Number

The Supreme Court found the agreement, made by the correspondence, plain and said it obligated defendant to supply plaintiff's requirements for one year, less the amount due on a prior order. Until that was exhausted plaintiff couldn't demand oil on the contract in suit; hence defendant was not released because plaintiff failed to make a premature demand. Neither regarded the amount so due as the essence of the contract or attempted to fix it definitely. Plaintiff says "a car or two," and defendant says "to begin after you have taken out what is yet due you on previous contract." The court said "a car or two" signifies an indefinite small number and may include as many as seven. It is similar to "a few." Where indefinite words are used and the naming of the quantity is regarded, not as in the nature of a warranty, but only as an estimate of the probable amount, good faith is all that is required of the party making it.

Refinery Lost on Each Gallon Furnished

In a letter to plaintiff the refinery states the real truth that each gallon furnished under the contract would be at a considerable loss to it. But the court said the refinery would not be released from all liability for a year because by a fortuitous circumstance it was saved harmless for the first two months' supply. This was to defendant's advantage. And to justify rescission of a contract because of falsehood it must have been relied on by the complaining party to his detriment.

Notice to Discontinue Manufacture Relieves Buyer From Responsibility for Full Purchase Price

The Appellate Division of the Supreme Court of New York reverses judgment in the action of Frederick T. Commoss, as seller, to recover for 220 net tons of steel plates against William C. Pearson. These plates were to be shipped to a party in California, and from there exported to Japan. After the sales contract was made the Government promulgated a rule against exporting plates to Japan after a given date. The manufacturers of this plate, the National Enameling & Stamping Co., reported it impossible to make the plates before expiration of the time limit. The buyer failed to get an extension export permit, and wrote the plaintiff to do nothing further with the order for that time. The manufacturers replied to the buyer saying the order would be held until it heard from him again. The buyer further telephoned to the office of the seller, Commoss, and, not finding him in, gave the information to one McFarland, who promised to communicate same to Commoss.

At this time none of the plates had been made up. Later the full order of 220 tons of plates was rolled; this was done without any notice whatever from the buyer, Pearson.

The law applicable to the case is found in section 145, subdivision 4, of the Personal Property Law of New York, providing:

Provisions of the New York Law

"If, while labor or expense of material amount are necessary on the part of the seller to enable him to fulfill his obligations under the contract to sell or the sale, the buyer repudiates the contract or the sale, or notifies the seller to proceed no further therewith, the buyer shall be liable to the seller for no greater damages than the seller would have suffered if he did nothing toward carrying out the contract or the sale after receiving notice of the buyer's repudiation or countermand. The profit the seller would have made if the contract or the sale had been fully performed shall be considered in estimating such damages."

Now, said the court, if the buyer seasonably notified seller's agent not to proceed with the manufacture of certain steel plates, and also notified the mill which was making the plates, and the mill promised not to proceed further without notice from the buyer, the buyer was absolved, under the above law, from damages for labor and material thereafter expended in manufacturing the plates, and was not liable for the full purchase price on breach of the sales contract.

Buyer's Counterclaim Denied

Again, the buyer set up a counterclaim because the goods were not tendered to him within the time specified in the contract, but the court said he could not complain where he had directed the suspension of their manufacture until further notice which he had never given. Neither was the contract for the sale of steel plates for export an illegal contract because thereafter a Government embargo on such shipments was promulgated, where it is not shown that either party intended to make shipment without Government permit. The parties might lawfully stipulate that the payment should become due forthwith, as was done in this case, after the plates were rolled and before delivery.

The court said that undoubtedly all parties believed that the embargo upon the exportation of these plates would soon be released, and they acted accordingly; but neither the mill nor the seller had the right to proceed, after having been notified to suspend the manufacture until further notice from the buyer. If that further notice were delayed an unreasonable length of time, it would amount to an absolute repudiation; but when the mill acquiesced in the request to suspend the manufacture until further notice, and when such a request, transferred to plaintiff, brought no protest, the buyer might properly rest upon its liability for such damages as had accrued upon the contract at the time the notice was given, and the seller cannot hold the defendant to any greater damages.

The Borderland of Manufacturing — When Mining Is Also Manufacturing

The Supreme Court of Pennsylvania has been called to pass upon the question whether a mining company in that state was not really carrying on the business of manufacturing. The action was one instituted by the state against the Welsh Mountain Mining & Kaolin Manufacturing Co., and arose out of a statute allowing to mining companies an exemption from capital stock tax of so much of the capital stock as is used in manufacturing. The company claimed it was engaged in manufacturing and on that ground refused to pay the capital stock tax.

The facts were that the company was incorporated under the Pennsylvania laws for the purpose of "mining fire clay, fire sand, feldspar and kaolin, with the right to prepare for market and vend the product of their mines." This company, during the tax period involved in the suit, leased its property and plant to the Silican Products Co. and the Silican Sand Co., which operated the mining property.

Basis of the Claim

The mined rock is crushed and sieved to the desired mesh. The silica sand thus obtained is used principally for molding in the steel foundry trade, and to some extent for concrete in the building trade. The rock has no commercial use or value as rock, but when changed into sand is known in the trade as "silica sand," and is worth from 45c. to 60c. a ton, and is adapted in that condition to particular uses, for which it was not adapted as rock.

Not Manufacturing, Says Court

Now, the question presented for the court to decide was whether this was manufacturing within the statute exempting the company from the tax. The company mines the silica rock and reduces it to desired sizes or to sand. It is still silica rock or stone bearing the appearance of the article as it leaves the mine, said the court, but with no regular shape or fixed size in the portions into which the rock is broken by the crusher. The pieces are sold as they come from the crusher without any attempt to remove the irregularities of the edges or make the pieces of uniform shape. This process is not manufacturing, the court held. And the fact that clay of various colors is sometimes added to the sand when colored silica is desired does not change the situation, said the court. That application of labor to an article either by hand or mechanism does not make the article necessarily a manufactured article was announced as a settled principle of law.

Factors in the Conversion of Sodium Formate to Oxalate

A Study of the Temperature, Pressure and Caustic Composition Factors Influencing the Percentage of Conversion of Sodium Formate to Oxalate—Temperature Control Essential—Oxalate Conversion Curves and Interpretation

By E. H. LESLIE* and C. D. CARPENTER†

THE formate process for the manufacture of oxalic acid as used in Europe has many variations, but basically it consists in allowing carbon monoxide gas to react upon a heated caustic alkali in the presence of more or less water, the temperature being controlled so that the formate produced is not decomposed into oxalate and carbonate. Without attempting to show the mechanism, that is, the part played by the water, the reaction may be represented:

$$NaOH + CO \rightarrow H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} + x \text{ cal.}$$

Temperature Control Essential

One of the greatest difficulties in so making sodium formate is the control of the temperature. Since the formate producing reaction is exothermic, a tendency to build up the temperature locally exists, thus bringing about a decomposition of the formate which has been produced. Fortunately the temperature at which formate is decomposed is considerably higher than that at which it is formed in the process under discussion, so that with adequate means of controlling the temperature difficulty need not be encountered in working the process. The temperature at which the decomposition referred to will take place and also the manner of the decomposition is a function of the composition of the material undergoing treatment particularly as regards its content of caustic alkali.

It can readily be seen that the controlling of the amount of caustic alkali in the finished synthetic formate is no easy matter, for while at the start of the reaction period the carbon monoxide comes in contact with the caustic readily, in the later stages of the conversion when the mass is pasty or solid the unconverted sodium hydroxide is brought in contact with the CO gas only slowly and with difficulty. Since the synthetic formate may thus contain caustic alkali, it is of importance to know what the effect of the presence of sodium hydroxide is on the conversion of the formate into oxalate.

Two Staged Reactions

Two main reactions take place when a pure formate is decomposed under carefully regulated conditions:

$$2H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} \rightarrow \begin{matrix}C\begin{matrix}O\\ \diagdown ONa\end{matrix}\\ C\begin{matrix}ONa\\ \diagup O\end{matrix}\end{matrix} + H_2$$

sod. oxalate

$$2H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} \rightarrow C\begin{matrix}O\\ -ONa\\ \diagdown ONa\end{matrix} + H_2 + CO$$

sod. carbonate

The second of these may take place in two stages: first, the formation of oxalate, and second, the decomposition of the oxalate into carbonate and carbon monoxide. It is of course necessary in commercial practice to avoid the formation of carbonate as far as possible, since the formation of this product results in a direct loss of oxalate, and also at a later stage in the making of oxalic acid in the loss of an equivalent amount of sulphuric acid.

The relative extent to which these reactions take place depends on temperature, pressure, and on the composition of the formate converted. As mentioned above, the content of NaOH in the formate is of special importance, and may introduce a further undesirable reaction, as we shall note below.

The experimental work which we report in this paper was designed to determine the effect of these various factors on the conversion of formate into oxalate.

Conversions Under Varying Conditions

Our study of the formate conversion involved the carrying out of a series of experiments in which approximately 10 g. of pure sodium formate mixed with definite amounts of sodium hydroxide were decomposed under carefully controlled conditions of temperature and pressure.

The sodium formate used contained 98.95 per cent formate and 1.0 per cent water. The caustic soda contained 92.25 per cent NaOH, 4.23 per cent Na_2CO_3 and 3.5 per cent water.

The formate and hydroxide were weighed out into a 250-c.c. round-bottomed flask, which was fitted with a one-hole stopper and pressure tube connection to a vacuum reservoir. This reservoir consisted of two 5-gal. glass bottles which were exhausted by an oil pump. A manometer indicated the vacuum in use.

When all was in readiness the round-bottomed flask containing the charge was plunged into a bath of molten nitrates of potassium and sodium contained in a 2-liter pressed steel bucket. The bucket was well insulated, and the bath could be maintained within 1 deg. C. with ease. Temperatures were measured by means of a Tycos nitrogen-filled mercury thermometer.

The flask was shaken vigorously in order to thoroughly mix the hydroxide and formate as the latter melted and the former dissolved in it, and to make uniform the temperature in the liquid mixture of these substances. The reaction was very vigorous in those cases where an extensive conversion took place, starting in from 2 to 4 min. and being complete very shortly

*Department of Chemical Engineering, University of Michigan, Ann Arbor, Mich.

†Department of Chemical Engineering, Columbia University, New York City.

thereafter. In some cases the decomposition was so rapid as to be almost explosive. In all experiments the heating of the flask was continued so that the total time was 15 min. The temperature of the bath in no case changed more than 1 deg. C. when the flask was plunged into the bath.

The conversion results in the formation of sodium oxalate and carbonate, which are solids at the temperature of the conversion. Consequently as the reaction proceeds the mass solidifies as gas is given off. This results finally in a puffed up, porous, white mass. The evolution of gas changed the pressure on the system somewhat, but this in no case amounted to a change of more than 40 mm. of mercury.

When the 15-min. heating period was complete the flask was removed from the bath, cooled, and the contents dissolved out. The oxalate was then precipitated as calcium oxalate, collected on a filter, washed carefully, redissolved in dilute sulphuric acid, and estimated by titration against potassium permanganate which had been standardized against pure sodium oxalate.

Discussion of Experimental Errors

It is evident that certain errors are unavoidable in the method we have used. One of these concerns the transmission of heat into the melted solids which are undergoing reaction. It is well known that in a case such as we are dealing with here the main resistances to the transmission of heat lie in the liquid or gas films on the two sides of the glass and not in the glass itself. The thickness of these films and hence their resistance to the flow of heat is greatly reduced by shaking the flask. In any event the results in our experiments are comparable in so far as temperature is concerned since the factors affecting heat transmission are substantially constant throughout.

We have mentioned the error due to change in pressure as the reaction proceeds. This of course influenced the results in a certain degree, but this pressure change was nearly the same in those cases where a considerable conversion occurred, and hence was nearly a constant factor. In those cases where little change occurred the pressure remained low, and as indicated in the results recorded favored the reaction. Hence the error does not destroy the conclusions drawn from the results.

Experimental Results

It is of course obvious that in order to accurately obtain continuous curves it would be necessary to perform many more determinations than are recorded as loci of the curves given, but it is believed that the data presented indicate with a fair degree of conclusiveness the effects of varying the conditions, temperature, pressure, and per cent of sodium hydroxide.

An inspection of the curves indicates that for given temperature and pressure there is some optimum percentage of sodium hydroxide. This shows up clearly in the curves, 2-in. mercury at 260 deg. C., 14 in. at 300 deg. and atmospheric pressure at 360 deg. C. It is probable that in all those cases where nearly quantitative conversions into oxalate were obtained with 1 to 1.5 per cent NaOH, a decrease in NaOH below 1 per cent and approaching 0 per cent would have given a markedly lower conversion.

The sodium hydroxide exerts a specific influence on the conversion of formate into oxalate which for want of an exact explanation we may call a catalytic influence. In addition to this catalytic effect the sodium hydroxide exerts a second influence which results in a lowering of oxalate yield. This is probably due to chemical reaction between the formate and hydroxide, thus

$$H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} + NaOH \rightarrow C\begin{matrix}O\\ -ONa\\ \diagdown ONa\end{matrix} \quad H_2$$

But it may be the result of a catalysis by the hydroxide of the reaction

$$2H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} \rightarrow Na_2CO_3 + H_2 + CO$$

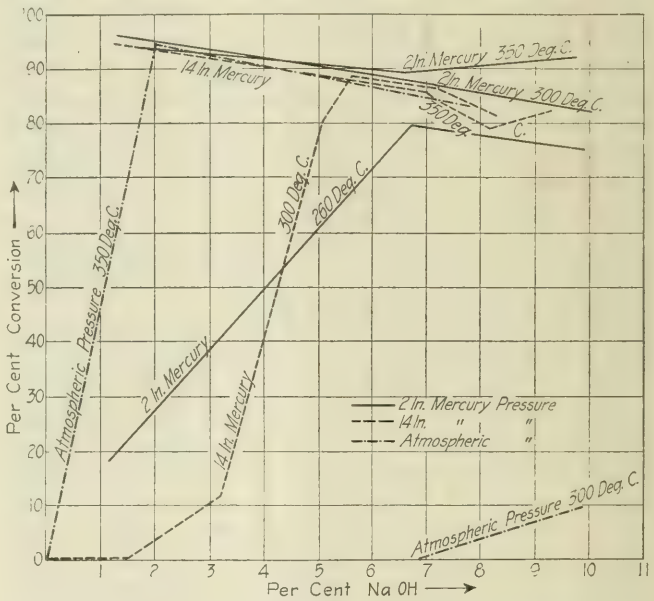
This latter reaction should probably be regarded as taking place in two steps: first, the formation of the oxalate, and second, the catalytic decomposition of the oxalate; thus

$$2H\text{-}C\begin{matrix}O\\ \diagdown ONa\end{matrix} \rightarrow Na_2C_2O_4 + H_2$$

$$Na_2C_2O_4 \rightarrow Na_2CO_3 + CO$$

Interpretation of the Curves

The point as to whether the NaOH reacts chemically with the formate, or catalyzes the carbonate forming reaction, or both, can be settled by analyzing the gases given off during the conversion and considering the



CONVERSION TO OXALATE FOR VARIABLE NaOH CONTENT AND AT DIFFERENT PRESSURES

hydrogen and carbon monoxide content of the gases in relation to the oxalate and carbonate content of the reaction product. We regret that we are unable to offer data on this point.

It is obvious from a consideration of the curves that an amount of sodium hydroxide approximating 1 per cent of the formate is the most desirable quantity to have present.

The curves show that the lower the pressure the more easily and effectively are the oxalate-producing reactions brought about. Too low pressures are undesirable from an operative standpoint both on account of cost and on account of the danger of explosion from a too rapid

reaction where fairly large quantities of formate are undergoing treatment.

In general we can say that increase in temperature produces increased yields. It is undesirable, however, to use temperatures over 360 deg. C. due to the increased rate of decomposition of the oxalate.

Considering the matter from the practical as well as the chemical standpoint, it is evident that the best conditions for the conversion of sodium formate into sodium oxalate are the following:

A proportion of NaOH approximating 1 per cent of the formate.

A pressure approximating 14 in. of mercury.

A temperature of 350 deg. C.

It is a matter of great difficulty to heat a large quantity of formate quickly to a temperature of 350 deg. C., and poor results will be obtained if the conversion takes place at lower temperatures when the pressure in use is 14 in. of mercury. The conversion process should therefore be a continuous one in which small quantities of formate only are subjected to the influence of the conditions at any one time. In this way the conversion temperature can be quickly reached, and danger of explosion which exists when large quantities are being handled is avoided. Following this general method we see no reason why results approximating a 90 per cent conversion should not be obtained in commercial practice.

Tests for Relative Corrosion

By Bertram Feuer*

Recently the researches of Bauer and Vogel,[1] Bengough and Hudson,[2] F. Goudriaan,[3] and the author with Reedy[4] have brought out some facts concerning corrosion that confirm the ideas worked out independently by various individuals using different methods of attack. In practically all these cases it was necessary to attack the problem from a more or less theoretical point of view and, no doubt, has led to promising results. Others, in their investigations, have worked for the sole purpose of seeking a remedy to counteract the deleterious action caused by the phenomena of corrosion. Among another group of workers can be classed those who have sought a means for testing or measuring the corrodibility of a metal in order to determine whether a particular metal would be best suited for a specific use. These workers have undoubtedly contributed matter of interest for the engineer who is confronted with the question from the practical standpoint and should have some means at his disposal for testing the suitability of his materials for various purposes. So far as sytematic testing is concerned, having regard to our present state of knowledge on the subject, this is out of the question.

For systematic testing it would be absolutely necessary to govern and study local conditions and other more or less accidental disturbances that occur in practice, but further difficulty is met with in sampling the metals to be tested, in reproducing the natural conditions of aëration, dilution, changes in electrolyte composition, slight mechanical abrasive actions, temperature fluctuations, etc. The oldest method is the immersion test. Strips of the metal are carefully cleaned and weighed, and are placed in samples of water or exposed to similar atmospheric conditions as will be met with in practice (e.g., in air for outdoor construction; in fumes of chemicals for metal that is to be used in industrial constructional work). After a long period of exposure the samples are taken out, carefully cleaned, dried and weighed. The loss of weight per unit surface per unit time is the corrosion factor.

In addition to the above-mentioned objections of inability to reproduce natural environments, the method possesses two great disadvantages.

1. It is very slow; accelerated corrosion tests, such as immersion in 20 per cent sulphuric acid or in 7.5 per cent sodium chloride, or again, in 1 per cent ammonium nitrate solutions, have been proposed and attempted, but it is found that the corrosion factors do not, as a rule, bear any relationship to those where the conditions of nature are at least being partly reproduced.

2. Corrosion may be either superficial or in the nature of pitting. It is obvious that a "pit" is more deleterious to strength—the important factor in constructional work—than an equivalent amount of superficial rusting. On the other hand, superficial rusting would hinder the proper action of a water meter, while a "pit" would probably cause no trouble. The process above described makes no differentiation between the two forms of corrosion. A further discord between the factors of various investigators is caused by the nature of the preliminary cleaning to which the metal surface is subjected.

G. and M. Whipple[5] introduced an electrolytic test for corrosion in which the rate of solution was accelerated by making the test piece of the metal the anode of a cell driven by current from some external source. This form of test brings out the "pittings" on the surface of the metal with great distinctness, and serves as a method for indicating the nature of corrosion.

Another electrolytic test devised by H. Hansen and W. Lewis[6] for determining the mutual corrosive effect of two metals consists in connecting electrodes of the two metals through an ammeter, keeping the solution about the electro-negative metal saturated with air, and measuring the current in the external circuit. Provided some standard metal to form the one electrode could be agreed upon, this method, which eliminates the necessity for the external current required in Whipple's test, is a great simplification of electrolytic corrosion processes.

There is one other method of testing corrodibility devised by G. and M. Whipple. This may be defined as an electrical survey method. By means of a sensitive galvanometer and a traveling contact pole of copper wire, the other terminal being connected permanently to the plate of metal, the magnitude of the current flowing through the galvanometer, when contact is made in the surface of the metal, is determined. Uniformity of surface currents is taken to indicate low corrosive tendencies, while alterations of any magnitude are associated with a tendency to rust. The value of the method seems to be somewhat vitiated by the presence of the metallic traveling touch electrode, which must undoubtedly both affect passivity and set up local currents not necessarily of constant magnitude.

The author in his work on corrosion was interested in the problem concerning water-meters and therefore

*Chemist, Illinois State Water Survey Division.

[1] *Mitt. Kgl. Materialprüfungsamt*, vol. 36, p. 144 (1918).

[2] *J. Inst. of Metals*, vol. 21, p. 1 (1919).

[3] *Chem. Weekblad*, vol. 16, p. 1270 (1919).

[4] *J. Ind. Eng. Chem.*, vol. 12, p. 541 (June, 1920).

[5] *Fourth Int. Cong. App. Chem.*, vol. 11, p. 15 (1912).

[6] *Fourth Int. Cong. of App. Chem.*, vol. 11, p. 43 (1912).

limited his study to the action of dilute solutions of the salts, commonly found in water, on brasses and bronzes. In this work a simple test with the ferroxyl indicator[7] was found useful. Later work suggested that the plotting of potential fall between the surface of the metal and the solution in which it is immersed, by the aid of an auxiliary electrode, would give figures equally significant in value and free from the disadvantage alluded to above. It should, however, be remembered that, according to theory, the rate of corrosion is determined solely by the magnitude of the local currents, and that determinations of e.m.f. are only of value in so far that they indicate solution-tendency and not the rate of rusting.

The apparatus used for this work is that ordinarily used for determination of emf. by means of a third electrode and is fully described in textbooks on theoretical electrochemistry. In this work the calomel electrode was used. For measurement of the current an ordinary instrument on which one scale division measured one milliampere was found convenient. A more sensitive current instrument was placed in the circuit in order to read current magnitudes between scale divisions of the larger instrument.

The samples tested were uniform in size, having a surface area of 20 sq.cm. Table I gives a list of the samples used together with their compositions.

TABLE I.

No.	Zn Per Cent	Cu Per Cent	Sn Per Cent	P Per Cent	Al Per Cent
1	5	95	..	..	..
2	10	90	..	..	..
3	20	80	..	..	..
4	30	70	..	..	..
5	40	60	..	..	..
6	..	92	8	..	..
7	39	60	1	..	..
8	..	95	4.5	0.5	..
9	92	..	..	..	8
10	(c. p. Zn)	..	..	..	..
11	..	(c. p. Cu)	..	..	..

The accompanying figure shows the results obtained with the ten metals. The current values are plotted as ordinates and as a matter of convenience the logarithms of the potential values were used and are plotted as abscissæ. Upon examination of the curves the relative corrodibility of the ten metals when immersed in a 0.1 normal solution of KNO_3 is evident. These results, in a sense, check with those obtained by using the ferroxyl indicator referred to above. The use of this method has proved very interesting and it is hoped that in the near future it will be possible to study other alloys together with a variety of solutions, whereby some reliable data can be obtained and possibly a satisfactory practical method of testing be devised.

Urbana, Ill.

The Lead and Zinc Industry in Japan*

LEAD is mostly found in the form of galena, which is closely associated with zinc-blende ores. The principal lead mine in Japan is the Kamioka, in Gifu Prefecture. Inquiry at the Mitsui Mining Co. (Mitsui Kozan Kabushiki Kaisha) showed that in 1918 the output of this mine was 7,408,309 lb. of lead.

The quantity and value of the annual production of lead in Japan from 1913 to 1918 is given in Table I.

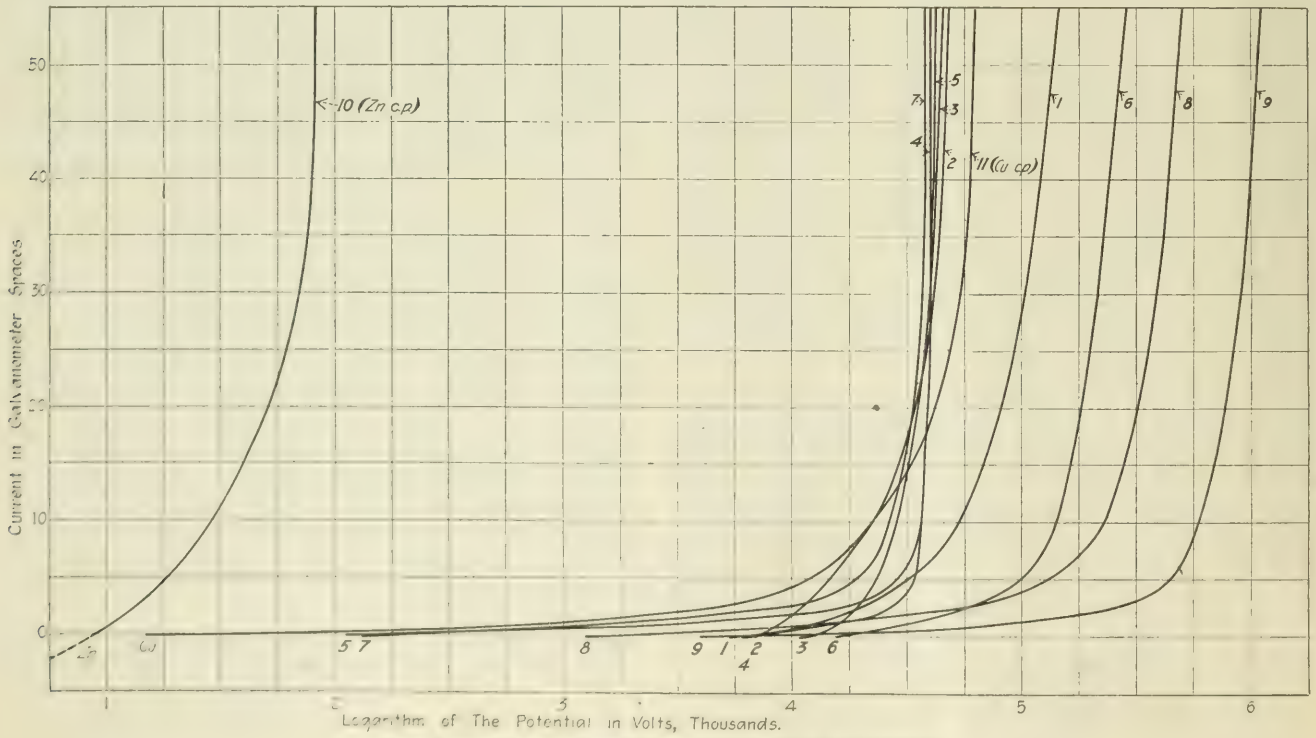
TABLE I. PRODUCTION OF LEAD IN JAPAN, 1913–1918

Years	Lb.	Value	Years	Lb.	Value
1913	8,393,138	$308,006	1916	25,268,685	$1,872,332
1914	10,138,205	412,400	1917	35,127,077	2,822,018
1915	10,567,457	486,729	1918	23,742,236	2,070,266

Okayama Prefecture leads in lead production. In 1918 the amount was given at 7,573,669 lb., valued at $675,-975. Gifu Prefecture was next with 7,440,368 lb., valued at $646,442. Other principal lead producing Prefectures, in the order named for 1918, were Fukuoka, Miyagi, Akita and Yamaguchi.

Producers and smelters were buoyed up by high prices

*Report of Vice-Consul H. T. Goodier, Yokohama, *Commerce Reports*, May 24, 1920.



RELATIVE CORRODIBILITY OF METALS TESTED

ruling during the war and by the hope that strikes and political conditions in the United States, Spain, Australia and Mexico, the principal lead-producing countries of the world, would create a world-wide shortage. However, this hope does not seem to have fully materialized, and the lead market has become quiet as a consequence. Paint manufacturers, having lost a considerable share of their trade with Singapore, the East Indies and India, as a result of renewed competition from Europe, are buying lead for actual needs only. This, together with increased cost of materials for smelting and higher wages, has caused a considerable reduction in output as compared with 1917. If the 1919 figures were available they would undoubtedly show a still more noticeable decrease in amount and value, many of the companies having been forced into financial difficulties.

Prices for lead (Australian) reached their highest in September, 1918, when 1 picul (about 133 lb.) was worth $15.52 in Yokohama. The lowest was $5.85 per picul, in June, 1914. In March, 1920, the price was $13.21, a recovery of about $4 per picul since last October. However, mounting costs make lead mining and smelting increasingly less profitable to the small company run uneconomically, as most of them are, especially in view of high transportation charges. The cost of production of refined lead is estimated at about $8 per picul at the smelters.

Imports of lead and lead ore into Japan from 1915 to 1919, largely from Australia (for lead ingots and slabs), are given in Table II.

TABLE II. IMPORTS OF LEAD AND LEAD ORE INTO JAPAN, 1915–1919

	Lead Ore		Lead Ingots and Slabs		Other	
Years	Lb.	Value	Lb.	Value	Lb.	Value
1915....	(a)	(a)	32,279,973	$1,450,656	2,872,805	$175,860
1916....	(a)	(a)	46,230,232	3,720,089	3,460,964	278,704
1917....	50,520,532	$1,253,759	35,024,068	2,926,798	1,567,652	144,154
1918....	7,989,466	191,130	120,283,002	7,351,379	1,447,808	153,538
1919....	330,667	8,007	79,607,814	5,432,046	(b)	(b)

(a) Not known. (b) Statistics not yet available.

In 1915 Australia sold to Japan 24,599,868 lb. of lead ingots and slabs, valued at $1,102,933. The same year the United States sold to Japan 5,790,156 lb., valued at $248,307. In 1919, while imports of lead slabs and ingots from Australia had increased to only 32,366,341 lb., valued at $2,551,042, imports from the United States jumped to 27,239,280 lb., valued at $1,604,866.

In 1914 Japanese consumption of lead was estimated at 43,753,000 lb., a great share of which was imported from Australia. In 1918 the estimated consumption had reached 144,025,000 lb.

Imports of White and Red Lead and Litharge

The imports of white and red lead and litharge, most of which came from the United States, are given in Table III.

TABLE III. JAPANESE IMPORTS OF WHITE AND RED LEAD AND LITHARGE

Years	Lb.	Value
1916	323,445	$31,365
1917	14,973	2,419
1918	18,401	2,661
1919	212,912	20,995

Lead is not exported from Japan in quantities sufficient to classify separately.

Only since 1913 has Japan engaged in zinc smelting. Prior to that time zinc ore was shipped abroad and the refined product then imported. The largest zinc mine is the Hikoshima in Yamaguchi Prefecture. In 1918 the production of this mine was given as 27,672,960 lb. of zinc and 230,720 lb. of lead. The estimated consumption of zinc in Japan increased from 25,512,000 lb. in 1914 to 60,761,000 lb. in 1918. Consumption has, however, very materially decreased since 1918.

Table IV shows that the production of zinc ore has been steadily declining since 1913, but that the output of refined zinc increased until 1918, in which year a decrease is shown.

TABLE IV. PRODUCTION OF ZINC ORE AND REFINED ZINC

	Zinc Ore		Refined Zinc	
Years	Metric Tons	Value	Lb.	Value
1913	34,676	$472,303	(a)	(a)
1914	14,138	140,752	13,140,265	$682,454
1915	6,121	179,845	46,958,601	6,456,866
1916	2,187	91,257	86,652,256	13,567,052
1917	163	13,576	121,596,436	13,462,153
1918	(a)	(a)	88,701,073	8,838,867

(a) Production not stated.

European Demand Stimulates Zinc Industry

When the war broke out, zinc experienced a boom in Japan, due to heavy demands from Great Britain and Russia. Prices went up, and many new companies, both mining and smelting, were formed. While there was a large disparity between costs and selling prices, these companies all made good profits. However, with the beginning of summer, 1916, prices started to go down. With decreased foreign demands and increased cost of production and transportation charges, many of these companies have had to either temporarily suspend operations or considerably restrict their activities, the latter course being taken by several of even the middle-sized companies. Much of this financial trouble noticeable among the smaller zinc operators is probably due to pyramiding subscribed capital on the basis of abnormal profits and excessive dividends declared, instead of creating and maintaining a safe reserve fund.

The estimated cost of production of refined zinc at the smelters is about $11 per picul (133⅓ lb.). Prices of 98 per cent pure zinc per picul ranged from $6.41 in June, 1914, to $27.40 in December, 1915. Since then prices have hovered around $12 as an average. In March, 1920, the price per picul was $13.96. The margin of profit, considering transportation charges, is thus proportionately low at present.

Yamaguchi Prefecture led in zinc production in 1918 with 27,672,972 lb., valued at $2,535,822. Fukuoka and Okayama followed in the order named, with over 18,000,000 lb. each. Other important producing centers were Miyagi, Hyogo, and Osaka.

Operation of Mines

In Japan, the principal uses of lead are for the making of paint, cables and piping, and in producing acetic acid. The principal uses of zinc are for plating and making paints.

In the mining of lead and zinc, primitive hand methods are used by the smaller companies. The operations of the larger ones, however, compare favorably with those used in the lead district in Idaho. There are 2,364 miners employed in zinc mining, while 1,046 are employed in lead mining.

The Mitsubishi Kogyo Kabushiki Kaisha pay their miners an average of about 75c. a day, with two holidays a month. The underground miners work about 56 hr. a week; surface workers usually have a 77-hr. week.

TABLE V. IMPORTS OF ZINC ORE, INGOTS, SLABS AND GRAINS, SHEETS AND WASTE

Year	Ore		Ingots, Slabs and Grains		Sheets		Waste	
	Lb.	Value	Lb.	Value	Lb.	Value	Lb.	Value
1915	(a)	(a)	6,487,784	$637,056	1,210,109	$157,277	11,125,057	$769,465
1916	(a)	(a)	7,218,985	980,277	1,203,998	228,577	4,401,937	427,889
1917	207,450,533	$3,899,905	10,015,693	879,392	2,694,159	595,171	1,633,445	110,124
1918	133,093,068	2,433,883	5,443,656	681,263	2,981,136	759,511	1,622,656	122,903
1919	61,845,733	1,122,932	12,629,181	1,463,480	3,276,672	555,480	722,444	36,661

(a) Not known.

The imports into Japan of zinc ore, of ingots, slabs, and grains, of sheets, and of waste during the past five years are shown in Table V.

During 1917 and 1918 a great deal of zinc ore was imported for smelting, mostly from Australia. However, since 1918 imports of zinc ore have decreased considerably, owing to a smaller foreign demand for the refined article, thus causing many smaller smelters in Japan to suspend operations.

Although no definite statistics in support thereof can be presented, indications are that foreign refined zinc and zinc manufactures, principally sheets from the United States, will once again find a growing market in Japan, owing to transhipping and speculative activities in connection with the increased demand for plating in China.

Exports and Principal Countries of Destination

The exports of zinc ore have shown a steady decline since 1915, when they amounted to 13,618,250 lb. On the other hand, exports of zinc ingots and slabs increased until 1917, since when they have shown a noticeable decrease. Japanese exports of zinc ore and of ingots and slabs from 1915 to 1919 are given in Table VI.

TABLE VI. JAPANESE EXPORTS OF ZINC ORE AND INGOTS AND SLABS

Years	Zinc Ore		Zinc Ingots and Slabs	
	Lb.	Value	Lb.	Value
1915	13,618,260	$179,846	(a)	(a)
1916	4,865,332	91,258	51,586,452	$9,596,461
1917	362,400	13,576	81,853,012	10,442,511
1918	11,332	234	37,739,584	4,519,766
1919	(a)	(a)	12,629,180	1,463,480

(a) Statistics not available.

The principal countries of destination for the exports of zinc ingots and slabs during the past three years were as follows:

TABLE VII. COUNTRIES OF DESTINATION FOR EXPORTS OF ZINC INGOTS AND SLABS

Countries	1917		1918		1919	
	Lb.	Value	Lb.	Value	Lb.	Value
Asiatic Russia	16,370,736	$1,943,703				
British India			7,851,343	$931,442		
China					2,912,616	$296,935
France	13,277,885	1,777,815	15,802,908	1,753,365		
Great Britain	42,452,701	5,472,124	9,330,916	1,166,264	8,586,588	1,048,423
Kwangtung Province					357,452	30,946

Japanese Imports of White Zinc

The quantity and value of the imports of white zinc into Japan during the past five years are shown in Table VIII.

TABLE VIII. JAPANESE IMPORTS OF WHITE ZINC

Years	Lb.	Value
1915	632,958	$52,133
1916	557,941	65,379
1917	97,026	5,143
1918	497,112	26,146
1919	212,912	20,995

Water-Power Development in Canada

The Dominion Water Power Branch, Department of the Interior, and the Dominion Bureau of Statistics, Department of Trade and Commerce, have just published the results of an exhaustive census and analysis of the developed water power of Canada. Their report, with figures complete to Jan. 1, 1920, is of exceptional interest as indicative of the extent to which the water resources of the Dominion are being put to advantageous use.

Practically every great industrial center in Canada, the report declares, is now served with hydro-electrical energy and has within easy transmission distance ample reserves of water power. Active construction in hydro-electrical enterprises is fast linking up the few cities which are still unserved and which have water-power reserves in their vicinity.

Horsepower Installed

There is installed throughout Canada about 2,418,000 turbine or water-wheel horsepower, of which 2,215,000 hp. is actually and regularly employed in useful work. The larger figure includes the total installed capacity at full gate, including reserve units. It does not, however, include hydraulic exciter units. A large number of the plants now operating are designed for addition of further units as the market demands. The ultimate capacity of such plants and that of new plants now under construction total about 3,385,000 hp.

Of the total power installed 1,756,791 hp., or 72.7 per cent, is installed in central electrical stations. By central electrical stations are meant stations which are engaged in the development of electrical energy for sale and distribution. Central station power is sold for lighting, mining, the electrochemical and electrometallurgical industries, milling and general manufacturing. In the pulp and paper industry 473,265 hp. is utilized, of which 381,631 hp. is generated directly from water in paper and pulp establishments, while 91,634 hp. is purchased from hydro-central electric stations.

Other Uses of Energy—Capital Invested

Hydropower used for other purposes and other industries may be listed as follows: For lighting, 434,613 hp.; in the mining industry, 177,728 hp.; in flour and grist mills, 42,736 hp.; in lumber mills and sawmills, 37,918 hp.; in other manufacturing industries, 172,955 hp. In further reference to the foregoing total of water power developed in Canada it ought to be noted that during the fiscal year ended March 31, 1919, there were exported from plants included in the tabulation 175,000 hp.-yr.

The total installed water-wheel and turbine power in hydro-central electric stations is 1,756,791 hp. Fuel auxiliaries installed as standbys in these hydro stations bring the total installed primary capacity up to 1,873,989 hp., connected to 1,449,180 kva. dynamo capacity. The total capital invested in these central stations, inclusive of transmission and distribution systems, is $369,464,961, or an average of $210 per installed primary horsepower.

Scientific Control of the Filter Station—V

General Discussion and Summary of Features on Filter Press Operation—Types of Presses and Their Application—Materials Used in Construction of Presses—Pressure Devices—Scope of Centrifuging, Decantation and Flotation*

BY ARTHUR WRIGHT, M.E.

WHEN consideration is given to the fundamental principles of filtration in designing the machine and in operating it, no other system is as simple, direct and positive for the clarification of liquors handled in the industries. When, however, the operation or design of the filter is faulty, centrifugals, decantation methods, flotation schemes, etc., can be substituted and prove more economical.

It is rare that the work done in one operation by a filter can be duplicated by other methods without repeating the operation or supplementing with the use of a filter. The scum from flotation machines is washed and dried in filters, the residues from decantation installations dewatered in a filter and it is common to complete the clarification of liquids issuing from continuous centrifugals through a clarifying filter. Such methods savor too much of "two bites at a cherry" and can scarcely be considered when the correct filters are installed and operated properly.

TYPES OF PRESSES AND THEIR APPLICATIONS

One cause for the substitution of filters is found in faulty design. This is not serious when insufficient filter area or cubical caking capacity has been provided, for such troubles are overcome by additional machines. When, however, wrong types are employed, real difficulties arise. It is becoming better recognized that no one filter can satisfy all requirements and that some types are better for some specific duties. The following classification meets general conditions although local considerations may require radical modification in it:

Plate and Frame Filter Presses—Dry discharge; material requiring frequent filter cloth removal; acids, saline liquors in machines of wooden construction.

Vacuum Leaf Filter—Acid filtration; open tank.

Pressure Leaf Filter—Generally applicable to all materials, but less satisfactory on acid liquors and those containing too freely filtered solids.

Vacuum Continuous Filters—Free-filtering solutions not too hot.

Vacuum Dewaterer Hoppers and Rotating Sand Tables—Crystalline or granular solids too fine for good centrifugation or corrosive to centrifugals.

The matter of design does not end with the selection and construction of the filter best suited for the material in hand, but must include the layout of the machine in the plant. It is most important that the layout be made so that the operator can conveniently observe the operation and handle the valves.

MATERIALS USED IN CONSTRUCTION

When handling acid liquors the amount and nature of the acid present will dictate the materials of construction to be used. But little reliance should be put on protective paints even when handling weak liquors and at relatively low temperatures. The coating is likely to be imperfect even when successive coats are applied, due to the practical difficulty of getting a clean, dry surface on which to apply the coating. The bond between the coating and the metal or material used is not great at its best, and one small exposed point is sufficient to soon nullify the whole coating. Enamel coatings are thoroughly resistant when well applied and free from cracks. Difficulty with this type of coating arises when working on liquors the temperature of which varies from room temperature, for the metal expands at a rate different to that of the coating and cracks develop in the coating. Much improvement in this regard has been effected by enamel manufacturers, and there is hope that eventually this difficulty will be overcome. Lead is highly resistant, but has the unfortunate property of expanding without contracting correspondingly. This is what gives the open tank filters such an advantage, for the creeping of the lead is in no degree as serious as with closed containers. In weak acids several alloys are put out which stand up sufficiently to be practical materials of construction. Here, however, as with the use of monel metallic filter cloths, the design must not allow local electrolytic action to be set up by the use of two dissimilar metals or alloys whose electrical conductivities are not approximately equal.

Alkali filtration prior to the advent of metallic cloths was a troublesome if not an impractical process for industrial work. Metallic cloths are today practical mediums capable of withstanding the action of the strongest caustic liquors, but there are principles to be observed if their application is to be economical or efficient. Most alkaline liquors carry materials in suspension or in solution that have a tendency to scale formation. When handling such materials it is almost imperative that an open weave of cloth be used, for the scaling effect is rapid upon the filter medium due to the lower pressure on the outlet of the leaf often being sufficient to induce evaporation with the consequent scale deposit. Obviously a closely woven or rolled cloth is rendered impenetrable quicker than a more open cloth.

BACK PRESSURE AND SUCTION OPERATION

In closed delivery pressure filters scale formation can be lessened and in some cases eliminated by maintaining sufficient pressure on the outlet of the leaves. With hot liquors this pressure lessens the boiling effect at the surface of the medium and with supersaturated liquors crystallization is retarded or eliminated when the liquor is under pressure. The amount of back pressure required is a variable with the material being

*For Parts I, II, III and IV, see CHEM. & MET. ENG., vol 22, Nos. 22, 23, 24 and 25, June 2, 9, 16 and 23, 1920, pp. 1,015, 1,077, 1,119 and 1,201.

handled, but it will often be found sufficient when a standpipe is run to the floor above. Good design will make this a U pipe, broken at its high point to prevent any siphon action, and returning the effluent within the observation of the operator. Such a back pressure must operate to decrease the flow, but the amount of decrease can be offset with a higher pump pressure. Too many times this decrease is exaggerated. This same argument arises where a suction is put upon the outlet of a pressure filter. In either case the effective working pressure is the difference in pressure between that in the filter outside the leaves and that inside the leaves. Consequently a back pressure simply subtracts from and a suction simply adds to the effective pressure in pounds per square inch and surely the simplest expedient to increase the working pressure is to increase the pumping pressure.

When handling weak acids or alkalis with cotton cloths, provision should always be made to keep the cloths wet. If allowed to dry, the weak liquid becomes concentrated and will eat into the cloths. When a press is standing idle, it is good practice to fill it with water or to remove the cloths and submerge them.

Surmounting Difficulties of Vacuum Filters

Some important filter installations have been made of intermittently operated type filters where, from the nature of the material, continuous type filters would seem to have been the better machines. In these cases the continuous filters were found lacking by reason of their inability to deliver a positively brilliant filtrate and to hold their vacuum due to the excessive cracking of the cake when air dried. Both of these difficulties are surmountable, and continuous filters should have been used. To overcome the clarity objection the valve should have been constructed with another outlet which registers with the arc in which the filter cloth first dips into the liquor and the initial cake is formed. Here is the only opportunity for cloudy liquor, and the delivery into this outlet should be returned to be refiltered. For the second there is no good reason, with drum type filters at least, for blanking off the valve at the point where the cracks allow free air to pass through. In this way the capacity of the vacuum pump is maintained for effective suction and will be found well able to hold the required vacuum.

Means of Forcing Liquids Through Presses

The choice of pump to be used in pressure filtration is a matter of more moment than simply to supply sufficient pressure. Oscillating pumps have little to recommend their use in filtration, for the rising and falling pressure exerts a hammer-like action on the cake being formed and increases its resistance without adequate returns. Also, these pumps, even when supplied with ball valves, give much annoyance by the poor seating of the valves due to the grit and other solids of suspension wedging in the valves. The montejus system of feeding filters is without doubt the best from the filtration point of view, but is costly in compressed air consumption. Centrifugal pumps are becoming more and more popular for this class of work, and for most materials they are excellent. It is when handling flocculent precipitates and when the pump is too large for the outflow of effluent that there is any difficulty with this type of pump. In such cases the rotor becomes an agitator that is too effective in breaking up the flocculent precipitates whose preservation is necessary for good filtration. In overcoming this difficulty the rotary positive displacement pump is becoming more and more generally used and its freedom from valve troubles and oscillating pressures surely warrants its use. Provision must positively be made against excessive pressure occurring in the filter when using this type of pump, for they develop pressures dependent upon the power of their drive.

A common fault often met with is lack of uniformity in the percentage solids fed to the filters. Good filtration calls for a uniform mix of those solids that settle readily and those which settle with difficulty. This requires the use of efficient agitators and too much emphasis cannot be placed upon the admirable work now being done by the non-swirl agitators on the market.

Decantation and Flotation

Continuous decantation systems are highly economical methods for the handling of large volumes of liquors the solids in which settle readily and leave a satisfactorily clear supernatant liquor. Their low labor and operating costs as well as their automatic operation are distinct advantages. They are especially applicable for the handling of calcium sulphate thrown down from phosphoric, oxalic, citric and similar acids, for they are easily constructed acid proof to these materials and effect results seldom approached by filters working on the same liquors. By using weak liquor washes on the successive settlings so that the settlings progress from strong to weak liquors with a final mixing with fresh water, while the supernatant liquors advance from weak to strong liquor, all water entering the system leaves it as strong liquid and the settlings are discharged from the system low in soluble content. The final settlings can then be handled on a continuous type filter, if desired. The large area required for such an installation is prohibitive in some plants, but it will often pay to construct a new department for an installation.

Flotation methods of separation are effective in clarifying liquors the solids of which are capable of being propelled upward by reason of the bombardment of the fine air bubbles ascending through the liquor. In handling greases, gums, fats, etc., this method of separation has much to commend itself, for such materials are difficult to filter and do not settle or float readily.

The advance that has been made in clarification methods and apparatus by Americans is a just cause for congratulation for every citizen of our country. But plant superintendents and operators must still strive to overcome the inertia of being too easily satisfied with results obtainable in their plant, for true economical production can be had only by maintaining equipment and processes up to their maximum efficiency. It may not be amiss to report that some companies in their wisdom have periodic investigations made throughout their plants and count the expense well merited when the reports simply commend present working without making suggestions for improvements. The writer has endeavored to have such investigations inaugurated, for they are signs of true progress and the surest means of preventing dry rot in any organization. Along these lines it is also gratifying to note that more and more concerns are taking up the slogan "Instruct the Operator," for he, in the last analysis, should be the filter expert in his department if the company is to have the most efficient plant.

Motion of Droplets and Particles in the Field of the Corona Discharge

By an Appropriate Arrangement of Apparatus the Paths of Particles in Electrostatic Fields Were Determined—While Four Different Effects Can Be Distinguished, the Corona Discharge Is Largely Responsible for the Action of Cottrell Precipitators

BY RICHARD C. TOLMAN AND SEBASTIAN KARRER*

THE use of the corona discharge for the precipitation of fumes and smokes as in the Cottrell precipitator and for the production of chemical reactions as in commercial ozonizers has become a matter of considerable technical importance[1] It seemed to us possible to obtain a clearer idea of the nature of such discharges by following the behavior of droplets of liquid or small solid particles in the field of a corona current. The motion of these particles was found to depend not only on the potential gradient at the particular point in the field where the particle is located, but also on the type of ions present which could be adsorbed by the particle. The method is thus capable of giving considerable information as mechanism of the corona discharge.

Instrumental Set-up

The apparatus used consisted essentially of a transformer to provide the high voltage necessary for the corona current, a kenotron for rectification in case direct current was desired, a discharge chamber consisting of a central wire between two parallel sheet metal plates, jets for introducing droplets of liquid or solid particles into the corona field, electrostatic voltmeters for measuring the potential between the wire and the plates, an arc for illuminating the droplets or solid particles, and a camera for photographing their motion, all as shown diagramatically in Fig. 1.

The transformer was a Thordarson, wireless transformer, Type P, with an adjustable magnetic shunt giving potentials from 0 to 20,000 volts.

The kenotron was a General Electric low voltage kenotron. Most of the experiments were made with a single kenotron. It was found, however, that the general nature of the results was unchanged by the use of a transformer with split secondary and two kenotrons, thus providing a steadier direct current than with the apparatus connected as shown in the diagram.

The discharge chamber was constructed from two sheet tin plates 6 x 8½ in. placed 2 in. apart. The central wire was nichrome, 0.011 in. in diameter.

Jets for introducing the liquid droplets were made of glass drawn down to give a fine stream. The liquids were forced through under pressure, provided by a definite head of water, or by gas from cylinders maintained at a constant pressure with the help of a mercury manometer. The jet was arranged so that the droplets fell in a stream parallel to the central wire, in a line directly between the wire and one of the plates, and were adjustable as to distance from the wire.

Arrangements were made for grounding the jet when desired by introducing a fine wire into the jet close to its point of issue. In the case of a non-conductor like turpentine, to obtain the desired earthing effects it was necessary to introduce the wire into the stream after it actually left the nozzle. In the case of water the wire could be anywhere near the tip.

Electrostatic voltmeters were of the Braun type and General Electric attracted-disk type.

The arc was focused on a small hole in an opaque screen and the beam of light passed through a slit to limit the beam and remove stray light which would be reflected from the plates. The angle between the beam and the horizontal was adjusted to give the best illumination and this was obtained at an angle of about 28 deg.

The camera was provided with a lens having an effective aperture of 1 in. and a focal length of 4½ in. Exposures lasted for about ⅔ sec. and the lines shown in Figs. 2 to 9 illustrating this article are each one the path of a single illuminated particle. This time of exposure was found sufficient to give the total path of

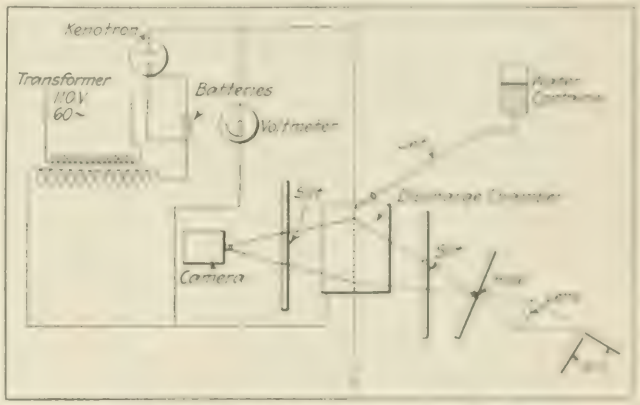


FIG. 1 DIAGRAM OF APPARATUS USED

the particle across the field of the plate. With shorter exposures it was possible from the length of path recorded to calculate the velocity of the fall of the particles, which in the case of the liquids with the pressures employed was in the neighborhood of 10 to 20 cm. per sec.

Experimental Results

In order to describe the motion of droplets and particles in the field of the corona discharge, we have found it convenient to distinguish four different methods by which the droplets may obtain an electric charge—namely, (1) by electrostatic induction, (2) by conduction from the earth when the jet is grounded, (3) by the adsorption of gaseous ions, present in the field

Contribution from the Fixed Nitrogen Research Laboratory.

*Published by permission of George J. Roberts, Special Assistant to the Chief of Ordnance.

[1]The technical importance of the corona discharge was particularly called to our attention by the Bureau of Mines, which provided funds for a survey of existing Cottrell precipitating installations.

FIG. 2. WATER FALLING THROUGH NON-CHARGED FIELD
FIG. 3. INSULATED STREAM OF WATER ATTRACTED TO GROUNDED WIRE. PLATE AT —4800 VOLTS

of the corona discharge, and (4) by direct contact with the central wire. We shall now proceed to the discussion of these phenomena under the headings, "Induction Effect," "Earthing Effect," "Corona Effect" and "Contact Effect."

Induction Effect

When a stream of water was introduced into the field between the wire and plates, there was a general tendency noticed for the jet as a whole to bend toward the wire. This is apparently the familiar phenomenon of the motion of a particle having no initial charge toward the more intense part of an electrostatic field. This phenomenon results from the fact that charges of equal magnitude are induced on opposite sides of the particle, and since those on the side of the more intense field (in this case on the side of the wire) experience the more intense electrostatic force, the particle as a whole moves into the intense part of the field.

This effect is illustrated by Figs. 2 and 3. The former photograph shows the stream of water falling through the field of view without any potential applied to the discharge chamber. Fig. 3 shows the bending of the stream toward the wire owing to the described induction effect. In order to make it certain that this induction does exist and that the bending of the stream is not caused by the leak of electricity from the earth into the water, the water was insulated and the wire itself earthed, so that any leak to the water would give it a charge of the same sign as the wire and hence lead to motion away from the wire. In spite of this, the jet bends toward the wire as shown in Fig. 3, clearly demonstrating the induction effect.

It will also be noticed that the application of the electrostatic field leads to a spreading out of the stream of water. This may be partly due to the greater induction effect acting on the particles on the side of the stream nearer the wire, partly due to an actual separation by induction of electricity to the two sides of the stream, and partly due to the mutual repulsion of the different parts of the stream if it as a whole gets an electric charge by leak.

With a non-conductor like turpentine the induction effect could not be obtained. With small particles of aluminum and zinc the induction effect was very noticeable.

Earthing Effect

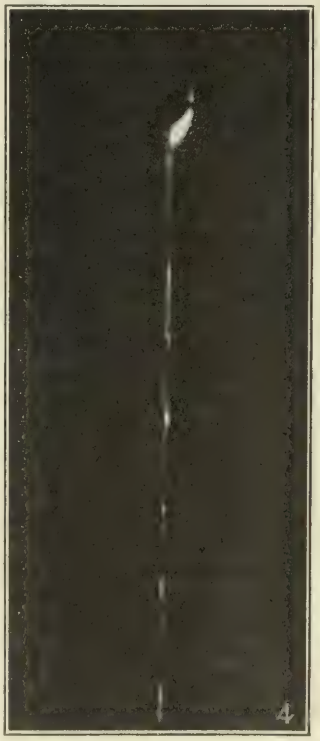
As already described, arrangements were made so that the stream of material issuing from the jet could be earthed, and the effect then determined of earthing either the central wire or the plates. At voltages which were not so high as to make the effect disappear in comparison with the corona effect, the motion of the earthed stream of droplets or particles toward the unearthed electrode was very marked. This is shown in Figs. 4 and 5.

In both these experiments the jet was earthed. In the first case the plate was also earthed, driving the jet sharply to the wire; in the second case the wire was earthed, driving the jet to the plate.

As might be expected, it was very difficult to obtain a decided earthing effect with turpentine because of its low conductivity. Benzyl alcohol showed less earthing effect than water; benzene and petroleum oil a very slight earthing effect. In the case of our metal particles, which were fairly large and of course of high conductivity, the separation of charges was so great that the induction effect always made the particles go toward the wire without reference to the earthing.

Corona Effect

As soon as the voltage between the central wire and the plates has been raised to a point high enough so that appreciable current begins to flow, as indicated by the well known hissing noise of the "silent" discharge,



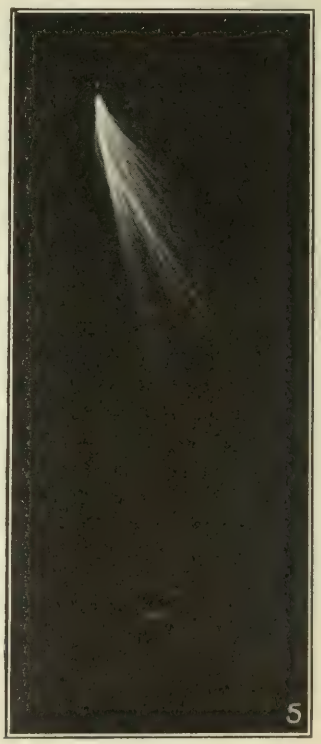


FIG. 4. GROUNDED WATER BENT SHARPLY TO WIRE AT —2700 VOLTS. PLATE EARTHED
FIG. 5. GROUNDED WATER JET DRIVEN FROM EARTHED WIRE AT LEFT (NOT SEEN) TOWARD PLATE AT +2700 VOLTS

a new effect, which we have called the corona effect, becomes of great importance in determining the motion of the particles or droplets. Experimentally we find, under such conditions of high voltage, that the particles have a great tendency to assume a charge of the same sign as the central wire and move away from it. This corona effect occurs whether the central wire is positive or negative. If the plate is earthed and the jet of water also earthed, some of the particles can be forced toward the wire against the corona effect, at least for part of their path. With turpentine, the corona effect always predominates greatly over the earthing effect. With liquids of conductivity intermediate between turpentine and water the ratio of the corona effect to the earthing effect has an intermediate value.

The corona effect for benzyl alcohol is illustrated in Figs. 6, 7 and 8. In these experiments the plate was earthed and hence at a low voltage the leak to the benzyl alcohol from earth was enough to force the stream to the wire by the earthing effect which we have already discussed (Fig. 6). At a high voltage, however, as shown in Fig. 8, the corona effect completely overcomes the earthing effect.

FIGS. 6, 7, AND 8. INSULATED BENZYL ALCOHOL STREAM UNDER INFLUENCE OF CHARGED WIRE (AT LEFT) AND EARTHED PLATE

Fig. 6 at + 2500 and Fig. 7 at +4000 volts show earthing effect. Fig. 8 shows corona effect preponderating at +8000 volts

It should be noted that the corona effect is of main importance in determining the behavior of Cottrell precipitators. Theoretically, we may explain this corona effect by reference to the probable mechanism by which the ionization necessary for carrying the corona current is produced. In the neighborhood of the central wire, the potential gradient is initially steeper than in the main portion of the field, owing to the geometrical configuration of the apparatus. Hence the major part of the ionization by collision necessary for carrying the current will take place in the neighborhood of the wire. Ions produced in this "ionization region" of the opposite sign to the central wire will be attracted to the wire and ions of the same sign as the wire will be repelled to the plates. Hence inside this "ionization region," ions of the opposite sign to the wire will predominate, thus increasing the initial steepness of the potential gradient which leads to the formation of the "ionization region." Outside of this small "ionization region" we may expect ions of the same sign as the central wire to predominate in number, and hence if our droplets or particles have anywhere near equal adsorptive affinities for positive and negative ions, they will obtain in general the same charge as the central wire and move toward the plate.

Looking at this theoretical explanation from the reverse point of view, it seems to us that the observed experimental facts demonstrate with a high degree of certainty that the space charge in the field of a corona discharge, except in the immediate neighborhood of the central wire, is of the same sign as the central wire. This disagrees with the conclusions of Booth[2], who found the density of the space charge to be zero over the largest part of the corona field. His method, however, involves besides the original uncertainties inherent in any method of using an exploring electrode, two successive graphical differentiations, obtaining quantities of nearly the same magnitude, which then have to be subtracted one from the other in order to obtain the desired density of the space charge.

The fact that particles and droplets pick up from the major portion of the corona field the same charge as the central wire with great readiness is further shown by their behavior in the field of an alternating corona current. This is illustrated by Fig. 9. Here, in spite of the fact that the current is reversing sixty times a second, the motion of the droplets of turpentine is almost uniform toward the plate. In other words, inside of a small fraction of a sixtieth of a second, the space charge and the consequent charge on the droplets reverse in sign. This observation explains the fact that it is possible to obtain some precipitation in the Cottrell process using alternating current.

Contact Effect

A fourth method by which particles may obtain a charge in the field of a corona current is by direct contact with one of the electrodes. In particular they may come in contact with the central wire, obtain a very heavy charge from the central wire and then be repelled with great violence right through the ionization region to the plate. This is shown in Fig. 10.

Corroborative Experiments With Single Particles

In order to confirm the existence of the induction, earthing, corona and contact effects by which a charge may be imparted to a particle, experiments were made on single particles suspended in the field on glass fibers and on thin metal wires. The phenomena expected were reproduced. At high potentials the particle was always repelled from the central wire by the corona effect, at low potentials the particle could be made to move toward either electrode desired by taking advantage of the

[2] *Phys. Rev.* (2), vol. 10, p. 266 (1917).

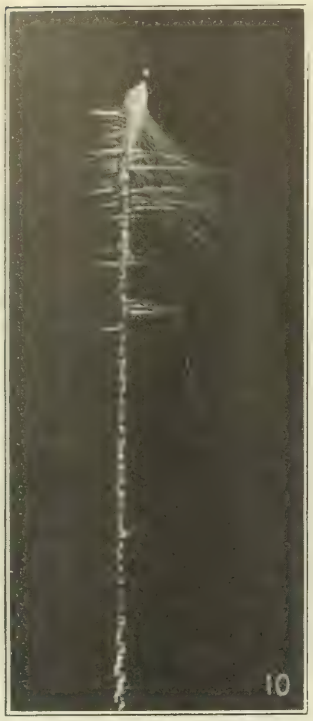


FIG. 9. INSULATED TURPENTINE DROPLETS DEFLECTED FROM WIRE CHARGED WITH 60 CYCLE ALTERNATING VOLTAGE OF ±9000. PLATE GROUNDED

FIG. 10. VIOLENT EXPULSION OF EARTHED WATER DROPLETS ON COMING IN CONTACT WITH WIRE AT +8000 VOLTS

earthing effect, and at any voltage the particle was repelled from the central wire after coming in actual contact with it.

Waterfall Effect

In connection with our experiments on the earthing effect, it was noticed in the case of water that the jet breaks into finer particles when positively charged than when negatively charged. This apparently means that the surface tension of water is lowered more by a positive charge of electricity than by a negative charge.

This conclusion would seem to stand in agreement with the phenomenon known as the waterfall effect—namely, that droplets of water naturally have more tendency to assume a positive than a negative charge of electricity. This would of course be expected if the surface tension of water is lowered more by positive than by negative electrification, since that would mean that the potential energy of the droplet is more lowered by positive than negative electricity, which means of course that there is more natural tendency for water to pick up positive than negative electricity, since in general electrostatic systems rearrange themselves in the direction of minimum potential energy.

Conclusion

It is believed that this article demonstrates the existence of four methods by which particles in the field of a corona discharge may obtain charges of electricity—namely. by induction, by conduction of electricity from the earth, by the adsorption of ions present in the corona field, and by actual contact with an electrode. The motion of the particles is determined by the charge which they receive by one of these methods and of course of the potential gradient.

It is shown that the space charge in the major part of the field of the corona discharge is of the same sign as the central wire, in contradiction to the conclusions of Booth.

It is believed that the adsorption of ions having the same charges as the central wire is the underlying process in the action of Cottrell precipitators.

An incidental observation on the behavior of streams of water shows that they break up into finer particles when positively charged than when negatively charged. This was shown to be in accord with the well-known waterfall effect.

Potash Mines of Alsace

French potash and the conditions of that industry, as viewed since the Alsatian district was incorporated in the national domain, are reviewed by the American Trade Commissioner in Paris.

With the exception of the Société de Kali Sainte Thérèse, under Alsatian-French control, all of the potash mines in Alsace were owned and operated by German companies before the war. The first company to extract potash in Alsace was formed in 1906. At the time of the armistice there were fourteen companies, controlling 109 concessions and seventeen mines, these companies being, in turn, controlled by four large groups. The Sainte Thérèse group controls thirty-three concessions, the Deutsche Kaliwerke group controlled forty-eight concessions, the Wintershall group thirteen concessions, and the Hohenzollern group fifteen concessions. The German holdings, under liquidation since the armistice, are being operated for the account of the French Government.

300 Per Cent Increase Since Armistice

Until the Alsatian mines passed under French control the German Government regulated the sale of potash from them and from the German mines in order to prevent overproduction and to keep prices at a uniform level. During the year 1913 the German and Alsatian mines produced 11,600,000 tons of crude potash, 6 per cent of this amount, or approximately 696,000 tons, being the quota from the Alsatian mines. When the Germans left, some of the mines were found to be in a flooded state, and considerable pumping and repairs were necessary. Since the armistice the production has been increased by more than 300 per cent.

The total production of crude potash for 1919 was about 550,000 tons. During this period the average production per miner was increased from 0.933 ton per day to 1.48 tons per day.

The estimated production of crude potash from the Alsatian mines during 1920 is 1,320,000 tons, or about 220,000 tons of pure potash. It is expected that this output will increase to 2,040,000 tons of crude, or 340,000 tons of pure potash, in 1921, and to 2,340,000 tons of crude, or 390,000 tons of pure potash, in 1922.

Lack of Transport Curtails Export

Since the armistice the United States has been unable to secure anything like the quantity of potash it urgently requires. This is due almost entirely to the transport crisis in France. The lack of railway transport likewise reduces the shipments of coal necessary for the reduction of the higher grades of potash.

It should be remarked that the mines now in operation in Alsace are alone capable of supplying the world's needs. Otherwise expressed, it is merely a matter of stimulating production to the required level. —*The Review*, May 15, 1920.

Economic Aspects of the Chilean Nitrate Industry*

A Summary of the Economic Features of the Chilean Nitrate Industry, Showing the World-Wide Requirements of This Chilean Natural Product for Agricultural and Industrial Purposes—Work of the Nitrate Producers' Association and Outlook for Future Developments

CHILE is the only country in the world known to contain commercially important deposits of nitrate of soda, a product which has a wide variety of uses, but is best known as a valuable fertilizer. Two grades of nitrate are produced: 95 per cent, or ordinary nitrate, which is used for fertilizer purposes, and 96 per cent, or refined nitrate, which is used for manufacturing purposes. Before the war approximately 75 per cent of the nitrate marketed was of the lower grade. Private business in Chile and government revenue are both dependent on the prosperity of the nitrate industry, since this one product ordinarily constitutes nearly 80 per cent of the country's exports, and the export tax on nitrate and its principal byproduct, iodine, constitutes more than half the government's total income.

There is a great deal of speculation concerning the probable duration of the beds, but the very range of the conclusions arrived at shows on what inadequate data they have been based. One expert estimates the explored deposits to contain 240,000,000 metric tons of nitrate, and calculates the contents of the unexplored region to be twice as large. According to these figures it would require over 240 years to exhaust the supply at the present rate of production. Other estimates are less optimistic and set a much earlier date for the exhaustion of the beds.

The nitrate region consists of five important districts.[1] The relative importance of the principal districts is shown in Table I, giving the number of oficinas producing plants operated in each district, the extraction of caliche (the raw product from which nitrate is produced), and the amount of nitrate derived, during 1917:

TABLE I PRODUCTION OF THE PRINCIPAL NITRATE DISTRICTS IN 1917

Districts	Oficinas in Operation	Caliche Mined Metric Tons	Nitrate Produced Short Tons	Nitrate Produced Metric Tons
Tarapaca	76	10,330,984	1,433,213	1,302,921
Tocopilla	7	1,822,334	250,690	227,900
Antofogasta	30	9,172,026	1,184,225	1,076,568
Aguas Blancas	7	1,066,473	160,149	145,590
Taltal	9	1,923,257	272,858	248,053
Total	129	24,315,074	3,301,135	3,001,032

Caliche differs in appearance and composition in various zones. It usually contains (besides sodium nitrate) sodium chloride, sodium sulphate, potassium nitrate, sulphates of lime and magnesia, sodium iodate and sodium biborate in varying proportions. The sodium nitrate content varies from less than 10 per cent to over 70 per cent, the average sodium nitrate content of the caliche extracted during 1917 being 17.48 per cent.

Iodine, the most important byproduct of the nitrate industry, is extracted from the liquor which remains after the nitrate has been precipitated. Although some sodium iodate is contained in practically all caliche, iodine is produced by only a portion of the nitrate companies, and the output of these companies is carefully regulated by a producers' trust in order that the limited market may not be overstocked. The average pre-war exports amounted to approximately 475,000 kilos annually; but during the war, the exports were much larger: 708,800 kilos in 1915, 1,323,000 kilos in 1916, and 759,000 kilos in 1917. Germany was the principal purchaser of iodine before the war, the United States second, and Great Britain third.

Another byproduct, nitrate of potassium, is engaging the attention of various experts. One chemical engineer asserts that this salt exists in the caliche throughout all parts of the nitrate region and that the caliche used by at least a hundred of the oficinas contains from 1 to 2 per cent. An American company is reported to have perfected a refrigerating process by means of which it can manufacture this byproduct at small cost.

Cost of Labor and Supplies in the Nitrate Fields

The laborer in this arid zone requires great strength and endurance under the most trying of living conditions. The nitrate region produces no fresh fruits or vegetables, and he is obliged, therefore, to live largely on imported canned goods. He receives a far higher wage than any other class of Chilean laborer, but on the other hand the cost of all the necessaries of life is exceedingly high. To compensate the laborer for the hardships of the situation, the nitrate operators are compelled to provide living quarters for employees and their families and to maintain stores where they can purchase food, clothing and household furnishings.

At the outbreak of the war, 53,000 laborers were employed in the nitrate fields. Immediately afterward this number materially decreased, but in 1915 it began to increase again and in 1917 had reached 56,000. Of this number, about 43,000 were Chileans, and the remainder largely Peruvians and Bolivians. Before the war the average daily wage of the nitrate laborer was 6.48 Chilean paper pesos, and in 1917 the average wage was 6.81 Chilean paper pesos. (In 1914 the exchange value of the paper peso was about 20c.; during the war its value fluctuated between 14c. and 33c.)

Nitrate producers must import all their supplies, such as fuel, machinery and parts, and bags in which to ship the nitrate; and the cost of all these commodities has increased materially during the last few years. One manufacturer reported in 1918 that petroleum, which had formerly cost 41½s. ($10.98) per ton, then cost 150s. ($36.45); that the cost of coal had increased from 29s. to 115s. (from $7.06 to $27.95); and that jute bags, which he had formerly purchased for 3½d. (7c.) each, had reached the high figure of 22d. (46c.). A million tons of fuel was consumed in nitrate mining and refining in 1917. Of this total 65.5 per cent was

*Abstracts from Latin American Circular 67, Bureau of Foreign and Domestic Commerce.

[1] See CHEM. & MET. ENG., vol. 22, No. 14, p. 655.

petroleum, 28.6 per cent coal, and the remainder such fuel substitutes as straw and grain. Apparently no wood was used. Before the war most of the coal was imported from Great Britain. Petroleum comes principally from Mexico and the United States.

Nitrate is packed for shipment in jute bags holding about 200 lb. each. These bags are imported from India and about 30,000,000 of them are ordinarily used each year.

Relative Importance of Native and Foreign Companies

The greater part of the capital invested in the nitrate industry is Chilean and British. The amount of American capital in the field is relatively small but is increasing. German interest in the business was growing until checked by the war. The comparative importance of the native and foreign nitrate plants can be judged by their proportionate share in the total production for the year 1917, as shown in Table II.

TABLE II. COMPARATIVE IMPORTANCE OF NATIVE AND FOREIGN NITRATE PLANTS

Nationality	Number of Oficinas	Annual Production—Short Tons	Annual Production—Metric Tons	Per Cent of Total
Chilean	54	1,399,995	1,272,723	42.41
British	44	1,246,622	1,133,293	37.76
German	7	177,148	161,044	5.37
American	2	86,404	78,549	2.52
Peruvian	7	86,549	78,681	2.62
Spanish	4	76,639	69,672	2.32
Slavic	7	179,465	163,150	5.44
Others	4	51,613	46,920	1.56
Total	129	3,304,435	3,004,032	100.00

Sixty per cent of the nitrate manufactured by Chilean companies is the product of five large concerns, Compañía de Salitre de Antofagasta, Compañía Salitrera El Loa, Compañía Salitrera El Boquete, Compañía Salitrera Lastenia, and Compañía de Salitres y Ferrocarril de Agua Santa.

La Compañía de Salitre de Antofagasta is the oldest and one of the most important nitrate producers in the country. It owns a strip of nitrate land about 32 km. long by 4 km. wide in the Antofagasta district and employs 15,000 men. Its oficinas consume 80,000 tons of coal yearly, and the public stores which it has established at its plants purchase 8,000,000 paper pesos worth of general merchandise annually. It produced 340,000 metric tons of nitrate during 1917, 10 per cent of the total amount manufactured during the year. In connection with its nitrate business, the company has built up a large general import and export business, for which it maintains a fleet of four tugs and about a hundred barges at Antofagasta.

Compañía Salitrera El Loa owns about 14,000 acres of land in the Antofagasta district about 95 miles from the coast on the Antofagasta and Bolivia Railroad. It has seven oficinas and produced nearly 212,000 tons of nitrate during 1917. Compañía Salitrera El Boquete has two oficinas located in the Antofagasta district and produced 94,000 tons of nitrate in 1917. Compañía Salitrera Lastenia, also located in the Antofagasta district, has two oficinas and produced 79,000 tons of nitrate during 1917. Compañía de Salitre y Ferrocarril de Agua Santa owns six oficinas in the Tarapaca district and manufactured 55,000 tons of nitrate in 1917.

Important Foreign Companies

The 1917 statistics show eight English companies whose annual production of nitrate amounted to over 50,000 metric tons. The combined output of these companies represented over 60 per cent of the total quantity of nitrate manufactured by English firms during that year.

There are four German nitrate firms. These companies are equipped to produce considerable quantities of nitrate, but were forced to close many of their plants during the war, and, therefore, their 1917 production does not represent their normal output. Compañía Salitrera H. B. Sloman owns four oficinas in the Tocopilla district, two of which were open in 1917 and produced 58,000 tons of nitrate. Compañía Salitrera Alemana owns four oficinas in the Taltal district, only one of which was operated during 1917, producing 42,000 tons of nitrate. Salpeterwerke Gildemeister A. G. owns three oficinas in the Tarapaca district, all of which were operated during the year; their total output was 50,000 tons. Salpeterwerke Augusta Victoria A. G. owns only one oficina. This oficina is located in the Antofagasta district and produced 10,000 tons of nitrate during the year.

The Grace Nitrate Co. and the Du Pont Nitrate Co. are the only American companies producing nitrate in Chile. The Grace company owns a well-equipped oficina in the Tarapaca district where it employs more than a thousand men. The company produced 42,000 tons of nitrate during 1917, all of which was sent to the United States. The Du Pont company has one oficina in operation in the Taltal district and is building a second in the Tarapaca district. Its nitrate production for 1917 was 35,000 metric tons.

The firm of Baburizza, Lukinovic y Cia. was founded by two members of the Slavic colony in Chile and one Chilean, and might be considered Slavic, although it is registered in Chile. This company owns three oficinas and about 69 sq.km. (1 sq.km. = 0.386 square mile) of nitrate land in the Antofagasta district. It employs 2,200 men at its nitrate plants and produced 123,000 tons of nitrate during 1917.

Markets for Chilean Nitrate

The market for nitrate steadily increased and Chile's profits from the exploitation of this natural monopoly increased proportionately until the beginning of the war, when the European demand for nitrate fertilizers practically ceased. Fortunately for the nitrate producers and for Chile, however, the Allies soon found that they needed this product for the manufacture of high explosives; and needed it so badly that they were willing to pay high prices, allocate shipping space to carry it from Chile to the United States and Europe, and furnish the necessary supplies to the producers in Chile; as a result, the intense depression which had begun with the declaration of war was quickly succeeded by an unparalleled prosperity.

TABLE III. CHILEAN NITRATE PRODUCTION AND EXPORT 1909–1918

Year	Production—Short Tons	Production—Metric Tons	Exports—Short Tons	Exports—Metric Tons
1909	2,322,057	2,110,961	2,348,454	2,134,958
1910	2,711,957	2,465,415	2,569,535	2,335,941
1911	2,773,125	2,521,023	2,694,467	2,449,515
1912	2,844,435	2,585,850	2,742,390	2,493,082
1913	3,049,479	2,772,254	3,012,173	2,738,339
1914	2,709,692	2,463,356	2,031,461	1,846,783
1915	1,930,820	1,755,291	2,225,733	2,023,394
1916	3,204,182	2,912,893	3,278,250	2,980,227
1917	3,304,435	3,004,032	3,053,918	2,776,289
1918	.....	.....	3,256,097	2,960,088

The steady increase of the normal pre-war demand

for Chilean nitrate, the depression occasioned by the outbreak of the war, and the subsequent recovery are all reflected in Table III, showing the annual production and exports for the 10-yr. period 1909-1918.

The cessation of hostilities in Europe brought to a sudden and complete halt the need of nitrate for ammunition manufacture and precipitated a period of depression similar to that of 1914. The decline in the market necessitated the closing of a considerable number of the oficinas and the curtailment of production at others; quotations of nitrate stock slid steadily downward; the efforts of the association of producers to maintain selling prices partially failed and they were forced to yield bit by bit in order to sell even a portion of the nitrate stocks rapidly accumulating on the Chilean coast.

Table IV, giving the comparison of nitrate production, exports and stocks in Chile, by months, for 1918 and 1919, shows the difficulties which this industry has been experiencing. The figures are unofficial estimates and the amounts are given in Spanish quintals (one Spanish quintal = 101.4 lb.), the commercial unit of measure for nitrate.

TABLE IV. COMPARATIVE MONTHLY PRODUCTION, EXPORT AND STOCK OF CHILEAN NITRATE, 1918 AND 1919

	Production		Exports		Stocks Remaining in Chile	
	1918	1919	1918	1919	1918	1919
Months	Quintals	Quintals	Quintals	Quintals	Quintals	Quintals.
January...	5,702,618	4,276,498	4,022,345	1,308,951	20,866,273	20,619,547
February..	4,935,804	3,396,211	3,943,769	952,159	21,858,308	23,063,599
March....	5,277,224	3,264,899	4,722,787	963,264	22,412,745	25,365,234
April.....	5,178,797	3,067,362	5,099,754	738,786	22,491,788	27,693,810
May.....	5,295,229	3,084,390	6,385,749	403,669	21,401,268	30,374,531
June.....	5,262,212	2,832,165	5,448,815	795,342	21,214,665	32,411,354
July.....	5,080,070	2,532,632	6,591,953	450,931	19,702,782	34,493,055
August....	4,868,416	2,376,563	6,036,664	1,236,509	18,534,534	35,633,109
September	4,612,448	2,269,619	5,334,556	960,619	17,812,426	36,942,109
October....	5,334,339	2,538,468	7,505,686	3,740,247	15,641,079	35,740,330
November.	5,212,752	2,714,461	5,009,261	2,085,739	15,844,570	36,369,032
December.	5,412,855	(a)	3,355,235	6,359,074	17,902,190	(a)

(a) Statistics not yet available.

Chief Markets for Chilean Nitrate

The United Kingdom, Germany and the United States were the chief markets for Chilean nitrate before the war, the three together taking approximately five-sixths of the total exports during 1912 and 1913. France, Belgium and Holland ranked first among the lesser markets. The statistics of the war years are of relatively little value in gaging the future demand in any country engaged in the European war: Germany and Belgium, formerly good markets, were unable to import any nitrate; the United States, France and Italy increased their imports, but used most of it for ammunition manufacture. From the point of view of the dealer who wishes to estimate the future demand for nitrate, perhaps the most significant development of the years 1917 and 1918 is the marked increase of nitrate exports to Japan.

Table V shows the exports of nitrate from Chile by countries of destination for the pre-war years 1912 and 1913 and the war years of 1917 and 1918.

TABLE V. EXPORT OF CHILEAN NITRATE BY COUNTRIES OF DESTINATION

Countries of Destination	1912 Metric Tons	1913 Metric Tons	1917 Metric Tons	1918 Metric Tons
United Kingdom.....	994,625	1,004,979	756,902	823,269
Germany.....	565,722	629,298		
United States.....	484,902	630,790	1,512,577	1,962,552
France.....	108,880	121,472	139,866	20,304
Belgium.....	92,929	118,690	.....	.....
Holland.....	98,747	100,379	43,997	
Italy.....	9,306	10,684	67,961	6,906
Japan.....	21,707	28,342	50,773	47,512
All other.....	116,264	93,705	204,213	99,545
Total.....	2,493,082	2,738,339	2,776,289	2,960,088

After the signing of the armistice, the United States Government no longer needed the nitrate purchased for war purposes and transferred the amount on hand from the War Department to the Agricultural Department for distribution to the farmers. This amount, plus a considerable quantity already held by the Agricultural Department, was sold at cost. As long as these stocks were available at low prices, there was little chance for the sale of privately held nitrate, but the last of this supply was disposed of in the spring of 1919 and subsequently all Government restrictions on nitrate imports were removed. The nitrate dealer has a free market once more and, what is of equal importance in his estimation, the Government plants for the manufacture of synthetic nitrate have been closed. Imports of nitrate of soda into the United States for the year 1919 were 407,459 long tons, about 65 per cent of the 1913 imports.

Apparently a relatively small proportion of the nitrate imported into the United States is used for fertilizer purposes. According to the War Trade Board, about 40 per cent is ordinarily used in the manufacture of explosives, 13 per cent for fertilizer, and the remainder for making sulphuric acid and for miscellaneous purposes. The Department of Agriculture reports that 564,000 tons was imported during 1914, of which amount 162,000 tons, about 29 per cent, was used for fertilizer purposes.

European Sales Restricted During 1919

About 80 per cent of the nitrate imported into Europe is ordinarily used for fertilizer purposes. It is said that there was an active demand for these fertilizers last year, but government restrictions, accentuated by the lack of shipping space, greatly restricted sales, especially during the early part of the season when the demand was strongest.

Great Britain had contracted for 680,000 tons of nitrate shortly before the signing of the armistice, practically all of which became available for ordinary market uses, and import restrictions were not removed until the major part of these government stocks had been disposed of. Since the middle of May, when government restrictions were finally removed, imports have been greatly hampered by the lack of available tonnage.

Germany has been unable to import nitrate because of the continuance of the blockade, but it seems unlikely that it would have been able to do so anyway, as at the present depreciated value of the mark, the selling price of nitrate fertilizers would be prohibitively high.

The reduction of acreage under cultivation in France and Belgium has somewhat curtailed the demand for nitrate fertilizers, but it is stated that consumption would have been nearly double what it was during the first half of the year had it not been for the congestion at the ports, the disintegration of the interior transport service, and government restrictions.

Chile has been greatly alarmed by this depression in the market for nitrate and by rumors hinting that nitrate was to be supplanted in Europe and America by two rivals, namely, sulphate of ammonia, a byproduct of coke, and synthetic nitrate produced by electric fixation of atmospheric nitrogen. To fully appreciate this alarm, it is essential to comprehend how dependent the nation is upon this one export.

Chile buys the bulk of its manufactured products abroad and pays the bill with the raw products exported, nearly 80 per cent of whose value is represented

by nitrate sales. Therefore the value of the Chilean peso abroad is directly affected by the market for nitrate, and nearly all private business in Chile is indirectly dependent on the nitrate industry.

Government Aid to Producers

The vital importance of the nitrate industry to the Chilean Government is graphically illustrated by the following facts: For the period 1901-1917 the export duties on nitrate and its principal byproduct, iodine, constituted 62 per cent of the total revenue received; during 1913, the last pre-war year, they constituted 57 per cent of the total revenue; and during 1917, the last year for which these statistics are available, they formed 65 per cent of the total. The government cannot afford to allow the exports of nitrate to decline nor can it afford to have the 50,000 laborers ordinarily employed in the nitrate fields idle.

During the depression of 1914 the government arranged to make temporary loans to the producers in order that they might not have to close their plants. Under this system the nitrate companies desiring them were issued government bonds, which they were at liberty to sell in the open market. These advances were to be guaranteed on nitrate stocks and to be refunded plus the accrued interest when said stocks should be sold. These arrangements have been continued up to the present time, the companies now being allowed to receive not to exceed four paper pesos for each Spanish quintal of nitrate delivered at the port of embarkation and not to exceed three pesos for each Spanish quintal stored at the oficinas. From August, 1914, to December, 1918, government loans to producers amounted to 103,946,000 paper pesos and reimbursement of these loans to 98,570,000 paper pesos. Loans during January, 1919, amounted to 9,561,000 paper pesos.

Further evidence of the government's interest in the welfare of the nitrate industry is afforded by the recent appropriations to the newly established industrial school for nitrate research; by the recognition accorded the scientific society lately formed by a number of Chilean and English nitrate companies; and by two plans recently discussed in Congress. The first of these plans, to centralize sales under government control, has been severely criticized; the second, to alter the basis of the nitrate tax, has been discussed several times but no definite action taken. The nitrate tax, as now imposed, is a fixed amount, 2s. 4d. ($0.568) per Spanish quintal of nitrate exported, and the cost of production varies according to the nitrate content of the raw material exploited and according to the size and efficiency of the reducing plant, wherefore some companies realize much larger profits than others. Under the plan now being discussed the tax would be levied on the profits of the companies rather than on the nitrate exported.

Protective Association Formed by Companies

During the recent crisis a second attempt has been made to organize the nitrate producers into an association which shall limit production and centralize sales, the object being to allow only as much nitrate to be exported as the consuming markets can absorb at a price high enough to afford reasonable profits to the producers. The first association was formed in 1901 and ceased to exist in 1909 because of a disagreement concerning production allotments to certain companies. The present association is the outgrowth of the former association and the Nitrate Propaganda Committee organized by the English companies about 1889 and later known as the Asociacion de Salitre de Propaganda. This association has had headquarters in Chile and has had two distinct prerogatives: To keep a complete statistical record of the progress of the nitrate industry, and to increase the world market for nitrate through the education of the public as to its uses. For this latter purpose propaganda committees have been maintained in France, Germany, Belgium, Holland, Spain, Italy, the United States, Japan, Egypt, Cuba, Australasia, England and Wales.

The directors of this association felt the necessity of forming an organization which would have some control over the entire industry, that this organization should consist of the producers, and that it should be free from any sort of government control. They therefore appointed a committee to study the situation and draw up a plan for such an organization. This plan was presented and accepted at a meeting of the producers held in January, 1919.

Work of the Association

All the Chilean and English producers are now members of this association, and it is reported that the four German companies are to be admitted in the near future. The two American firms, the Grace Nitrate Co. and the Du Pont Nitrate Co., have not joined the association.

The duties of the association may be briefly summarized as follows:

1. To spread nitrate propaganda, commercial and scientific, throughout the world market.
2. To keep a statistical record of the industry.
3. To regulate exports and control production within certain general limits.
4. To fix selling prices periodically to accord with conditions governing the market and factors governing the cost of production.
5. To establish nitrate stocks at convenient ports.
6. To study and encourage new methods of refining and mining.

The association has followed the established custom of selling nitrate f.o.b. Chilean ports. Prices are quoted in shillings and pence per Spanish quintal of 101.4 lb. The association could not hope to sell nitrate at 13s. ($3.163) per quintal for ordinary, or 95 per cent nitrate, and 13s. 6d. ($3.285) for refined, or 96 per cent, the prices at which the Allied Governments were purchasing it at the close of the war, but attempted to fix a selling price of 10s. 1d. ($2.454) for ordinary and 10s. 4d. ($2.514) for refined, a price above the average for any year prior to 1917. As the report of sales issued in October, 1919, shows, however, it has not been able to maintain this price, its average selling price for nitrate sold up to October having been 9s. 0.5d. ($2.20) for ordinary and 9s. 4.2d. ($2.28) for refined, and for nitrate to be delivered between October and March, 1920, having been 9s. ($2.19) for ordinary and 9s. 3d. ($2.25) for refined. At these average prices, it had disposed of 17,358,000 quintals of ordinary and 866,000 quintals of refined up to October, and had contracted for 16,500,000 quintals for future delivery.

Encouraged by the slight improvement in the market, the association raised its price in October to 9s. 7d. ($2.33) per quintal for delivery up to Dec. 15 and 9s. 9d. ($2.37) for later delivery up to June 30, 1920. Between October and December prices were gradually increased until in December nitrate for immediate delivery was sold at 9s. 7d. ($2.33) and for future delivery from 10s. 6d. to 12s. ($2.56 to $2.92).

The profits of the last few years have afforded many of the producers an opportunity to fortify themselves against this anticipated period of depression. The following statistics, compiled from recently published reports, of some of the more important English and Chilean companies illustrate to what extent they have taken advantage of this opportunity.

The fourteen English companies which close their year in December had a total capitalization of £4,189,000 at the end of 1918 and £404,900 outstanding in debentures, against which they had £1,216,359 in reserves and £786,573 in their carry forward accounts. They had distributed £592,275 in dividends for the year, an average of 14.1 per cent, and had added £155,000 to the reserves and increased their carry forwards. (The value of the pound sterling is $4.8665 at normal exchange.)

La Compañía de Salitre de Antofagasta, the largest nitrate producing company, made a profit of 22,305,520 paper pesos for 1918, out of which 11,520,000 was distributed in dividends, 10,000,000 added to funds for exploitation and amortization of property, and the remainder to a contingency fund. The company is capitalized at 16,000,000 paper pesos, has a reserve fund of 2,000,000, a contingency fund of 2,674,955, a fund of 32,000,000 for exploitation and amortization of property, an insurance fund of 2,500,000, and a fund of 2,000,000 paper pesos to provide for fluctuation in exchange.

Compañía Salitrera El Lon, another large Chilean company, made a net profit of £450,314 during 1918, out of which £227,500 was distributed in dividends, £200,000 placed in the fund for amortization of oficinas and land, and the balance placed in the dividend fund.

Compañía Salitrera Lastenia made a net gain of £184,197 during 1918, out of which £124,800 was distributed in dividends, and the remainder placed in the dividend fund. This company is capitalized at £624,000, has a reserve fund of £20,000, a fund of £8,029 for operation, a fund of £14,024 to provide for the fluctuations of exchange, and a dividend fund of £75,795.

Outlook for Future Reassuring

According to the representatives of the association abroad the prospective demand for nitrate fertilizers for use on next year's crop is excellent. The largest problem is that of ocean transportation; indeed so serious is this one factor that the sales for some time to come will probably be limited by the available shipping space and the prevailing freight rates. Uncertain exchange and disturbed political and economic conditions in Europe will tend indirectly to reduce consumption also.

The association reports the present outlook decidedly encouraging, although no spectacular recovery is expected. It is estimated that exports for the present nitrate year (July 1, 1919, to June 30, 1920) will not exceed 30,000,000 Spanish quintals (about 1,400,000 metric tons).

The educational work in the application of Chilean nitrate to the soil has been successfully carried on since the formation of the original association of producers and the resultant demand is expected to continue for a long time to come.

If Chilean nitrate is ever displaced to any great extent in the fertilizer field the process will be so slow as to work little hardship on the producers. Such replacement certainly can never keep pace with the rate of increase in demand for nitrogen fertilizers.

Calibration of an Optical Pyrometer

By W. E. Forsythe

AN OPTICAL or other pyrometer is calibrated by finding the relation between the reading of the scale, whatever that may be, and the temperature of the standard source with which it is compared. In the disappearing-filament type of optical pyrometer the quantities involved are the current through the pyrometer filament and the temperature of a black body when the filament as observed through the eyepiece apparently matches in brightness the black-body image located in the plane of the pyrometer filament.

The direct way to calibrate the pyrometer is to have a black body that can be operated at various known temperatures over the entire range that it is desired to use the pyrometer. This is always very difficult and sometimes impossible. The main trouble is to get a black body that will stand the high temperatures and at the same time it is difficult to get a satisfactory method of measuring these temperatures. Standard black bodies are seldom operated at a temperature higher than that of melting palladium (1,828 deg. K.).

Thermocouples that have been operated for any length of time at this temperature are not reliable in their indications. For the above reasons, when calibrating for temperatures above the range of thermocouples, use must be made of standard melting points or another optical or a radiation pyrometer. There are not many metals that can be conveniently used for this purpose. The two that are most commonly employed are gold (1,336 deg. K.) (deg. K. indicates degrees Kelvin, i.e., absolute Centigrade) and palladium (1,828 deg. K.). There are no metals with melting points between these two that can be used without much trouble due to oxidation.

An optical pyrometer can be calibrated from a black body held at a particular temperature[1]. Since the black body thus used is to be the standard of reference, a standard temperature, that is, one determined by means of a standard melting point, is generally chosen. A very good temperature for such work is that of melting palladium, or the palladium point. There are three reasons for the choice of this point. In the first place, it is about as high a temperature as a platinum-wound furnace can be operated. In the second place, this temperature is about as high as the pyrometer filament will stand if it is to have a long life. In the third place, the temperature of melting palladium is very well known in terms of the laws of radiation and the temperature of melting gold.

Reduction of Apparent Radiation

To calibrate an optical pyrometer from a furnace held at a particular temperature it is necessary to have some means such as a rotating sectored disk (to be described below) or an absorbing glass of known transmission for cutting down the apparent brightness of the incident radiation. If readings are made of the current through the pyrometer filament for an apparent brightness match with a rotating sector or an absorbing glass of known transmission between the pyrometer lamp and the standard black body, there will be obtained a measure, in terms of a current through the pyrometer filament, of a brightness that is some known factor of that of the standard black body at the standard tempera-

[1] C. E. Mendenhall, *Phys. Rev.*, vol. 32, p. 74 (1911).

ture. If monochromatic radiation is used, it is easy to calculate the temperature, T_2, of the black body corresponding to this measured brightness, that is, to this current through the pyrometer filament from T_1, the standard temperature, by the following formula derived from Wien's equation:

$$\log R = \frac{c_2 \log e}{\lambda}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] \qquad (1)$$

where R is the transmission of the sector, temperatures on the absolute Centigrade scale, and λ the wave-length used. If the measurements are made with a red glass in the eyepiece, the temperature that would correspond to this fraction of the brightness of the standard black body can be calculated just as before, excepting that in this case the effective wave-length of the red glass for this temperature interval is to be used. By using a number of such sectors, points can be obtained for a curve showing the relation between the temperature and current through the pyrometer filament. In Table I is given the transmission value of a number of sectors and the apparent temperatures, T_2, that would be obtained by their use in connection with a black body held at the temperature of melting palladium.

TABLE I.

Temperatures corresponding to different percentages of the radiation from a black body held at the temperature of melting palladium (1,828 deg. K.) using red glass with an effective wave-length which varies as is shown in column 2. C_2=14,350 μ deg.

Transmission of Sector*	λe*	T_2 Deg. K.
0.749	0.6652μ	1785
.499	.6653	1727
.2443	.6655	1632
.0830	.6657	1509
.0336	.6658	1426
.01668	.6659	1356
.00542	.6662	1267

*Last digit in this column approximated.

Use of Standardized Filament

It is very troublesome to operate a standard black body every time it is necessary to calibrate an optical pyrometer. Much time can be saved if a tungsten lamp with a filament of suitable size is standardized so as to have the same brightness for a particular part of a filament, when observed with the optical pyrometer, as the standard black-body furnace for one or more definite temperatures. Such standard lamps with single-loop wire filaments have been made, calibrated and used in this laboratory for this purpose for several years. The bend in the wire was made somewhat sharp and the center of this loop used as a point of reference. This method has recently been employed by a number of the research laboratories of the country using lamps calibrated at several currents for temperatures between 1,200 and 2,000 deg. K.

For the highest accuracy the tungsten lamp that is to be used for calibration purposes should be standardized with an optical pyrometer using a red glass which is the same as that on the pyrometer to be compared, or correction should be made for the difference. If the effective wave-lengths are known, this correction can easily be made.[2] For practical purposes, however, if similar red glasses are used the error will be quite small.

Tungsten filaments have been found to depart very markedly from Lambert's cosine law in their radiation.[3] To avoid error due to this cause, care must always be taken in determining the temperature of circular filaments to measure the brightness of the central part of the filament. For this reason, the pyrometer filament should always be parallel to the background filament. This, of course, requires that the pyrometer filament be much smaller than the image of the background filament used as a standard.

A ribbon tungsten filament with some mark to indicate the exact spot sighted upon is sometimes used as a standard background against which to calibrate a pyrometer filament. The ribbon filament does not require as much magnification as the wire filament. A commercial form of the disappearing-filament pyrometer which has a small magnification can be calibrated, using such a ribbon filament, providing an extra lens is used between it and the pyrometer so as to give a large image of the filament. If a lens is used corrections must be made for its transmission, or the background lamp must be calibrated by means of the standard pyrometer with the lens before the lamp. The transmission of a lens is measured in much the same manner as is the transmission of a piece of absorbing or other glass. The method generally employed is to form an image with the lens whose transmission is being measured and then, taking care to see that the lens is not limiting the beam, to measure the brightness of this image and compare this brightness with that of the standard source as observed directly.

If transmissions are measured with the pyrometer, it is necessary to have it calibrated for relative brightness rather than for temperature. If a number of calibrated rotating sectors are available, this is very easily done. It is only necessary to find the currents through the pyrometer filament for apparent brightness matches against a standard source when the different sectors are used and plot a curve between relative brightness as given by the transmission of the sectors and the current.

If it is not possible to do this in an industrial plant, such work can always be done in a standardizing laboratory. From the transmission of the lens thus determined, the correction to the temperature can be calculated by means of equation (1), where in this case R is the transmission of the lens.

A ribbon-filament lamp and lens combination has been used to calibrate a Wanner type of optical pyrometer. In this case, the image of the filament was focused on the slit of the pyrometer and readings made by obtaining the relation between the scale of the pyrometer and the temperature of the ribbon filament, corrected, of course, for the transmission of the lens.

Approximate Values by Interpolation

If a rotating sector or an absorbing glass of known transmission is used between the source being investigated and a calibrated pyrometer lamp, the calibration of this pyrometer with the sector or absorbing glass can be extended above the standard black body. In this case, the temperature is to be calculated from the temperature corresponding to the current through the pyrometer filament and the transmission of the sector or absorbing glass used by means of equation (1) above, excepting that for this computation, R is the reciprocal of the transmission of the sector or glass and then T_2 will come out greater than T_1. A very convenient method is to work out such extrapolated temperatures for the various sectors, as shown in Table II.

In this table are given a series of extrapolated temperatures using different sectored disks. In column 1

[2] *Gen. Elec. Rev.*, vol. 20, p. 749 (1917).
[3] Worthing, *Astrophys. Jour.*, vol. 36, p. 345 (1912).

are given the initial temperatures, that is, the ones that would correspond to the pyrometer reading without any sector, and in the other columns are given the extrapolated temperatures corresponding to the same pyrometer readings when the sector whose transmission is given at the head of the column is used between the pyrometer lamp and the source studied. When these extrapolated temperatures are plotted against the initial temperatures the extrapolated temperatures corresponding to any pyrometer reading can be obtained. A like set of curves can be made for a series of absorbing glasses of known transmission. Such curves can then be employed with any pyrometer having the same red glass, providing the same sectors or absorbing glasses are used.

TABLE II.

Initial temperature	Extrapolated temperatures, using red glass, for various sectors with transmissions as given. $C_2 = 14{,}350\mu$ deg. Transmission of Sectors.				
	0.499*	0.2443*	0.0830*	0.01664*	0.00542*
Deg. K.	Deg. K.	Deg. K.	Deg. K.	Deg. K.	Deg. K.
1200	1249	1303	1398	1555	1692
1300	1357	1421	1530	1727	1898
1400	1466	1541	1671	1908	2117
1500	1577	1663	1815	2098	2353
1600	1687	1787	1963	2298	2608
1700	1799	1912	2115	2509	2883
1800	1911	2090	2272	2735	3182
1900	2024	2169	2432	2963	3507

* Last digit approximated

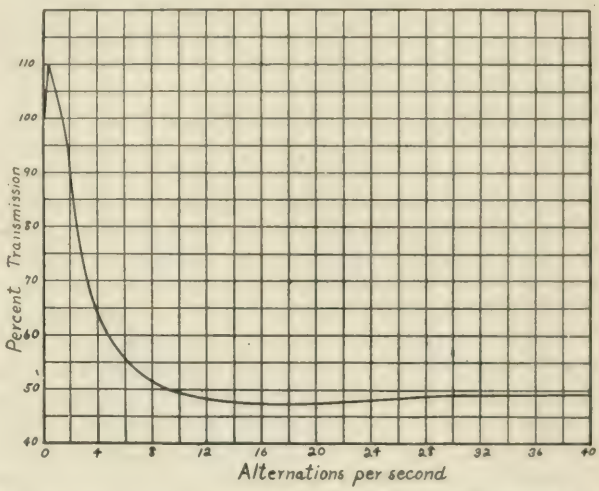
Sectors and Absorbing Glasses

A few words might well be said concerning the sectors or absorbing glasses that are used in calibrating the pyrometer or in extending the scale beyond that for which the pyrometer is calibrated directly. The list of sectors (about 35 cm. in diameter) given in Table I have been found satisfactory for temperature work The transmission of the sectors or absorbing glasses must be known to somewhat better than 1 per cent for accurate work. The sector must rotate at such a speed that no flicker is noticeable. To accomplish this, the alternations must be at least 30 to 40 per sec. This is for the condition where the open and closed spaces of the sector are about equal in size. If there is a very great difference between the open and closed parts of the sector, as for instance in the case of the 2-deg. sector with two 1-deg. openings, the speed must be higher. If the motor available will not rotate the sectors fast enough when there is but one opening and one closed part, it is often a great help to make more open spaces. A good plan is to have six openings, which will reduce the necessary speed considerably. For a sector as small as two having a 1-deg. opening this is impossible without making the sector too large, because if the sector opening is too small there is danger of an error due to diffraction. In this case, with a sector the size of the one here used, it is necessary to have a motor that will rotate it something like 3,500 r.p.m.

In the accompanying figure are shown the values found for the transmission of a 180-deg. sector as a function of the speed in alternations per second. This transmission was measured with the optical pyrometer. It can be seen, as shown in the curve, that the value found is constant and equal to the transmission of the sector for alternations above about 30 per sec., but below that the transmission at first becomes smaller and then larger, and an apparent transmission of over 100 per cent is obtained for a speed of alternations of about 1 per sec. The transmission, of course, approximates 100 per cent for zero speed.

The values found for the transmission for speeds corresponding to alternations between 10 and 30 per sec. is due to a flicker which bothers the observer. It might be that another observer would get slightly different values for the transmission for such speeds. For speeds slower than 10 alternations per sec. the observer attempts to make settings when the open part of the sector is passing before the opening. There is a very great flicker and settings are attempted using only the bright part. The value found for extremely low speeds is due to the apparent over-shooting of the brightness of the source when viewed only for the short time as compared with the pyrometer filament, that always has about the same brightness.

If the sector has a long opening measured in the direction of the radius, care must be taken to always use about the same part of this opening. This is to avoid error due to the fact that the radial sides of the openings may not be straight or may not be in a radial direction.



TRANSMISSION OF 180-DEG. SECTOR (TRANSMISSION 0.492) AS A FUNCTION OF THE SPEED OF ROTATION IN ALTERNATIONS PER SECOND

Absorbing glasses are not, in general, neutral tint. However, this is not necessary. All that is needed is to have a glass whose spectral transmission is nearly enough independent of the wave length to enable different observers to make brightness comparisons with very nearly the same results. The absorbing glass must be mounted in such a manner that the exact part that was calibrated is always used. This is because even the best absorbing glass is apt to vary in its transmission from point to point. Mounting must also be such that the beam of light will always make the same angle with the absorbing glass. Most absorbing glasses, when used with the red glass of the pyrometer, have a transmission that depends upon the distribution of energy, that is, the temperature of the source. This, of course, must be known and allowed for in accurate work.

Nela Research Laboratory,
Cleveland, Ohio.

Export Embargo on Gum Copal in Sierra Leone

Consul W. J. Yerby has reported from Dakar, Senegal, that an order in council of April 26, 1920, prohibits the exportation of gum copal from that colony for a period of three years beginning Sept. 30, 1920.

Synopsis of Recent Chemical & Metallurgical Literature

Magnesite Refractories.—From the scattered articles appearing in the technical press of the last generation and a survey of the salient facts in the entire field pertaining to the occurrence, preparation and properties of magnesite for refractory use V. SPOTTS MACDOWELL of the Harbison-Walker Refractories Co. and RAYMOND M. HOWE of the Mellon Institute have prepared an exhaustive paper on the subject which appears in the March, 1920, issue of the *Journal* of the American Ceramic Society. The development of this refractory began as early as 1860 in Europe for use in the bessemer process and has progressed to the production of 131,924 tons of calcined material in 1918. Iron oxide is now used to secure the proper sintering and bonding properties and is incorporated at extremely high temperatures.

The principal crystalline deposits are found in Austria-Hungary, Washington State and the Province of Quebec. Cryptocrystalline or amorphous beds occur in Greece, California, India, the Transvaal, Venezuela and the Cedros Islands, off the coast of Mexico.

The preparation in Europe and California involves largely burning in bottle-shaped kilns, while Canadian and Washington producers employ the rotary type. In the small ware magnesia crucibles are sometimes made by machining the brick. Linings for graphite laboratory crucibles used in preparing ferro-alloys are molded in place by tamping calcined magnesia around a wooden core. The core is removed, the lining dried, and burned in a carbon resistance furnace to a temperature above 1,755 deg. C.

Magnesia brick is commonly made from a dead-burned magnesite containing 4.5 to 8 per cent Fe_2O_3. Bonding material is not ordinarily used in American practice. The magnesite is mixed in a wet pan with a small amount of water and moldings are made in power press. After drying in tunnel driers rectangular down-draft kilns are used for burning and the bricks are then cooled slowly to avoid cracking.

The properties of the brick are given in this paper as to color, texture, specific heat, microscopic structure, chemical composition, crushing strength, thermal expansion, hydration and slaking.

Carbon acts on magnesia at high temperatures to cause shrinkage fitting and a black soot consisting of an intimate mixture of magnesia and carbon deposits on the walls of the electric furnace. The reaction is generally thought to occur as follows:

$$\underset{\text{solid}}{MgO} + \underset{\text{solid}}{C} = \underset{\text{vapor}}{Mg} + \underset{\text{vapor}}{CO}$$

The vapors have a reversible reaction on the cool walls of the furnace to make this sooty mixture. The temperature of the reaction varies from 1,450 to 2,030 deg. C. as recorded by different observers.

The authors conclude with the following: "The field for investigation of the properties of dead-burned magnesite and magnesia brick, and of the possibilities of improving their commercial value, offers a number of attractive problems. The influence of texture and composition of the raw magnesite, and the effect of added impurities upon the properties of the burned product, are not thoroughly understood. How the change from amorphous magnesia to periclase crystals may be brought about most economically and completely, and the crystals bonded together to form a brick which will be strong at furnace temperatures, with minimum shrinkage and tendency to spall, are questions deserving much careful study."

A large selected bibliography of magnesite and magnesite brick dating from 1873 is appended to the paper.

Supplementing the Natural Gas Supply With Byproduct Coke-Oven Gas.—The rapid increase in the demand for natural gas, coupled with the exhaustion of wells in districts that owe an important part of their industrial development to the availability of this valuable fuel, presents a problem which already demands serious attention. At the Buffalo meeting of the Natural Gas Association, C. J. RAMSBURG pointed out the opportunities afforded by the byproduct coke industry in the way of supplementing our natural gas supply. The paper was published in full in *Gas Age*, vol. 45, p. 456; May 25, 1920.

Of the high-grade artificial gases available with present methods of manufacture, only two, coal gas and carburetted water gas, deserve serious consideration. A very important factor in the cost of carburetted water gas is the price of gas oil, and this has increased to such an extent as to make any large-scale competition of carburetted water gas with coal gas out of the question. Moreover, we are beginning to face a condition of oil shortage quite analogous to our natural gas shortage. This condition is seriously embarrassing the manufacture of carburetted water gas in many plants and has already led to the erection of a number of coal gas plants.

The gas produced by heating coal in retorts is usually referred to as coal gas, but the byproduct coke oven is capable of furnishing a high-grade gas which is just as truly coal gas as that made in the retort. Furthermore, the byproduct coke oven possesses many advantages over the gas retort for the large-scale manufacture of coal gas: The coke is of superior quality; the yields of ammonia and benzol are greater; the coal and coke are handled mechanically in relatively larger masses; the heating efficiency is greater; the life of the plant is longer. The annual consumption of coke-oven gas for domestic and industrial purposes (outside of iron and steel plants and other establishments with which the byproduct coke ovens are directly connected) is about 40,000,000,000 cu.ft.

To those who are familiar with the enormous rate at which natural gas is being produced and consumed, it might seem that any artificial source of supply must be small in comparison. However, it is estimated that the average normal consumption of coal for the manufacture of coke during the next five years will be approximately 86,000,000 net tons per year. If all of this coal were coked in byproduct ovens, we should have a gas yield of 10,500 cu.ft. per ton, or a total gas production of 900,000,000,000 cu.ft. of gas per year, which is probably a greater volume than the present annual production of natural gas. This figure represents the maximum possible gas production in connection with coke manufactured at the present average rate. We have not, however, got to the point where every ton of coke will be made in byproduct ovens.

Of the 86,000,000 tons of coal used for the manufacture of coke, it may be estimated that, during the next five-year period, 46,000,000 tons will be coked per year in byproduct ovens, with a total gas production of 480,000,000,000 cu.ft. The waste of gas from beehive ovens will continue at a rate of 420,000,000,000 cu.ft. per year.

One of the most important factors affecting the availability of coke-oven gas for use outside of the plant is the substitution of a low-grade gas for heating the ovens. Producer gas or blast-furnace gas is well adapted to this purpose, thus releasing the entire output of richer oven gas for distribution. The advantages of producer gas for heating the ovens may be summed up as follows:

First, the producers may be fed with small sized coke unsuitable for use in the blast furnaces. Here the equipment is simple and comparatively inexpensive, especially with respect to the gas-cleaning apparatus. The amount of coke required for the producers is 12 to 14 per cent of the weight of the coal charged into the ovens. This amount may readily be obtained by properly screening the oven product, leaving a high-grade, thoroughly clean coke for the use of the blast furnaces.

Second, where there is available a cheap coal, having fair coking qualities, but unsuitable for the manufacture of blast-furnace coke, such coal may be coked in some of the byproduct ovens, delivering thereby its byproducts and furnishing sufficient coke for the operation of the gas producers.

Third, where there is available cheap low-grade coal unsuitable for making blast-furnace coke, such material may be used directly in the gas producers.

Fourth, byproduct producers may be installed using any coal available. The equipment and operation of byproduct producers fits in very well with that of the byproduct coke plant, and the combination, costing much less than separate plants, offers many possibilities for increased economy and valuable returns. Heretofore, on account of coal values, the employment of byproduct gas producers has been more extensive in Europe than in America, and here, with the present appreciation of coal values, their development presents enormous possibilities.

As the demands of the natural gas industry for a supplementary supply of high-grade artificial gas outgrow the possibilities afforded by such byproduct coke plants as are operated in connection with iron and steel plants in any locality, it is certain that additional byproduct coke plants will be erected primarily to meet the needs of the natural gas industry. Much might be saved if it were possible to build the byproduct coke ovens at the coal mines, as has been the general practice in the case of beehive ovens; but this has hitherto seldom been permissible, either because the mines were located too far from the consumers of gas, or because the locations were in districts well supplied with natural gas. With diminishing natural gas supply, the peculiar relations of the natural gas industry with respect to the coal-mining regions of Pennsylvania, Ohio and West Virginia are likely to make it profitable to build byproduct coke ovens at the mines, because many coal mines supplying good coking coal are within easy reach of large natural gas distributing systems into which the coke oven gas could readily be conveyed. With a reasonable price for the gas and with proper methods of coke disposal, such plants can operate with maximum economy. The low price of land at the mines is an important item.

Progress toward the general use of gas as sole domestic fuel must necessarily be slow and depends largely on accustoming people to lower heat value standards. There can be no question that at present, from an economic standpoint, we are working on too high a level as regards the heating value of gas.

It is the opinion of many economists who have studied the problems of conservation and efficient utilization of our fuel resources that the ultimate ideal should be the conversion of all the coke into gas at the byproduct coke plant, so that the plant will supply all of its fuel product in gaseous form. It may be that we are in a transition period that will ultimately end in discontinuing entirely the use of solid fuel for most industrial and for all domestic purposes.

The proposition of gasifying all of the coke produced at the byproduct coke plants leads to the subject of mixed gases, because all of the surplus gas produced from the coke over and above the requirements of the plant for its own steam, power and heating will, in the majority of cases, be mixed with the coke-oven gas before distribution to the consumer. This subject is one of great importance. It has such a wide scope and involves so many subsidiary questions, both economic and technical, that it cannot be adequately treated within the limits of this paper. Attention will, however, be directed to a few leading points.

1. The mixed gas sold to the consumer must have such characteristics with respect to specific gravity and heating value as to meet his purposes satisfactorily without unduly increasing the investment required for his appliances.

2. The question of the rate of heating afforded by the gas is in many cases more important than the total heat units supplied. The rate of heating is, of course, a function of the flame temperature. For example, straight producer gas has been burned in cook stoves, but its flame temperature is so low that it works much too slowly to be practicable.

3. It is very questionable whether it ultimately pays to sell gas containing a large percentage of inert, incombustible constituents for wide distribution. The principle involved is much the same as in the transportation of coal containing high percentages of ash.

4. There are two generally feasible methods for the production of mixed gas at the byproduct coke plant with complete gasification of the coke, viz.:

(a) Gasification of the coke in producers using part of the producer gas to heat the ovens and the remainder to mix with the coke-oven gas. This method would produce per ton of coal over and above plant requirement, 10,500 cu.ft. coke-oven gas of 560 B.t.u. and 75,600 cu.ft. of producer gas of 130 B.t.u., making 86,100 cu.ft. mixed gas of 183 B.t.u.

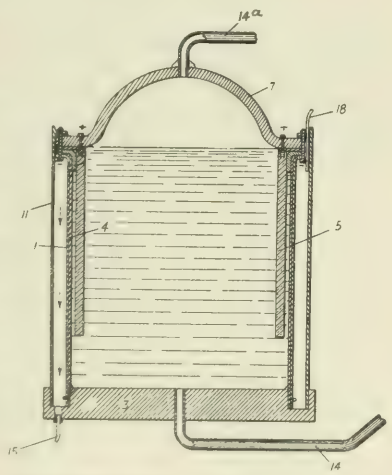
(b) Part of the coke is gasified in producers making sufficient gas to heat the ovens. The remainder of the coke is put into water gas generators and its carbon converted into blue water gas, which is mixed with the coke-oven gas. This method will produce per ton of coal 10,500 cu.ft. coke-oven gas of 560 B.t.u. and 22,600 cu.ft. blue water gas of 300 B.t.u., making 33,100 cu.ft. mixed gas of 383 B.t.u.

Recent Chemical & Metallurgical Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Compressed Ethylene. — Ethylene can be directly compressed to a high pressure, far in excess of that to which acetylene can be safely compressed, and can be stored in cylinders or containers without the use of an absorbent filling and solvent, and without the danger and disadvantages incident to the compression and storage of acetylene. The entire space of the cylinder can, accordingly, be filled with the compressed ethylene. Moreover, since the ethylene is present in a gaseous, rather than a "dissolved" or liquid state, the entire content of the cylinder can be made available, even in the coldest weather, without objectionable lowering of temperature due to evaporation. A cylinder having a cubical capacity of about 0.777 cu. ft. (commonly called a 100 cu.ft. hydrogen or oxygen cylinder) can be safely charged with from 150 to 200 cu.ft. of ethylene. Expressed in terms of cu.ft. ethylene per cu.ft. cylinder capacity, it is easily possible to charge 200 to 250 cu.ft. of ethylene per cu.ft., whereas with hydrogen and oxygen the cylinders contain only about 130 cu.ft. per cu.ft. (1,339,431; ARTHUR A. BACKHAUS, of Baltimore, Md., assignor to U. S. Industrial Alcohol Co.; May 11, 1920.)

Electrolytic Chlorine Cell.—The apparatus consists of: A perforated cylindrical iron cathode, 1, resting in an annular channel in the base member, 3; a cylindrical diaphragm, 4, inside of the cathode; a cylindrical graphite anode, 5; an exterior casing, 11; a dome, 7, bolted to the body of the cell in such a manner as to insulate the anode from the cathode and make the anode and cathode compartments gas tight. Sodium chloride solution enters the cell at the bottom through pipe 14. The products of electrolysis — chlorine, sodium hydroxide solution and hydrogen — are removed through 14a, 15 and 18 respectively. The dome-shaped head permits the level of the electrolyte to rise as the porosity of the diaphragm decreases, thereby insuring an even flow of liquor through the diaphragm at all times irrespective of the degree of porosity of the latter. The dome also serves as a conductor to the graphite anode, doing away with the copper busbar commonly used. (1,342,336; PAUL MCDORMAN, of Niagara Falls, N. Y., assignor to the Electro Chemical Co.; June 1, 1920.)



ELECTROLYTIC CHLORINE CELL

Electrolytic Hypochlorite Cell. — In hypochlorite cells where the hypochlorite is formed near the electrodes, there is a reduction in efficiency due to secondary reactions. At the cathode some of the OCl ions are reduced to Cl ions, while at the anode ClO_3 ions are formed by oxidation. JOHN GERSTLE, of Dayton, Ohio, has designed a cell in which the chlorine and sodium hydroxide are generated separately and then mixed in baffled chambers so that the hypochlorite formed does not come into contact with the electrodes. (1,342,378; assigned to Electro Chemical Co.; June 1, 1920.)

Sulphuric Acid Concentration. — Incrustations of sulphates which form in concentrating sulphuric acid in the cascade system may be removed by passing weak and strong acid through the cascade alternately. The weak chamber acid removes the incrustation left by the strong acid. (1,340,290; JOHN PATTEN, of Baltimore, Md., assignor of one-half to Samuel M. Shoemaker, of Eccleston, Md.; May 18, 1920.)

Sulphuric Acid from Sulphur Dioxide and Selenium Dioxide.—Selenious acid (prepared by treating selenium dioxide with water) will oxidize sulphur dioxide to sulphuric acid according to the equation:

$$SeO_2 + 2H_2O + 2SO_2 \leftrightharpoons Se + 2H_2SO_4$$

Complete elimination of the SeO_2 is assured by repeated treatment with SO_2 at about two atmospheres pressure. The precipitate of selenium is removed by filtration. It may be roasted to form the dioxide again. Tellurium dioxide may be used in the same manner. (1,341,462; PAUL HAESELER, of New York, assignor to the Liberty Laboratories, Inc.; May 25, 1920.)

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Gallic Acid.—Gallic acid is obtained by heating tannin with an amount of a metallic compound sufficient to effect a substitution of the hydrogen atoms of the carboxyl and hydroxyl groups formed on hydrolysis, and then decomposing the resulting gallate with an acid. An excess of the metallic compound is preferably employed, in order to coagulate the albuminous material. The metallic compounds referred to are the hydroxides, oxides and weak acid salts (e.g., carbonates and acetates) of the alkali and alkaline-earth metals, magnesium, lead, copper and zinc. (Br. Pat. 139,419—1919. NITRITFABRIK AKT. GES., Kopenick, Germany, April 28, 1920.)

Carbazol. — Carbazol is purified and obtained in well-defined crystals by slow dilution of its solution in concentrated sulphuric acid. This may be effected by exposing the solution to the atmosphere or other moist gas, with or without agitation, or by blowing air or other moist gas through the solution. The solution may first be diluted rapidly to a degree short of precipitation and then diluted slowly as described above. (Br. Pat. 139,441—1919. SOUTH METROPOLITAN GAS Co. and W. KIRBY, London, April 28, 1920.)

Treating Vegetable Fibers.—Vegetable fibers in the raw state, or bleached, or mercerized, and in the mass or in the state of laps, cops, card-ends, twistings, etc., or yarns or fabrics, are treated to impart to them the character of wool by steeping them at ordinary temperatures in nitric acid, preferably at a concentration of not less than 65 per cent, and then squeezing and washing the fibers. (Br. Pat. 136,568—1919, 136,569—1919. SOC. GILLET ET FILS, Lyons, France, Feb. 11, 1919.)

Current Events
in the Chemical and Metallurgical Industries

American Ceramic Society to Hold Summer Meeting at Chicago

The regular summer meeting of the American Ceramic Society will be held at the La Salle Hotel in Chicago Aug. 16, 17 and 18. Aside from a short business meeting the tentative program as outlined by the committee of the Chicago Section will be as follows:

MONDAY, AUG. 16

The members will assemble in the rooms provided at the La Salle Hotel about noon and will be taken by automobile to the plant of the Northwestern Terra Cotta Co. After an inspection of this plant the Lindsay Light Co.'s manufacturing plant will be visited. This company is engaged in the reduction of rare earths to be used in the manufacture of lamp mantles which the company produces, together with some of the rare metal compounds such as thorium, cerium, lanthanum and other nitrates derived from monazite sands.

TUESDAY, AUG. 17

Visit to the plant of the Coomley Manufacturing Co., maker of enamelware; the plant of the Burke Brick Co., manufacturer of common brick, and the Western Electric Co. plant.

WEDNESDAY, AUG. 18

A trip will be made to the manufacturing plants in the vicinity of Waukegan and North Chicago, including the Fansteel Products Co., manufacturer of pure tungsten, molybdenum and rare metals.

On Monday evening the informal dinner will be held at the La Salle Hotel, and on Tuesday and Wednesday evenings the visitors will be left to their own devices.

The detailed program will be published later.

Chemical Warfare Service on a Peace Basis

By July 1 the personnel of the Chemical Warfare Service will have been reduced by 50 per cent. This is by way of a general reduction from a war footing to a peace basis. The peace nucleus of the Chemical Warfare Service, however, expects to be a very active branch of the War Department. It has $4,000,000 at its disposition to use in its work during the next fiscal year. The manufacture of the latest type of the American gas mask is now reaching quantity production. The first mask of this type was completed June 4. Sufficient masks must be manufactured to equip the entire Army and National Guard. The new mask is described as a real fighting mask. It is comfortable to wear, permits clear vision and can be kept on continually, without particular inconvenience, as long as the wearer can go without food and drink.

Formal designation of the chief of the Chemical Warfare Service, who is to have the rank of Brigadier General, will take place shortly after July 1, it is believed, when the Chief of Staff will have returned from France. It is taken for granted that Colonel Amos A. Fries, who has been at the head of the service since the resignation of General Sibert, will be elevated again to the rank of general and assigned to the direction of the service in its permanent capacity as a separate branch of the War Department.

The Chemical Warfare Service, according to the new statute, is to have 100 officers. Only six of the officers now on duty with the Service hold permanent commissions, consequently ninety-four officers must be commissioned or detailed for duty with the Chemical Warfare Service. At present a large number of those interested in obtaining permanent commissions are taking the necessary examinations. It is the policy of Colonel Fries that 25 per cent of the officers be chemists. The principal duties of the remainder are of a military, constructional and manufacturing character, but even in those cases some chemical education is regarded as desirable.

In this connection, it may be remarked that the Chemical Warfare Service to date has been conducted almost entirely by temporary officers. They are responsible for much of the success which has been made by the Service. When the armistice was signed only 1 per cent of the officers in the Chemical Warfare Service were Regular Army men. Most of those were in the minor grades.

Resolutions Passed by the Natural Gas Conservation Conference

Definite progress was made in the Natural Gas Conservation Conference at the Department of the Interior on June 11, when tentative resolutions proposed by the National Committee on Natural Gas Conservation were approved. The conference included representatives of the Governors and Public Service Commissions of a number of the important natural gas producing and using states.

Some of the resolutions which were thus approved relate to industrial chemical activity very directly. Carbon black production, casinghead-gas recovery, and the substitution of natural gas for gas oil in making carburetted water gas are of special concern. The text of these resolutions is as follows:

> That the use of high B.t.u. natural gas instead of gas oil in carburetting manufactured gas, where same is made to supplement the decline in production of natural gas, be encouraged because the use of gas oil at 73c. per gal. has the equivalent B.t.u. value of 108 cu.ft. of natural gas at 1,100 B.t.u., giving the gas a comparative value of 75c. per 1,000 cu.ft. and thereby helping conservation.
>
> That carbon black be made when gas is produced in isolated sections with no present or reasonably prospective market for gas being produced, when gasoline has been extracted and when practical and modern and improved methods are used.
>
> That in the interests of good conservation and good service—wherever expedient—all gasoline that can be commercially separated from natural gas shall be so separated before the gas is started for market.
>
> That the Bureau of Mines be asked to turn over to this committee all data it may have on the carbon black industry with the view and purpose of helping this com-

mittee to determine what part of natural gas now used to manufacture carbon black could be diverted into public utility lines.

It is expected that a conference of state representatives of Pennsylvania, West Virginia and Ohio will meet soon in Pittsburgh to formulate a policy with respect to the gas exported from West Virginia into the two other states. It is hoped that similar measures mutually satisfactory to exporting and importing states will be arranged for Oklahoma, Kansas and Missouri, etc. It is also expected that regulations similar to the resolutions adopted by the conference will be made legally binding by some of the state legislatures. Especially is this action expected in Louisiana, where the Conservation Commissioner plans to introduce such legislation.

Federal Officials Organize

More than a hundred members of the Government service who are in responsible administrative and technical positions met on June 17 and perfected a tentative organization which is to be known as "The Federal Club." The purpose of the organization is by the interchange of views, and, where appropriate, by joint action to care for many of the general problems of the service which are common to several departments. Franklin D. Roosevelt, Assistant Secretary of the Navy, is the chairman of the temporary body, and Dr. E. B. Rosa, chief physicist of the Bureau of Standards, is chairman of the committee on organization and constitution. Some of the problems which have been suggested for the action of the club are classification and salaries of the technical services of the Government, and budget matters as affecting the executives of the various Bureaus.

New Zinc Oxide Company Formed at Leadville, Col.

The Western Zinc Oxide Co. has been recently formed at Leadville, Col., by a consolidation of the Western Zinc Concentrating Co. and the Leadville Zinc Co. The new company is controlled by J. F. McDonald, of Leadville, Charles J. Walker, of St. Louis, and other St. Louis capitalists. They are connected with the Downtown Mines Co.

A block of sixteen furnaces, a new pipe line, bag house and complete mining equipment is being added to the present plant. When the new unit is completed thirty-four furnaces will be in daily operation, giving the plant a capacity of about 100 tons of zinc oxide daily.

The new furnace building will be 120 ft. long by 44 ft. wide, and the bag house 700 ft. by 44 ft. Wetherill type furnaces are being built. It is planned to have the new unit in operation by Aug. 1. Charles H. Collins is president and manager of the new company.

Allocation of German Dyes

The War Trade Board Section of the Department of State announces that it is now prepared to grant allocation certificates providing for the importation of German dyes in amounts sufficient to supply the immediate requirements of individual consumers of the United States for a six months' period.

Before an allocation certificate providing for the issuance of an import license will be granted by the War Trade Board Section the consumer must file an application with the War Trade Board Section on an official form provided for that purpose.

Applicants are advised to estimate their requirements as accurately as possible, as all estimates will be carefully scrutinized. Any applications which appear to be excessive will not be acted upon until the matter has been investigated and found satisfactory to the War Trade Board Section.

Importations will be controlled by rules and regulations similar to those which governed the previous allocations. Licenses to import will be issued only when the dyes applied for are not obtainable from domestic sources on reasonable terms as to price, quality and delivery.

New Bodies Represented on the American Engineering Standards Committee

Five additional bodies have been admitted to representation on the main committee of the American Engineering Standards Committee. They are:

Electrical Manufacturers Council: Electric Power Club, Associated Manufacturers of Electrical Supplies, Electrical Manufacturers Club.

Fire Protection Group: National Fire Protection Association, National Board of Fire Underwriters, Associated Factory Mutual Fire Insurance Companies, Underwriters Laboratories.

National Electric Light Association.

National Safety Council.

Society of Automotive Engineers.

These, with the five engineering societies who founded the Committee and the three Government departments, added later (Commerce, Navy and War), make a total of thirteen organizations having representation on the main committee.

The constitution of the A.E.S.C. provides for representation of "groups of organizations." It is the policy of the committee to encourage representation by groups in such manner that a group shall represent substantially the entire field of a particular industry in order that it may "be of national scope." In the opinion of the committee the group plan makes both for efficiency in standardization work and for effectiveness of representation. The groups are autonomous, such matters as the apportionment of representatives and the allotment of fees among the constituent bodies resting wholly with the group.

Two of the new bodies have already designated their representatives as follows:

Electrical Manufacturers Council: Le Roy Clark, A. H. Moore, C. E. Skinner.

National Safety Council: C. P. Tolman, chairman, Manufacturing Committee; Albert W. Whitney, general manager, National Workmen's Compensation Service Bureau; Sidney J. Williams, secretary and chief engineer.

Storage of Poisonous Gases

Poisonous gases store very much better than had been expected. Recently completed tests by the Chemical Warfare Service show that all gases used in warfare except mustard and sulphur monochloride can be stored for long periods without deterioration. Even in the case of mustard gas, the deterioration is not great. All of the gases which were the subject of these tests had been in storage at least twenty months. Due to the corrosive properties of chlorine, some difficulty has been found in preventing its escape from containers after long periods of storing.

Uses of Bentonite Clay

Bontonite clay is a non-metallic mineral of commercial importance used in the manufacture of soap and antiphlogistine and the purification of water. It is produced principally in Wyoming and is marketed to the extent of a few hundred tons per year. Detailed information can be found in the United States Geological Survey Bulletins Nos. 260, 285 and 365; also in U. S. Geological Survey Professional Paper No. 153.

Mantle Lights Used in Canton

Many concerns in Canton use mantle lights, often burning gasoline or a low grade of kerosene. Those now on the market sell at from 30c. to 65c. each and come principally from the United States and England.

Personal

Prof. S. A. ARRHENIUS of Nobel Institute, Stockholm, Sweden, was awarded the Frank Medal by the Franklin Institute, May 19, 1920. Dr. Allerton S. Cushman, in connection with the presentation, read a paper by Prof. Arrhenius entitled "The World's Energy Supply."

Dr. JAMES BROWN, formerly research chemist for Zinsser & Co., Hastings-on-Hudson, N. Y., has accepted a similar position with the Calco Chemical Co., Bound Brook, N. J.

GEORGE A. CHRITTON spoke before the Chicago Chemists' Club weekly luncheon on trade marks, unfair trade and the law.

H. P. FISHBURN, formerly with the University of Idaho, is now chief chemist at the Casper, Wyo., works of the Standard Oil Co. of Indiana.

Dr. LOUIS J. GILLESPIE, professor of physical chemistry at Syracuse University, who was formerly with the Department of Agriculture, Washington, D. C., has resigned to go to the Massachusetts Institute of Technology as assistant professor on physicochemical research in the research laboratories of physical chemistry.

HOWARD A. HORNER, formerly metallurgist of the American Metallurgical Corporation, Philadelphia, is now with the Frick Co. of Waynesboro, Pa.

ROBERT M. KEENEY of Denver was East recently on a business trip.

FRANKLIN K. LANE, formerly Secretary of the Interior, received the honorary degree of Doctor of Laws at the commencement exercises at Williams College June 21.

OLIVER LOUD, formerly plant chemist of the citrus byproduct factory of the California Fruit Growers Exchange, Corona, Cal., and during the war assistant in physiological research with the Chemical Warfare Service, is now engaged as chemist at the refinery of the Standard Oil Co. of California, Richmond, Cal.

A. M. MUCKENFUS has resigned as professor of organic and industrial chemistry and director of that sub-department at Emory University, Atlanta, Ga., to accept the position of research chemist with the Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.

Sir W. J. POPE is to be nominated president of the Society of Chemical Industry, London, at the meeting to be held at Armstrong College, Newcastle-on-Tyne, July 13, 1920.

PAUL C. SKINNER, general manager of the Denver plant of the General Chemical Co., has been in Chicago recently on business.

HARRY A. TIEMANN, Colorado State Superintendent of Industrial Education, delivered an address recently before the Colorado Society of Engineers.

Current Market Reports

The Non-Ferrous Metal Market

New York, June 28, 1920.—The leading producers quote 19c. for all copper deliveries up to August, with the outside market at 18c. for spot. Platinum and palladium have advanced $5. Other prices are firm.

	Cents per Lb.
Copper, electrolytic	18.00@19.00
Aluminum, 98 to 99 per cent	33.00
Antimony, wholesale lots	8.00
Nickel, ordinary	46.00
Nickel, electrolytic	45.00
Tin, Straits, spot	48.50
Lead, New York, spot	8.00
Lead, E. St. Louis, spot	7.75
Zinc, spot, New York	7.75
Zinc, spot, E. St. Louis	7.45

OTHER METALS

Silver (June 24)	oz.	$0.99¾
Cadmium	lb.	1.40@1.50
Bismuth, (500 lb. lots)	lb.	2.70@3.00
Cobalt	lb.	2.50@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.60@1.85
Platinum	oz.	80@90
Iridium	oz.	300
Palladium	oz.	75@85
Mercury	75 lb.	90

FINISHED METAL PRODUCTS	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33.50
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	25.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	43.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS	Cents per Lb. Buying Price
Aluminum, cast scrap	24.00@24.50
Aluminum, sheet scrap	24.00@24.50
Copper, heavy machinery comp	15.00@15.50
Copper, heavy and wire	14.25@14.75
Copper, light and bottoms	12.50@13.00
Copper, heavy cut and crucible	15.00@15.50
Brass, heavy	9.00@10.00
Brass, light	7.50@8.00
No. 1 clean brass turnings	9.25@9.75
No. 1 comp. turnings	13.00@13.50
Lead, tea	5.00@5.50
Lead, heavy	7.00@7.25
Zinc, scrap	5.00@5.25

The Iron and Steel Market

Pittsburgh, June 25, 1920.

The rail transportation situation is growing no better, and even the more sanguine in the iron and steel industry do not look for any decided improvement until some distinctly new developments occur. Announcement of the findings of the Railroad Labor Board, expected now in two or three weeks, might help.

While there is no noticeable improvement in the shipment of pig iron or of finished steel, there is a distinct improvement in the movement of coal, at least from the Pittsburgh district, this arising without doubt from the coal car preference order of the Interstate Commerce Commission, effective at the beginning of last week. Connellsville coke operators complain that the order will result in the withdrawal of cars from the coke movement to put into the coal movement, but any such change if made would probably be to the advantage of the iron industry as a whole, through there being a better movement of coal to byproduct coke ovens.

Production of pig iron and steel ingots is at about the same rate as a week or a fortnight ago, the rate being not far from that of last March, when the highest rate was attained since October, 1918. In view of rather light demand in some quarters it is doubtful whether the total of demand is equal to the present rate of production. There is very little railroad demand and there is no large amount of steel being required for large works of construction. The Bridge Builders' and Structural Society reported May book-

ings of fabricated steel contracts equal to 61½ per cent of a month's capacity, against 68 per cent for April and 83½ per cent for March. Not a few manufacturing consumers are operating at well under capacity, partly from lack of orders, and even the automobile industry has slowed down, though that is of less consequence than would be assumed from the large part the automobile industry played in advancing the market early in the year, since at best the industry could not fill up more than say 6 or 7 per cent of the steel industry's capacity. An easier market for steel in the not distant future is therefore in prospect, unless there should be a large curtailment in output by labor disturbances or from fear of labor disturbances.

Market Prices

Connellsville coke continues very strong, with prices for spot shipment up 50c. to $1 in the week, furnace coke being $15.50@$16 and foundry coke $16@$17 per net ton at ovens. Some operators are quoting $12 as a flat price for furnace coke for second half, a price furnaces are unwilling to pay. There are also quotations at a ratio of 4 to 1 against basic pig iron at valley furnaces, which at the present pig iron market of $44 would mean $11 for the coke. Some coke operators expect pig iron to advance, while furnacemen who have bought on the 4 to 1 ratio probably expect it to decline.

A sale of 2,000 tons of bessemer pig iron at $44, valley, establishes the minimum of the market at this figure, an advance of $1, while small lots have gone at $45. Basic sold in one 2,000-ton lot at least at $44, an advance of 50c. Foundry remains at $45, valley. The market is made only by early deliveries, there being no disposition on the part of consumers to buy for the remainder of the year, and thus the technical position is one that readily admits of advances or declines in future. The present market, being made on prompt lots at a time when deliveries are difficult, is not much of a criterion.

A sale of over 5,000 tons of open-hearth sheet bars has been made at $75, which would indicate a continuance of the very strong market, but there were attendant circumstances suggesting that the buyer had some ulterior motives in making the purchase. A sale of a fair tonnage of 3 x 3-in. billets is reported at $67.50, indicating an easier market, since standard billets have been quotable nominally at $60@$65 and small billets not long ago were regarded as worth $10 over 4 x 4-in. billets.

The plate market is easier, as prompt deliveries will hardly bring 3.50c., perhaps not over 3.25c., while not long ago very late deliveries were in demand at 3.25c. and prompt deliveries were bringing up to 4.50c. Other descriptions of finished steel have softened less, but the general trend is for prompt deliveries to bring smaller premiums than formerly, with extended deliveries held at former levels, but in less demand.

A few lots of heavy melting steel have been bought by Pittsburgh district consumers in the past week at $26.50, delivered. Nominally these transactions record an advance of 50c. in the market, but it is characteristic of the scrap market to have a certain level as "the market" and then when consumers buy they pay 50c. more. Borings have been in good demand at $18, with $18.50 now quoted, while machine shop turnings are off $1, at $14.50@$15. Cast scrap is stronger at $33@$34 and cupola sizes are stronger at $40@$41, both cases reflecting the difficulty in securing pig-iron deliveries.

Ferro-Alloys

Prompt ferromanganese has slumped, as was to be expected, the recent stiffness being due to a few consumers being short at the time, although covered for second half, and prompt is now worth but little more than the $200, delivered, which is still quoted on second half contracts. Spiegeleisen is $72.50@$75 at furnace. Electrolytic ferrosilicon is about $78@$80, delivered, for 50 per cent and $150, delivered, for 75 per cent. Bessemer ferrosilicon remains quotable at $62.50 for 10 per cent, $65.80 for 11 per cent and $69.10 for 12 per cent, f.o.b. furnaces at Jackson and New Straitsville, Ohio.

The Chemical and Allied Industrial Markets

New York, June 25, 1920.

The chemical market continues in the same weak position it occupied during the previous period, buying being confined to present requirements only and offerings being small with no assurance of early delivery. It is difficult to decide whether there has been any improvement in the rail situation with so many conflicting opinions being given by those engaged in the trade, but it is evident that there are more cars rolling and that terminal facilities are less congested than they were a few weeks ago. Succeeding *barium chloride*, which is still nominally quoted at $170@$200 per ton, *copperas* has come up in the last week or two and is commanding prices ranging between $3 and $4 per cwt. There is considerable difficulty in locating spot even at these figures and the best that producers can offer is late summer shipment. Domestic producers are standing firm at 12½@13½c. per lb. for *gray salammoniac* and 16@16½c. for the *white* grade. While it is reported English material is being imported a few cents below this price, volume of imported arrivals has not yet reached proportions that have warranted a reduction in domestic material. Improvement has been noticed in the *muriatic* supply and this material is accordingly somewhat easier at $3.10@$3.25 per cwt., although there is by no means a normal supply on hand, which is partly due to the slow arrival of material from producers' plants.

Considerable interest is being manifested in *carbon tetrachloride* and buying has been active at 12@15c. per lb. depending on the quantity and time of shipment desired. *Salt cake* has come up another notch and it is practically impossible to locate material at less than $30 per ton, and $34 seems to be the average price being asked by those holding resale material. There is some *caustic soda* offered at $6@$6.25 per cwt., but how much is obtainable at this figure it would be hard to say. It is rumored, however, that the firm making this offer has considerable supplies on hand. *Glycerine* continues at former levels, with 28c. the average price, and *sodium bicarbonate*, which is practically out of the hands of producers, who are sold out, came up to $2.45 as a low mark, against $2.25 per cwt. of the previous report.

Coal-Tar Products

The best that can be said about this market is that it is no worse than it was last week, implying no changes of real importance. The unsettled conditions which still prevail in Japan are a contributing factor to the continued dullness evident in this market. Buying is light, but offerings of the more desirable items on the list are lighter, and the trade continues to jog along with a noticeable mark of expectancy in its stride. *Naphthalene* is still off the market with resale material being offered nominally at 18c. per lb.; one large producer of this item is still making deliveries on contracts at 9c., which is in turn being offered on the open market at prevailing figures. There has been little interest displayed in *aniline* oil, which is listed around 35c. per lb., while, on the contrary, *aniline* salts have come up slightly with a low mark of 42c. per lb.

Oils

There has been no activity evidenced in this market during the period. The Japanese situation is tending to keep the market for Oriental oils quiet and while no drops of importance have occurred the only reason is that there is no material being offered and no inquiry being made. *Chinawood* oil, which has been steadily declining, is down as low as 18½@19½c. per lb., with practically no business being done. *Cottonseed* also came down and crude is offered as low as 15½c. per lb. *Summer yellow* is being bid around 18¾@19c. per lb.

St. Louis, June 21, 1920.

The demand for heavy chemicals, which has been manifested for the past few months, still continues and prices in some lines show an upward trend. Local production is practically back to normal, although producers are hampered by the slow movement of carload shipments. A recent local embargo on less than carload shipments, caused by a strike of the transfer companies' employees, has held up all

shipments to and from the East. This strike is now settled and the embargo should be lifted shortly.

Sulphuric Acid—The demand for sulphuric acid continues good and prices are unchanged. The 60 deg. grade is quoted at $15@$16 per ton in carload lots and the 66 deg. grade at $22 per ton. The price of oleum is unchanged at $27.50 per ton.

Muriatic Acid—The demand for this chemical is heavy and local producers report supply practically all sold up. The 18 deg. is quoted in carload lots at $25 per ton and $2 to $2.25 per 100 lb. in carboys. This is an advance of $4 per ton in the past two weeks.

Nitric Acid—Supply plentiful and prices unchanged. Quoted in carload lots at $7 per cwt. for 36 deg. grade, $8 for 38 deg., $9 for 40 deg. and $10 for 42 deg.

Sodium-Bisulphate—Demand is heavy and the supply limited. Quoted at $6 per ton. This is an advance of $2 per ton during the past two weeks.

Phenol—The supply of this chemical is plentiful and demand continues good. Quotation unchanged at 12c. per lb. in quantities of 15 tons or over.

Zinc Chloride—Price unchanged at $3.50 to $3.75 per cwt.

Zinc Oxide—Local supplies are very low and producers quoting 10c. per lb., in large lots, for third quarter delivery.

Chicago, June 23, 1920.

The very gradual return to normal trade conditions in the chemical market continues, although it is so gradual as to cause the general appearance to remain almost the same from week to week. Such price changes as have been noted have, with a few exceptions, been downward and the whole trade seems to be quietly and calmly awaiting developments.

As a unit, freight conditions are improved. Plenty of individuals can be found who will assert the contrary, but these are interests whose sources of supply happen to be in points still embargoed, or whose rolling stock requirement is such that they have particular difficulty in securing cars.

Heavy Chemicals

Alcohol and its derivatives remain the headliners so far as demand is concerned. Today's quotation on methyl grade, 95 per cent, is $3.65 per gal. in barrels, when obtainable. Dye, celluloid and similar manufacturers whose requirements for wood alcohol is absolute are being supplied after a fashion, but all consumers who can possibly use *denatured* are being forced to the slower acting product. This is in fair supply and can be had at $1.09@$1.11 per gal. *Ethyl* grade is in better supply than for some time in the past and is quoted in single barrels at $5.57½ per gal. and 5c. less in 5-bbl. lots. The alcohol condition is subject to steady improvement, as factories handicapped by their inability to secure adequate supplies of molasses are being converted to corn.

Formaldehyde is in about the same condition it has occupied for the past two months so far as supply is concerned, but apathetic buying has forced the price down to 53c. per lb. in barrels. Trade needs greatly exceed visible supply, but this is a condition which, with the opening of several new producing plants, will be gradually overcome. There is apparently nothing to prevent lower prices on this commodity in the near future. The previously noted strong tone to *glycerine* continues, present quotation on c.p. grade being 28c. per lb. in drums. Manufacturers report less transportation trouble recently but shipments are still uncertain.

In general, *alkali* products are off fractionally. The main trouble is in the difficulty of shipping goods from the factory, producers reporting variously a car shortage of from 40 per cent to 90 per cent of their requirement. The trade, knowing that local supply is bound to be easier some time, and probably soon, are reluctant to pay high prices. Today *soda ash* is quoted on contract at 3½c. per lb. and for immediate delivery out of stock at 3¾c. These figures represent a quarter cent decline. *Caustic soda*, at 6@6½c. per lb., is also off ¼c. *Sal soda* remains unchanged at $1.60@$1.65 per cwt., the concentrated being offered at $3 per cwt. *Bleaching powder* is up sharply, 7c. per lb. being asked for delivery from stock and but little to be had at any price.

Blue vitriol has been subject to frequent fluctuation with a range of only about ¼c. Today's quotation on the large crystals in carloads is 8¼c. *Aqua ammonia*, on contracts, remains unchanged, and spots have been unable to retain their previous high mark, being quoted now at 9½@10c. Short supply has forced spot quotation on *copperas* up to 4c. per lb. and producers are not able to supply the demand. *Soda nitrite* is sharply off, offers being made in the neighborhood of 20c. per lb. Available stocks are being reduced and further fluctuation is to be expected. Some interest has been shown in *carbon tetrachloride*, with spots occasionally offered below the factory price. Quotations have ranged all the way from 11@12¾c. per lb. and the market remains uncertain. *Salt cake* is up, spots bringing $40 a ton and even more.

Coal-Tar Products

The word dull describes the coal-tar market in all its factors. Because the demand for *benzol* is more pressing than for other items of the line its shortage is most obvious. Difficulty in shipping the goods is the principal obstacle, and this is not so pronounced as in the recent past. Today's receipts are offered at 28c. per gal. in cars. *Toluol* is almost as scarce and is likewise held at 28c. *Cresol* has shown an upward tendency, recent offerings being around 17c., but demand is showing a decided falling off.

Aniline oil and *aniline salt* have reacted from their high marks of May and are now offered at 33@35c. and 37@40c. per lb. respectively. Supplies remain very short, but users seem unwilling to pay the price in the face of increasing volume of supply coming from the producer. Former quotations on *naphthaline* of 16c. per lb. on balls and 15c. on flakes hold good. Supply is limited in the face of an active demand. Coal-tar acids remain practically unchanged in price with the exception of *picric* which is up to 29@30c. per lb., and has become hard to locate even at that figure, and *salicylic* which has been offered as low as 48c. The entire coal-tar line is subject to frequent fluctuation which denies a healthy tone to the market.

Vegetable Oils

The oils, for some time the weakest of the chemical lines, show further reductions and increased lack of interest. *Linseed oil* alone is practically holding its own, $2.02 per gal. being the current quotation on the raw product in barrels out of local stocks, and $1.65@$1.70 ruling on carload lots. Varying guesses on the incoming crop of flax seed have a tendency to discourage active buying and a drop in price is freely predicted in some quarters.

Oriental oils, already weakened by the Japanese financial crisis, were further affected by the recent failure of a large brokerage concern on the Coast. It is rumored that this will precipitate large stocks of various oils on the market for immediate sale. Consumers are inclined to be cautious in buying for the added reason that, in many cases, they are unable to effect shipment of their finished products. This combination of circumstances has forced prices down to a new level. *Manila coconut oil* is quoted in sellers' tanks on the Coast at 16½@16¾c. per lb., the same grade going for 16@16½c. in barrels f.o.b. Chicago. Actual transactions are few and some were at an even lower figure. *Soya bean oil* in tanks, f.o.b. Coast, is 12@12½c., with the refined, deodorized grade bringing 16@16½c. from local stocks in barrels.

Nominal quotation on *corn oil*, prime, in tanks, is 14¾@15c., with practically none changing hands. *Cottonseed oil* is equally quiet, car quotations being, on crude around 14c. and on prime summer yellow, 17c. Cash offers would probably entice lower figures.

Flotation Oils—Naval Stores

Present quotations must be regarded as purely nominal, premiums being the rule rather than the exception. *Turpentine*, pure gum spirits, is quoted at $2.18@$2.25 per gal. *Pine oil*, equally scarce and desirable, is $2 for the .933 pure steam-distilled and $1.85@$1.90 for the destructively distilled. Approximately similar conditions prevail in *rosins*, with local market ranging from $3 to $4 above Savannah on the various grades.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.65 – $0.75
Acetone	lb.	$0.15 –$0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.50
Acetic, 56 per cent	cwt.	6.00 – 7.50	8.00 – 9.00
Acetic, glacial, 99½ per cent, carboys	cwt.	15.50 –16.00	16.50 – 17.50
Boric, crystals	lb.	.15 – .15½	.15½ – .16½
Boric, powder	lb.	.15 – .15½	.15 – .16
Citric	lb.	1.05 – 1.12	1.17 – 1.18
Hydrochloric (nominal)	cwt.	2.00 – 3.00	3.10 – 3.25
Hydrofluoric, 52 per cent	lb.	.13½ – .14	.14½ – .15½
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)		—	—
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.60 – .65
Phosphoric, Ortho, 50 per cent solution	lb.	.14 – .23	.24 – .25
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.25 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 –19.00	—
Sulphuric, 60 deg., drums	ton	—	—
Sulphuric, 66 deg., tank cars	ton	23.00 –24.00	25.00 – 26.00
Sulphuric, 66 deg., drums	ton	35.00 –40.00	45.00 – 50.00
Sulphuric, 66 deg., carboys	ton	36.00 –40.00	50.00 – 55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 –30.00	37.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 –30.00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 –35.00	40.00 –
Tannic, U. S. P	lb.	1.45 – 1.50	1.55 – 1.60
Tannic (tech.)	lb.	—	.60 – .90
Tartaric, crystals	lb.	—	.80 – .85
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl, 95%	gal.	—	2.50 – 2.70
Alcohol, Methyl, pure	gal.	—	3.50 – 3.55
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.10 – 1.15
Alcohol, denatured, 190 proof (nominal)	gal.	—	1.05 – 1.10
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08¾	.09 – .09½
Alum, chrome lump	lb.	.15¼ – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.02 – .03	.03½ – .04½
Aluminum sulphate, iron free	lb.	.03½ – .04	.04½ – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10¾	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – .13½	.13½ – .14½
Ammonium nitrate	lb.	.08½ – .09½	.10 – .11
Ammonium sulphate	lb.	.07 – .07¼	.08½ –
Amylacetate	gal.	—	5.00 –
Amylacetate tech	gal.	—	4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	.15 – .16	.16½ – .17
Arsenic, sulphide, powdered (red arsenic)	lb.	.20 – .21	.22 – .23
Barium chloride	ton	150.00–160.00	170.00–200.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.09½ – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)		—	—
Blue vitriol (see copper sulphate)		—	—
Borax (see sodium borate)		—	—
Brimstone (see sulphur, roll)		—	—
Bromine	lb.	.70 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	—
Calcium carbide	lb.	.04½ – .04½	.04¾ – .05½
Calcium chloride, fused, lump	ton	23.00 –25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01¾	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.50 – 6.50
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.12 – .13	.13½ – .15
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)		—	—
Caustic soda (see sodium hydroxide)		—	—
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)		—	—
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)		—	—
Epsom salt (see magnesium sulphate)		—	—
Ethyl Acetate Com. 85%	gal.	1.35 –	1.40 –
Ethy Acetate pure (acetic ether 98% to 100%)		—	1.75 –
Formaldehyde, 40 per cent (nominal)	lb.	.36 – .40	.57 – .65
Fusel oil, ref	gal.	—	5.25 – 6.00
Fusel oil, crude (nominal)	gal.	—	—
Glauber's salt (see sodium sulphate)		—	—
Glycerine	lb.	—	.26½ – .28½
Iodine, resublimed	lb.	4.10 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	—	2.90 – 3.10
Lead acetate, normal	lb.	— .2	.13½ – .16
Lead arsenate (paste)	lb.	.11 – .1	.13 – .17
Lead nitrate, crystals	lb.	—	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P.	100 lb.	3.00 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	—	3.25 – 3.60
Nickel salt, double	lb.	—	.14 – .16
Nickel salt, single	lb.	—	.16 – .18
Phosgene (see carbonyl chloride)		—	—
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.35 – .37	.45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.52 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – .95
Potassium carbonate, U. S. P.	lb.	—	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28
Potassium chlorate, crystals	lb.	$0.15 –$0.16	$0.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.31 – .35
Potassium iodide	lb.	—	3.35 – 3.60
Potassium nitrate	lb.	.15 – .17	.19 – .21
Potassium permanganate	lb.	.75 – .80	.85 – .95
Potassium prussiate, red	lb.	.90 – 1.00	1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.35 – .36
Potassium sulphate (powdered)	ton	$225.00 –240.00	—
Rochelle salts (see sodium potas. tartrate)		—	—
Salammoniac (see ammonium chloride)		—	—
Sal soda (see sodium carbonate)		—	—
Salt cake	ton	30.00 –32.00	34.00 – 36.00
Silver cyanide (nominal)	oz.	—	1.25 –
Silver nitrate (nominal)	oz.	—	.74 – .76
Soda ash, light	100 lb.	—	3.50 – 3.60
Soda ash, dense	100 lb.	—	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09½ – .12
Sodium bicarbonate	100 lb.	2.45 – 2.60	2.75 – 3.50
Sodium bichromate	lb.	.30 – .33	.34 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .10½
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 – .10½	.10½ – .11
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.25 – 6.00	6.25 – 6.50
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.19 – .19½	.20 – .21
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	—	.39 – .40
Sodium prussiate, yellow	lb.	.23 – .27	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01¾	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2.50
Sodium sulphide, crystal, 60–62 per cent (conc)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, powdered	lb.	.17½ – .18½	.19 – .20
Sulphur chloride	lb.	.05¾ –	.06 –
Sulphur, crude	ton	22.00 –	—
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 –
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran	lb.	.13 – .13½	.13½ – .17
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ –	.13 – .15
Zinc oxide, U. S. P	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03¾	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.40 —	$1.50
Alpha naphthol, refined	lb.	1.60 —	1.70
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, drums extra	lb.	.35 —	.40
Aniline salts	lb.	.42 —	.50
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.35 —	1.40
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U.S.P	lb.	.90 —	1.00
Benzoate of soda, U.S.P	lb.	.80 —	.90
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.40
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	3.50 —	4.00
Beta naphthol, sublimed (nominal)	lb.	.80 —	.90
Beta naphthol, tech (nominal)	lb.	.65 —	.85
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 —	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 —	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 —	.75
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	1.50 —	1.60
Dimethylaniline	lb.	1.35 —	1.55
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.40 —	.45
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.80 —	.85
H-acid (nominal)	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.15 —	1.30
Monochlorbenzol	lb.	.18 —	.20
Monoethylaniline	lb.	2.00 —	2.40
Naphthaline crushed, in bbls. (250 lb.)	lb.	.17 —	—
Naphthaline, flake	lb.	.17 —	.18
Naphthaline, balls	lb.	.16 —	.18
Naphthionic acid, crude	lb.	.75 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitro-toluol	lb.	.18 —	.25
Ortho-amidophenol	lb.	3.25 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.35 —	.45
Para-amidophenol, base	lb.	2.50 —	3.00
Para-amidophenol, HCl	lb.	2.50 —	3.00
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	1.50 —	1.55
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.60 —	3.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.20
Pyridin	gal.	2.00 —	3.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0.—	—	$0.52
Salicylic acid, U. S. P.	lb.	.50	—	.6
Salol	lb.	.90	—	1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.27	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.28	—	.32
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	
Toluol, in drums	gal.	.29	—	.32
Xylidine, drums, 100 gal.	lb.	.44	—	.50
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities

Beeswax, refined, dark	lb.	$0.36	—	$0.39
Beeswax, refined, light	lb.	.39	—	.40
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1. (nominal)	lb.	1.00	—	1.05
Carnauba, No. 2, regular (nominal)	lb.	.85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.43	—	.44
Japan	lb.	.21	—	.22
Montan, crude	lb.	.23	—	.25
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.09½	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½	—	.12¼
Paraffine waxes, refined, 128-130 m.p.	lb.	.14½	—	.15
Paraffine waxes, refined, 133-135 m.p.	lb.	.16½	—	.17
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb.	.26	—	.27
Stearic acid, triple pressed	lb.	.27	—	.28

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.80
Pine oil, pure, dest. dist.	gal.	1.60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.50	—	$18.00
Rosin E-I	280 lb.	18.50	—	19.75
Rosin K-N	280 lb.	20.00	—	21.00
Rosin W. G.-W. W.	280 lb.	21.25	—	23.00
Wood rosin, bbl.	280 lb.	17.00	—	17.00
Spirits of turpentine	gal.	1.85	—	
Wood turpentine, steam dist.	gal.	1.70	—	1.80
Wood turpentine, dest. dist.	gal.	1.40	—	1.50
Pine tar pitch, bbl.	200 lb.		—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.00
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.87	—	.89
Rosin oil, second run	gal.	.89	—	.92
Rosin oil, third run	gal.	1.04	—	1.05
Rosin oil, fourth run	gal.	1.12	—	1.12

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.37½	—	$0.38
Upriver coarse	lb.	28½	—	.29½
Upriver caucho ball	lb.	.30	—	.30½
Plantation—First latex crepe	lb.	.38	—	.39
Ribbed smoked sheets	lb.	.38¼	—	.39
Brown crepe, thin, clean	lb.	.37	—	.38
Amber crepe No. 1	lb.		—	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.22
China wood oil, in bbls.	lb.	.18½	—	.19½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½	—	.19½
Corn oil, crude, in bbls.	lb.	.17½	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½	—	.16
Cottonseed oil, summer yellow	lb.	.18½	—	.19
Coteonseed oil, winter yellow	lb.	.21	—	.22
Linsed oil, raw, car lots (domestic)	gal.	1.57	—	1.67
Linseed oil, raw, tank cars (domestic)	gal.	1.52	—	1.62
Linseed oil, boiled, car lots (domestic)	gal.	1.60	—	1.70
Olive oil, commercial	gal.	3.10	—	3.25
Palm, Lagos	lb.	.12½	—	.13½
Palm, bright red	lb.	.13	—	.13½
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.13	—	.15
Peanut oil, refined, in bbls.	lb.	.22	—	.24
Rapeseed oil, refined in bbls.	gal.	1.70	—	1.72
Rapeseed oil, blown, in bbls.	gal.	1.80	—	1.85
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½	—	.13½

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f.o.b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Buena Creek, S. C.	net ton	$22.50	—	$25.00
Barytes, ground, off color, f.o.b. Buena Creek	net ton	15.00	—	20.00
Barytes, crude, 88% to 94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off color, f.o.b. Cartersville	net ton	16.00	—	19.00
Barytes, crude, 88% to 94% ba., Cartersville	net ton	12.00	—	
Bone ash, dry	lb.	.09	—	.09½
Blanc fixe, pulp	net ton	60.00	—	80.00
Casein	lb.	.15	—	.18
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05½
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	7.50	—	8.00
Feldspar, ground, f.o.b. Baltimore	net ton	22.00	—	25.00
Feldspar, ground, f.o.b. North Carolina	net ton	16.00	—	20.00
*Feldspar, ground, f.o.b. N. Y. State	net ton	16.00	—	20.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00		
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00		
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala.	lb.		—	.01
Graphite (dust facing grade 50%) Ashland, Ala.	lb.		—	.02
Graphite, crucible, 80% carbon Ashland, Ala	lb.		—	.05
Graphite, crucible, 90% carbon Ashland, Ala	lb.		—	.10
Graphite, crucible, 85% carbon	lb.		—	.08
Graphite, crucible, 88% carbon	lb.		—	.09½
Graphite, crucible, 90% carbon	lb.		—	.10½
Pumice stone, imported, lump	lb.	.04	—	.50
Pumice stone, domestic, lump	lb.	.06		
Pumice stone, ground	lb.	.04	—	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton		—	10.00
Quartz (acid tower) 1½ @ 2 in., f.o.b. Baltimore	net ton		—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton		—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange, fine	nominal lb.	1.40	—	
Shellac, orange, superfine	lb.	1.50	—	
Shellac, A. C. garnet	lb.	1.05	—	1.15
Shellac, T.N.	lb.	1.20	—	1.30
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	9.50	—	14.00
Talc, roofing grades, f.o.b. Vermont	ton	8.00	—	9.00
Talc, rubber grades, f.o.b. Vermont	ton	9.00	—	15.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00	—	15.00
Talc, talcum powder grade, California	ton	20.00	—	35.00
Talc, imported	ton	60.00	—	70.00

Refractories

All f.o.b. Works:		
Chrome brick, 9 in. straights and sizes	net ton	$80-90 at Baltimore
Chrome brick	net ton	75-80 at Chester, Penn.
Chrome cement	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay	1,000	45-50 at Clearfield, Penn.
Clay brick, 2nd quality	1,000	40-45 at Clearfield, Penn.
Fire clay	net ton	5—7 at Baltimore
Magnesite, dead burned	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	85-90 at Chester, Penn.
Magnesite brick, 9 in. straights	net ton	90 at Baltimore
Magnesite brick, 9 in. sizes and shapes larger than 9 in.		Regular extras
Silica brick	1,000	50-55 at Mt. Union, Penn.
Silica brick, 9 in. straights, and sizes	1,000	55, Chicago District

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.17	—	.18
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon	lb.	.18	—	.19
Ferro-manganese, 70-80% Mn.	gross ton	200.00	—	250.00
Spiegeleisen, 16-20% Mn.	gross ton	70.00	—	75.00
Ferro-molybdenum, 50-60% Mo, per lb. of Mo.	lb.	2.25	—	2.75
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90	—	1.10
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All f.o.b. Mines, Unless Otherwise Stated

Carnotite 96% U_3O_8, per lb. of U_3O_8	lb.	$2.75	—	$3.00
Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	unit	.60		.65
Chrome ore, 40%, min., Cr_2O_3, f.o.b. Atlantic Seaboard	unit	.70	—	.85
Coke, foundry, f.o.b. ovens	net ton	16.00	—	17.00
Coke, furnace, f.o.b. ovens	net ton	15.00	—	16.00
*Coke, petroleum, refinery, Atlantic Seaboard	net ton	24.00		
Fluor spar, gravel	net ton	22.50	—	25.00
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50	—	
Fluorite, 52% CaO_2 per lb. ore	lb.	.02	—	
Manganese ore, 45% Mn and over	unit	.80	—	.85
Manganese ore, chemical (MnO_2)	gross ton	75.00	—	85.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.85	—	
Monazite, per unit of ThO_2	unit	4.00	—	
Pyrites, Spanish, fines, c.i.f.	unit	.12	—	
Pyrites, Spanish, furnace size, c.i.f.	unit	.11	—	
Pyrites, Spanish, run of mines, c.i.f.	unit	.12	—	.14
Pyrites, domestic, fines	unit	.12	—	.14
Rutile, 95% TiO_2 per lb. ore	lb.	.20	—	.25
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00		
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium ore per lb. of V contained	lb.	1.00	—	3.00
Zircon, washed, iron free	lb.	.10	—	.12

*Nominal

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

LOS ANGELES — The Robertson Cole Studios, Inc., Currier Bldg., has awarded the contract for the construction of a moving picture studio on Gower St. and Melrose Ave., to the Milwaukee Bldg. Co., 403 South Hill St. A chemical laboratory will be installed in same. Estimated cost, $100,000.

SAN PEDRO—The Fabri-Cord Tire Co., 917 Natl. Bank Bldg., Los Angeles, has purchased a site on 17th St. and plans to build a 3-story, 60x250-ft. factory on same. Estimated cost, $2,000,000. S. H. Christian, pres.

Connecticut

FAIRFIELD—The Bridgeport Deoxidized Bronze & Metal Co., Iran Ave., has purchased a 23-acre site along the New York, New Haven & Hartford R.R., here, and plans to construct a large bronze factory on same.

MONTVILLE—The Robert Gair Paper Corp., Thames River Division, will soon award the contract for the construction of a 2-story, 250x400-ft. manufacturing building. Estimated cost, $500,000.

Illinois

CHICAGO—The Kroeck Paper Co., 220 Institute Pl., is building a plant at Paulina and Superior Sts. Estimated cost, $240,000.

Indiana

WEST HAMMOND—R. G. Pierce, archt., 10 South La Salle St., Chicago, will soon award the contract for the construction of a 1-story, 210x560-ft. steel plant, here, for the La Salle Iron Works, 2305 South Halsted St., Chicago. Rolling mill, heat treatment and pickling equipment will be installed in same. Estimated cost, $650,000.

Iowa

HAWARDEN—The Bd. Educ. rejected all bids for the construction of a 2-story, 60x150-ft. school including chemical and physical laboratories. Estimated cost, $135,000. G. L. Lockhart, 391 Endicott Bldg., St. Paul, Minn., archt.

Maine

CARIBOU—The Aroostook Federation of Farmers plans to build a large fertilizer plant here. Estimated cost, $50,000.

Maryland

BALTIMORE—The Natl. Enameling & Stamping Co., Race and Ostend Sts., has awarded the contract for the construction of a 2-story, 61x76-ft. addition to its tin stamping factory, to the John Waters Bldg. Co., 23 East Center St., at $100,000.

Massachusetts

CAMBRIDGE—The Ltd. Plate Glass Co., 30 Sudbury St., Boston, has awarded the contract for the construction of a 2-story, 100x200-ft. factory on Albany St., to N. H. & H. A. Root, 6 Beacon St., Boston.

Michigan

DETROIT — The International Metal Stamping Co., Artillery & Muster Aves., has awarded the contract for the construction of a 1-story, 79x532-ft. factory on Artillery Ave., to the H. G. Christman Co., 315 Stevens Bldg., at $130,000. Noted June 9.

Missouri

BROOKFIELD—The School Bd. plans to build a school. A general chemical laboratory will be installed in same. Estimated cost, $165,000. A. W. Baker, secy. W. E. Hulse & Co., 309 Securities Bldg., Des Moines, Ia., archt.

NEVADA—T. B. Craig, Supt. of State Hospital 3, will receive bids until July 1 for the construction of a 2-story, 40x80-ft. hospital. A bacteriological laboratory will be installed in same. Estimated cost, $60,000.

New York

GREYCOURT—The Dept. of Correction, Municipal Bldg., New York City, rejected all bids for furnishing all labor and material for the construction of a sewage disposal plant for the New York Women's Farm Colony here. Work will be re-advertised. Noted May 5.

North Dakota

BISMARCK—The Bd. of City Comrs. will receive bids until July 12 for the construction of a complete waterworks system, including a 79x114-ft. filtration plant and a 73x113-ft. sedimentation basin, rapid sand filters of 750,000-gal. capacity, dry feed chemical machines, etc.

JAMESTOWN—The Bd. Educ. is having plans prepared for the construction of a 3-story, 230x240-ft. junior high school. A chemical laboratory will be installed in same. Estimated cost, $200,000. Shannon Boyd & Boyd, archts.

Ohio

AKRON—The city received only bid for furnishing sulphate and aluminum to the bureau of water service and water supply, Dept. of Pub. Serv., from the General Chemical Co., 112 North Adams St., $25,800.

AKRON—E. A. Zeisloft, Dir., of Pub. Serv., Delaware Bldg., will receive bids until July 9 for the construction and equipment of an addition to the water purification plant. Filter equipment will be installed in same.

GARRETTSVILLE—The McWade Tire & Rubber Co., 711 Union Bldg., Cleveland, plans to build a 2-story rubber factory here. Estimated cost, $75,000.

MASSILLON—The Alloy Electric Steel Castings Co. has awarded the contract for the construction of a 1-story, 50x150-ft. mill building, to the Boldt Constr. Co., 6110 Euclid Ave., Cleveland, at $60,000.

WORTHINGTON — W. P. Vest, village clk., will soon award the contract for the construction of a sewage disposal plant for the city. Jennings, Laurence Co., Hartman Bldg., Columbus, engrs.

Texas

BRIDGEPORT—The Phoenix Clay Corp., 1215 Southwestern Life Bldg., Dallas, plans to build a brick and tile plant here, which will have a daily capacity of 125,000 brick or 150 tons of tile. Address C. W. Martin, pres.

FARMERSVILLE—The Bd. of Directors of the Farmersville Sewer Co. has awarded the contract for the construction of sanitary sewer lines and 2 sewage disposal plants, to J. W. Crook, Paris, at $43,856. Noted June 16.

Wisconsin

MILWAUKEE—The Amer. Metal Products Co., Clinton St. and Kinnickinnic Ave., has purchased a 6-acre site on Burham St. and plans to construct a modern 80x220-ft. foundry on same. Later the company plans to build a rolling mill. C. J. Zarse, genl. mgr.

MILWAUKEE—The Supt. of Lighthouses will soon award the contract for furnishing and delivering acetylene gas in acetone, gasoline, kerosene, etc.

PORT WASHINGTON—The Turner Mfg. Co. will soon award the contract for the construction of a 1-story, 150x160-ft. foundry and factory addition. Frank D. Chase, Inc., 645 North Michigan Ave., Chicago, archt. Noted June 23.

New Brunswick

MONCTON—The Record Fdry. & Machine Co., Ltd., plans to build a 50x140-ft. foundry. Estimated cost, $75,000. H. G. Jackson, mgr.

Ontario

KANORA—The St. Francis Pulp & Paper Co. will soon receive bids for the construction of a pulp and paper mill along the English River north of here. Estimated cost, $5,000,000.

LONDON—The city plans to supply St. Thomas and London with water from Lake Erie. Estimated cost of pipe line, $3,000,000. Plans include a filter plant at an annual charge of $500,000.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold its summer meeting at the La Salle Hotel in Chicago, Aug. 16, 17 and 18.

THE AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

THE AMERICAN ELECTROPLATERS' SOCIETY will hold its eighth annual convention in Rochester, June 30 to July 3. Headquarters will be at the Seneca Hotel.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS is holding its twelfth semi-annual meeting as follows: June 28 and 29 in Montreal, June 30 in Ottawa, July 1 in Ontario, July 2 in Shawinigan Falls, July 3 in La Tuque, July 4 in Chicoutimi and July 5 in Quebec.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its one hundred and twenty-second meeting Aug. 20 to Sept. 3, at Lake Superior.

THE AMERICAN MINING CONGRESS will hold its next convention in Denver Nov. 15.

THE AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

THE AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

THE FOREST PRODUCTS LABORATORY will hold its decennial celebration at Madison, Wis., July 22 and 23, 1920.

THE INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

THE INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its mid-summer meeting at Boston, July 15 and 16.

THE IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

THE SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its twenty-seventh annual meeting June 29 to July 3, at the University of Michigan, Ann Arbor, Mich.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its fall meeting at Saratoga Springs, N. Y., Sept. 1, 2 and 3.

New Publications

NEW BUREAU OF MINES PUBLICATIONS: Bull. 78, Approved Explosion-Proof Coal-Cutting Equipment, by L. C. Ilsley and E. J. Gleim; Bull. 95, A Glossary of the Mining and Mineral Industry, by Albert H. Fay; Bull. 140. Occupational Hazards at Blast-Furnace Plants and Accident Prevention, by Frederick H. Willcox; Bull. 183, Abstract of Current Decisions on Mines and Mining, by J. W. Thompson; Tech. Paper 227, The Determination of Mercury, by C. M. Bouton and L. H. Duschak; Blowholes, Porosity and Unsoundness in Aluminum-Alloy Castings, by Robert J. Anderson; Tech. Paper 245, Quarry Accidents in the United States During the Calendar Year 1918, by Albert H. Fay; Tech. Paper 250, Metal-Mine Accounting, by C. B. Holmes; Tech. Paper 252, Metal Mine Accidents in the United States During the Calendar Year 1918, compiled by Albert H. Fay.

Vol. 22, No. 18 May 5, 1920 *Pages 825-868*

CHEMICAL & METALLURGICAL ENGINEERING

H. C. PARMELEE, *Editor*

Contents

A Comparative Test Upon High-Speed Steels—I 829
By A. J. Langhammer.
Notes on a Competition made by Packard Motor Car Co. of modern high-speed steels. Preliminary observations on current sales practices and a general review of various classes, and the effect of chemical compositions and heat treatment.

Operation of the Gainesville Castor Oil Plant 833
By J. H. Shrader and A. C. Goetz.
A Description with many details of the expeller and solvent extraction process of obtaining a high recovery of oil from castor beans. Cleaning and tempering beans. Drying and bleaching oil. Cake extraction and operating difficulties.

Supply of Inorganic Nitrogen in the United States 841
By Major D. P. Gaillard.
The Inadequate Domestic Supply of nitrogen in the United States is supplemented by importations from Chile. Summary of figures on consumption and supply showing deficiency even if Government plants are operated.

Synthetic Acetic Acid and Acetone 847
By J. T. Rooney.
Description of the process and method of production of acetic acid, acetates and acetone from calcium carbide. Acetylene generation and catalytic hydration. Oxidation of acetaldehyde to acetic acid. Acetone.

The Commercial Synthesis of Sillimanite 851
By Andrew Malinovszky.
A Description of a cupola process for fusing alumina and silica to form sillimanite crystals. Reactions consist of forming carbides under reducing, and combusting them under oxidizing conditions.

British Chemical Industry 828

Automatic Gas Analysis Apparatus for Government Helium Plants 832

A Plea for the Scientific Study of Cellulose Chemistry 838
By Harold Hibbert.

Electrochemical Industries in Sweden 840
By J. W. Beckman.

Photo-Sensitizing Dyes in Demand 840

Influence of Slag and Nitrogen on the Corrosion of Iron 845

Canada's Foreign Trade for 1919 850

Production of Turpentine From Douglas Fir Pitch 853

Artificial-Silk Manufacture in Great Britain 853

Mexican Exposition in 1921 853

Legal Notes 854
By Wellington Gustin.

Editorial 825

Synopsis of Recent Chemical and Metallurgical Literature 855

Recent Chemical and Metallurgical Patents 856

Current Events in the Chemical and Metallurgical Industries 858

Personal 862

Obituary 862

Current Market Reports—The Non-Ferrous Metal Market, the Iron and Steel Market, the Chemical and Allied Industrial Markets and Price Lists 862

Industrial Notes and Coming Meetings and Events 867

Professional Directory 129-131

Searchlight Section 132-151

Ready Reference 152

Alphabetical Index 158

McGRAW-HILL COMPANY, Inc., Tenth Ave. at 36th St., NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice-President
J. MALCOLM MUIR, Vice-President
F. M. FEIKER, Vice-President
JAMES H. McGRAW, Jr., Secretary
EDWARD CALDWELL, Treasurer

WASHINGTON, D. C., 610-611 Colorado Building
CHICAGO, Old Colony Building
PHILADELPHIA, Real Estate Trust Building
CLEVELAND, Leader-News Building
SAN FRANCISCO, Rialto Building
LONDON, E. C., 6 Bouverie St.
BUENOS AIRES, Calle Corrientes, 685

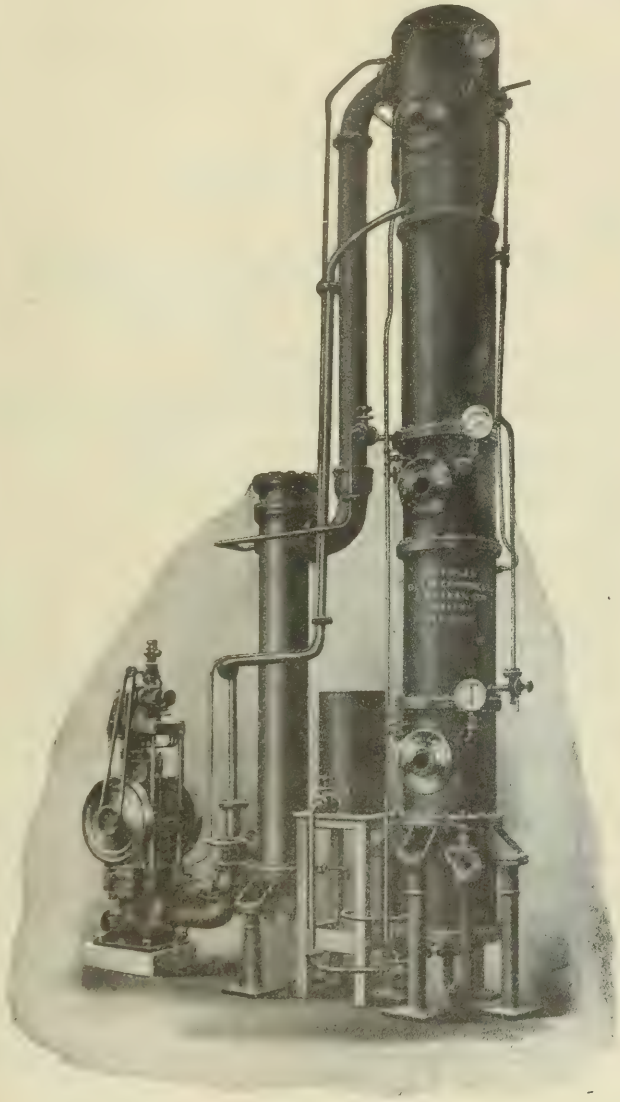
Cable Address: "Machinist, N. Y."

Publishers also of
Electrical World
Electrical Merchandising
Power
Electric Railway Journal
Journal of Electricity
American Machinist
Engineering News-Record
Engineering and Mining Journal
Coal Age
Ingeniería Internacional

The annual subscription rate is $5. Extra zone postage west of the Mississippi and in Alaska, Hawaii, the Philippines, Porto Rico, Canal Zone, Cuba and Mexico, $1. Extra postage in Canada, $2. Extra Foreign postage, $4 (total, $9, or 38 shillings). Single copies, 25 cents.
No back volumes for more than one year and no back copies for more than three months.
Change of Address—When change of address is ordered the *new* and *old* address must be given. Notice must be received at least ten days before the change takes place.
Copyright, 1920, McGraw-Hill Company, Inc.
Published weekly. Entered as second-class matter July 13, 1918, at the Post Office at New York N. Y., under the act of March 3, 1879.

Member Audit Bureau of Circulations. Member Associated Business Papers, Inc.
Circulation of This Issue, 15,160

EVAPORATORS



OUR PATENT
"MULTIPLEX"
FILM
EVAPORATOR

IS ESPECIALLY ADAPTED FOR HANDLING DELICATE LIQUORS. IT IS USED EXTENSIVELY FOR

GLUE

SODA LIQUORS

FOOD PRODUCTS

SUGAR AND GLUCOSE SYRUPS

TANNIN AND DYEWOOD EXTRACTS, ETC.

MANY REPEAT ORDERS FROM SATISFIED USERS

BLAIR, CAMPBELL & McLEAN, Inc.

COMPLETE CHEMICAL AND REFINING EQUIPMENT
COLONIAL TRUST BUILDING

PHILADELPHIA, PA.

TN
1
C45
v.22

Chemical engineering

Engin.

ENGIN STORAGE

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY